

**FOR CONTRACT NO.: 07-2159C4**  
**PROJECT ID: 0700000339**

# **INFORMATION HANDOUT**

## **MATERIALS INFORMATION**

**FOUNDATION REPORT FOR CARMENITA Rd/I-5 INTERCHANGE**  
**DATED MAY 12, 2010**

**GEOTECHNICAL DESIGN RECOMMENDATION FOR TYPE 1 RETAINING WALLS AT**  
**CARMENITA Rd/I-5 INTERCHANGE, DATED MAY 24, 2010**

**STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, 2006 EDITION**

**2007 SUPPLEMENT TO STANDARD SPECIFICATIONS FOR PUBLIC WORKS**  
**CONSTRUCTION, 2006 EDITION**

**LOS ANGELES COUNTY SANITARY DISTRICT AMENDMENTS TO STANDARD**  
**SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, 2006 EDITION AND**  
**STANDARD DRAWINGS FOR CONSTRUCTION**

**BATTERY BACKUP SYSTEM CONNECTION DIAGRAMS**

**ROUTE: 07-LA-5-2.9/4.9**

FOR CONTRACT NO.: 07-2159C4

# INFORMATION HANDOUT

## MATERIALS INFORMATION

### FOUNDATION REPORT

Foundation Report for  
Carmenita Rd & Route 5 Interchange  
EA 07-2159C1

**ROUTE: 07-LA-5, KP 2.9/4.9**

# INFORMATION HANDOUT

## **MATERIALS INFORMATION**

### GEOTECHNICAL REPORT

Geotechnical Design Recommendations for  
Type 1 Retaining Walls at Carmenita Rd and Route 5 Interchange  
EA 07-2159C1

**M e m o r a n d u m**

*Flex your power!  
Be energy efficient!*

**To:** MR. RAMIN RASHEDI  
BRANCH CHIEF  
DIVISION OF ENGINEERING SERVICES  
OFFICE OF STRUCTURE DESIGN  
BRIDGE DESIGN BRANCH 11

**Date:** May 24, 2010

**File:** 07-LA-05-KP2.9  
07-2159C1  
Retaining Walls at  
Carmenita Ave./I-5  
Interchange

Attn: Mr. Daniel Texler

**From:** DEPARTMENT OF TRANSPORTATION  
DIVISION OF ENGINEERING SERVICES  
GEOTECHNICAL SERVICES - MS 5  
GEOTECHNICAL DESIGN – SOUTH 1

**Subject:** Geotechnical Design Recommendations for Type 1 Retaining Walls at Carmenita Rd/I-5 Interchange.

In response to your request dated March 22, 2007, the Office of Geotechnical Design South-1 provides following geotechnical design recommendations for the Type 1 retaining walls to be built at the proposed Carmenita Ave./I-5 Interchange. The existing Carmenita Ave. OC (BR 53-0214) is to be replaced with a longer and wider structure with four additional onramp/off-ramp structures (C1 to C4 lines) connected to the mainline (B1 line). The limits of the wall alignments are presented in Table 1 of the memo.

This office performed subsurface exploration work for the proposed bridges from January to July of 2006 near the subject site. In addition, more exploratory work, including drillings and CPT soundings, was conducted from July to September 2008 for the proposed bridges and retaining walls. Also completed was the soil borings in Dec. 2004 for the Phase 1 report of the proposed improvements. The following recommendations are based on the review of the General Plan, review of existing as-built logs of test borings (LOTBs) for the existing bridge retrofit in 1996, and the recent site explorations from 2004 to 2008.

**Table 1. Locations and Heights of Retaining Walls**

Retaining Wall No.	Wall Limits		Reference Lines	Offset	Wall Type	Approx. maximum Wall Height (m)
	Beginning Station	End Station				
RW12	11+68	11+87	B1 Line	Right	Type 5*	2.1
	11+87	12+87	B1 Line	Right	Type 1	7.3
RW13	11+80	13+10	B1 Line	Left	Type 1	10.3
RW16	16+10	16+80	B1 Line	Right	Type 1	7.3
	16+10	16+60	D2 Line	Left	Type 1	4.2
RW17	16+33	17+72	B1 Line	Left	Type 1	7.3
RW37	36+60	37+50	C1 Line	Left	Type 1	4.8
RW38	37+29	37+50	C1 Line	Right	Type 1	6.1
RW39	37+80	38+34	C2 Line	Left	Type 1	6.1
RW44	36+90	38+34	C2 Line	Right	Type 1	6.1
RW43	40+81	40+90	C3 Line	Left	Type 1	3.6
RW42	40+80	42+00	C3 Line	Right	Type 1	4.2
RW41	40+58	42+15	C4 Line	Left	Type 1	7.3
RW40	40+58	41+12	C4 Line	Right	Type 1	7.3

Note: \* Type 5 wall with shallow foundation was proposed for southern portion of the RW12. The rest of RW12 and all other walls were Type 1 wall with driven pile foundations.

**SUBSURFACE CONDITION**

The Site is situated in the Central Basin of the Los Angeles Coastal Plain. The existing ground surface of the subject site is generally flat. From existing grade to approximately 14 m below, subsurface materials are mostly loose to medium dense silty sand (SM) and/or poorly graded sand (SP) interbedded with layer (or layers) of firm to stiff silt and sandy silt with plasticity ranging from low to high. One and half to 2.4 m of stiff lean clay or sandy clay (CL) layer was found at most of the boring locations from 14.3 m to 15.2 m below the ground surface. Below the depth of 16.5 to 17.4 m, subsurface materials are mostly medium dense to dense clayey sand (SC), silty sand (SM) and sand (SW/SP), with stiff to hard clay layer interbedded at various depths.

The project site is known to have environmental contamination issues. For the detailed description of these issues, please refer to the pertinent report for this project by the District 7 Office of Environmental Engineering and Feasibility Studies.

## **GROUNDWATER**

Based on review of existing well data and recent measurements, the groundwater table at the site has changed substantially over time.

Ground water was found from 16.4 m above mean sea level (MSL) to 14.3 m above MSL based on soil borings completed in May 1996 and December 2004, respectively. In our recent subsurface exploration, from July to September 2008, groundwater was encountered near both ends of the proposed main bridge (BR53-3018). The elevations of the water table for these water units were approximately 14.3 m above MSL, or 9.1 m below ground surface (bgs) close to retaining walls RW12 and RW13, and 13.7 m above MSL, or 11.6 m bgs close to retaining walls RW16 and RW17.

The encountered water as described above is considered perched water, and does not appear to be continuous across the site. For the convenience of discussion, this perched water is identified as the upper aquifer in the report.

The upper most regional aquifer underlying the site is Gaspar. This aquifer is continuous throughout the site and identified as the lower aquifer in the report. The highest groundwater table elevation of this aquifer over last 17 years is at Elev. 0.7 m (MSL) at Well No. 1051W (LADPW). The measurement was taken after the storm season of 2006. This groundwater elevation is slightly above the groundwater table reported in the log of test borings (LOTBs) of May 1996 for seismic retrofit of the existing bridge, which is at Elev. 0.0 m (MSL), or 24.4 m bgs. During current subsurface exploration performed from July to September of 2008, this lower aquifer was not measured at any of the boreholes, which were advanced to 26.4 m below existing ground surface.

However, measurements from three recently installed monitoring wells near the bridge site indicate that the highest groundwater table was at Elev. 6.2 m (MSL) as of August 21, 2009 to August 24, 2009. The above groundwater table reading is considered to be the highest for the lower aquifer.

## **SEISMIC STUDY**

The controlling fault for the site is the Puente Hills Blind Thrust (PHBT) located 4.2 miles northeast of the site. This fault will generate a Maximum Credible Earthquake (MCE) of moment magnitude 7.25, with a peak ground acceleration of 0.6g.

The site is within a potentially liquefiable zone in the State of California Seismic Hazard Zones mapping program. Liquefaction analysis identified the presence of a liquefiable soil layer from a depth of approximately 9.1 to 13.7 m (approximate elev. of 15 m to 11 m)

below the existing ground surface. The potential for ground rupture at this site due to fault movement is considered low since no known fault crosses the project site.

**CORROSION EVALUATION**

Soil samples were obtained at selected borehole locations during the site exploration for the bridge structures near the proposed retaining walls and tested for corrosion potential following the guidelines of the Corrosion Technology Branch. Based on the corrosion tests, the soils at the site are non-corrosive to reinforced concrete.

**Table 2. Corrosion Test Results**

Sample Location	Depth of Sample (m)	pH	Soluble Sulfates	Soluble Chlorides	Minimum Resistivity
Abut 1 (B1 Line)	9.1 - 14.0	8.29	N/A <sup>1</sup>	N/A <sup>1</sup>	1981 ohm-cm
	19.5 - 22.9	7.62	N/A <sup>1</sup>	N/A <sup>1</sup>	3744 ohm-cm
Bent 2 (B1 Line)	Composite	8.56	N/A <sup>1</sup>	N/A <sup>1</sup>	2300 ohm-cm
Bent 6 (B1 Line)	3.0 - 7.6	8.31	N/A <sup>1</sup>	N/A <sup>1</sup>	3548 ohm-cm
Abut 1 (C1 Line)	9.1 - 12.2	8.06	N/A <sup>1</sup>	N/A <sup>1</sup>	1726 ohm-cm
Bent 2 (C3 Line)	12.2 - 17.4	8.16	N/A <sup>1</sup>	N/A <sup>1</sup>	3561 ohm-cm
Abut 3 (C3 Line)	7.6 - 12.2	8.63	N/A <sup>1</sup>	N/A <sup>1</sup>	5000 ohm-cm
Caltrans Criteria for Non-corrosive Soil and Rock		> 5.5	< 2000 PPM	< 500 PPM	> 1000 Ohm-cm

**EMBANKMENT**

The settlement due to the embankment surcharge will be in the order of 150 mm near both abutments on B1 line. Most of the settlement is immediate settlement, which will take place during construction. Long-term settlement due to primary consolidation is estimated to be less than 25 mm. The maximum settlement at the retaining wall locations can be reduced to less than 50 mm, if piles are to be used underneath the retaining wall footings.

**EXISTING UTILITIES AT EMBANKMENT/RETAINING WALL LOCATION**

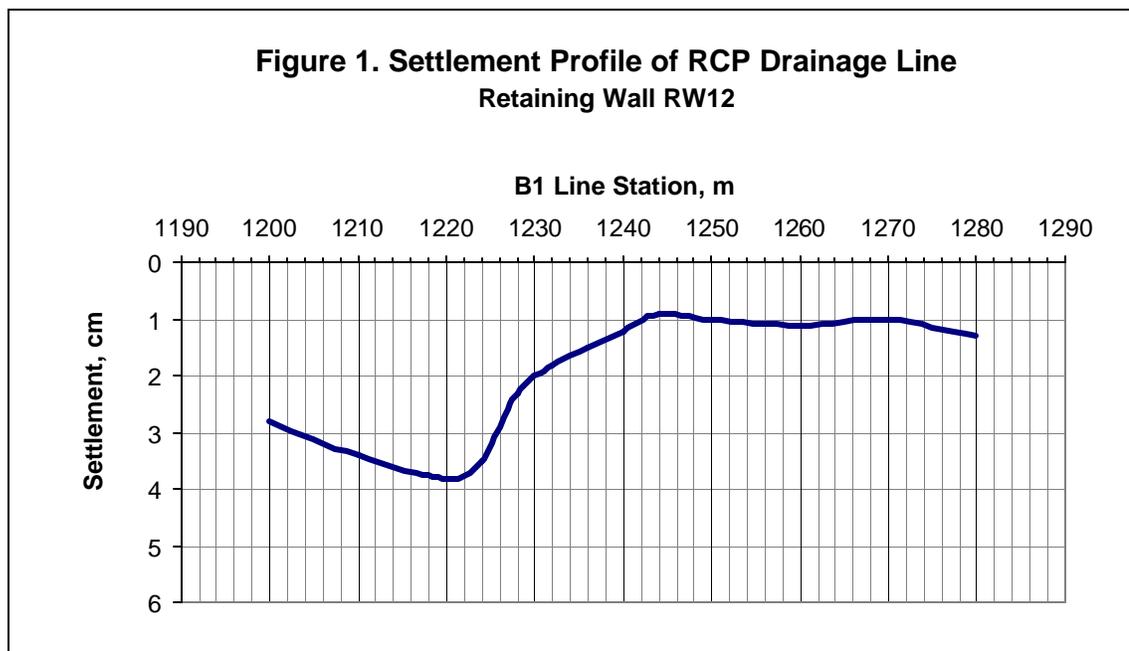
**RW12**

Several existing utility lines intercept the proposed retaining wall, RW12, at an angle of approximately 12 degrees at different locations at southern portion of the wall alignment, where Type 5 retaining wall with spread footing was proposed due to some restraints. The

embankment heights are mostly less than 1.9 m at the locations where the utility lines intercept the wall. The estimated settlement of most utility lines will be less than 30 mm, with relatively mild settlement gradient below the embankment and the retaining wall footing.

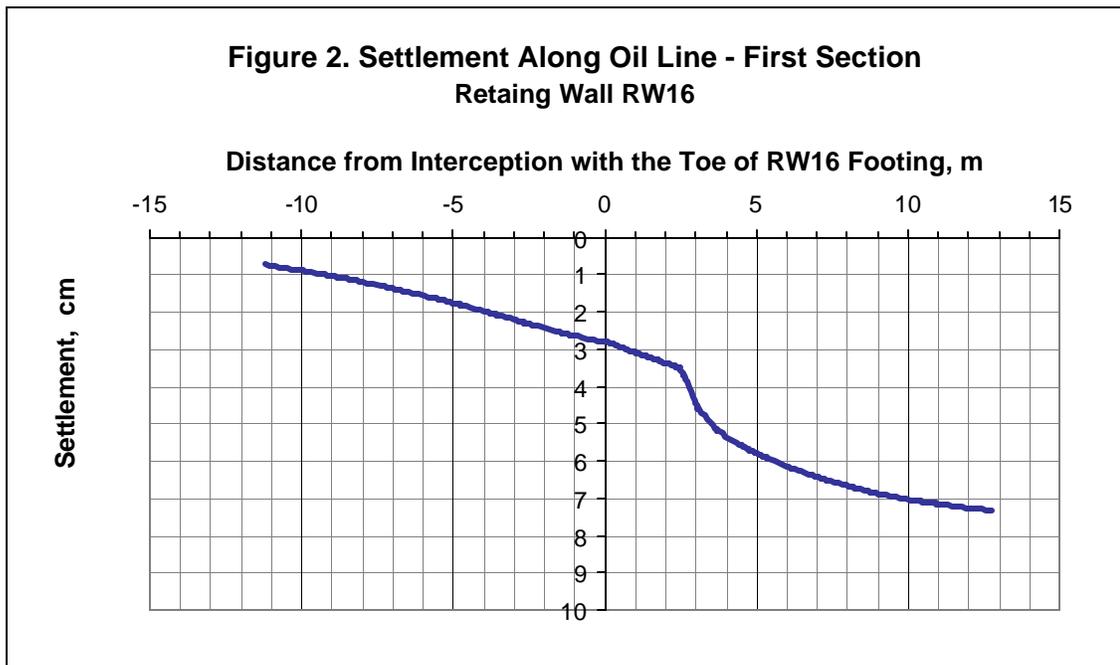
However, there is an existing 1.2 m diameter reinforced concrete drainage pipe (RCP) intercepting the retaining wall RW12 around Station 12+60 (B1 line), where the embankment height is about 5 meters. The differential settlement is expected to be less than 75 mm with the maximum settlement near and behind the heel of the pile-supported wall footing. The settlement gradient is relatively gentle due to the skew (12 degrees) of the alignments of the wall and the drainage pipe. But whether the drainage pipe can sustain the surcharge and settlement induced stress needs to be verified by the owner of the drainage pipe.

To accommodate pile installation, the District proposed realigning the RCP line, making the angle of the interception 45 degrees between the wall RW12 and RCP alignments. The approximate station of the interception is at 12+32 (B1 line), where the embankment height is about 3.6 m above the finished grade. The settlement profile along the realigned drainage line proposed by the District was obtained by Plaxis FEM analysis, and is presented in Figure 1 below.

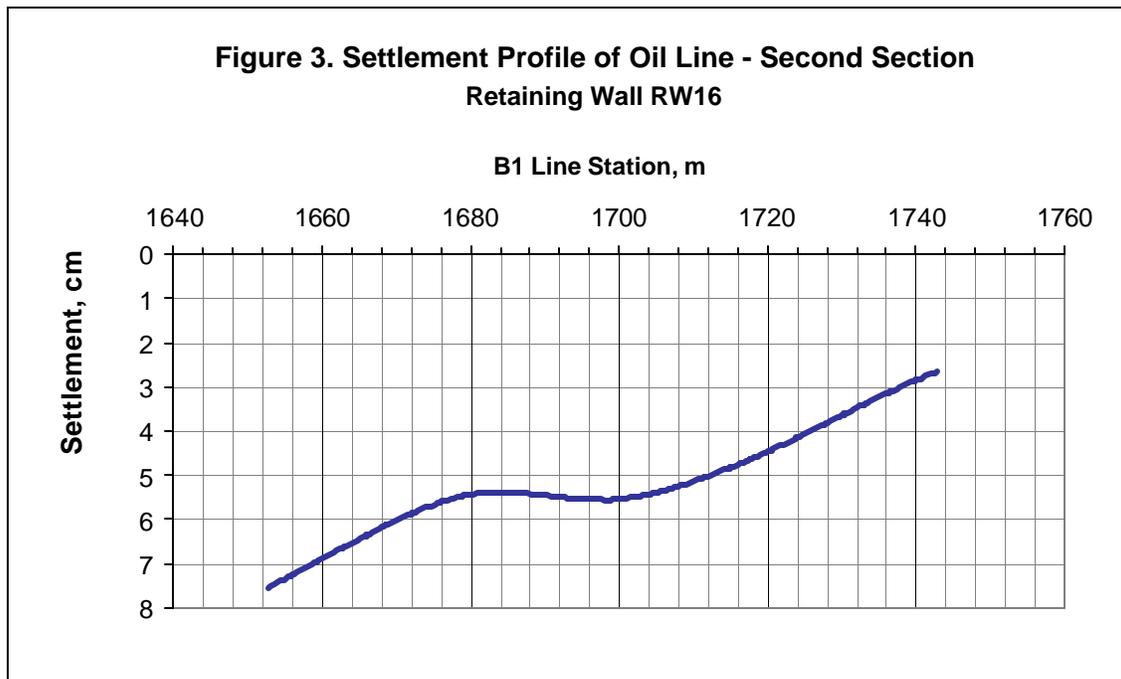


**RW16**

A 305 mm diameter oil line intercepts retaining wall RW16 near Station 16+68 (25.7 m right offset from B1 line). The pipeline runs approximately 7 meters into the embankment from southeast and then turn north and nearly parallel to the B1 line, away from the main bridge. With the oil line located deep into the embankment, the maximum future embankment height along the oil line will raise to 4.3 m high, making differential settlement of this utility line a serious concern. The estimated settlement profiles of this oil line are analyzed in two sections and presented in Figures 2 and 3 below using Plaxis FEM analysis. In the analysis, the oil line is considered to be flexible. The first section is from outside the embankment to the first turning point below the embankment fill. The second section is from the first turning point to the north, parallel to the B1 line.



Note: Negative distance indicates utility alignment outside the footing/embankment; positive distance is used for that part of utility alignment located underneath the RW16 footing and the embankment.

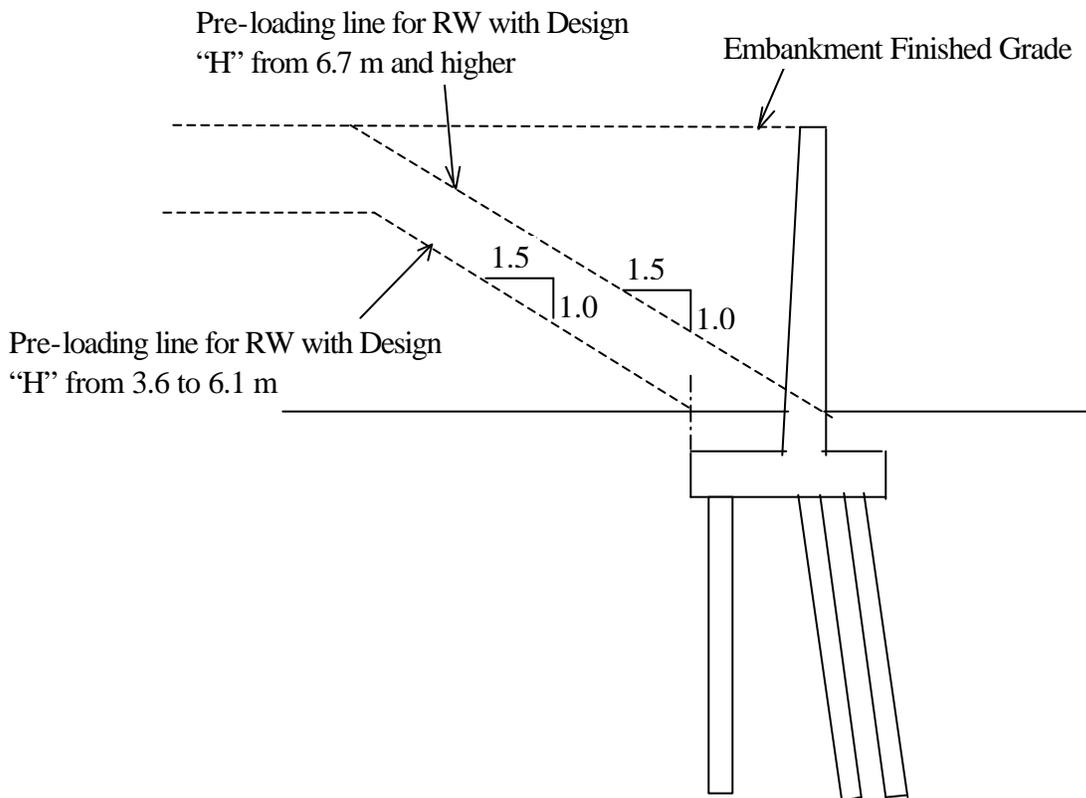


## GEOTECHNICAL RECOMMENDATIONS

- Except for the southern portion of RW12, the proposed retaining walls should be supported by driven piles due to relatively high compressibility of foundation soils. The closed-ended steel pipe piles Alternative “V” as prescribed in Standard Plan (2006) can be used, with 60-degree conical pile tip to reduce the direct transfer of the contaminants.
- The pile tip should be at 14.0 m below the bottom of retaining wall footings according to the subsurface conditions and the analysis of ultimate vertical static pile capacity using FHWA DRIVEN. The design axial pile capacity will be 400 kN per pile. The nominal pile strength will be 800 kN.
- Battered piles as shown in Plates B3-1 and B3-2 of Standard Plans (2006) should be used to improve the lateral resistance of the retaining wall foundations.
- To reduce the added stress on piles due to the compression of foundation soils under the new embankment fills, it is recommended that the embankment be compacted first to preload the foundation soils, before excavation for retaining wall footing and pile installation. Due to the construction site constraint, preloading should be conducted as follows:

- For retaining walls with design wall height from 6.7 m and above, embankment preloading will be needed. The height of preloading should be the proposed embankment height. The toe of the preloading need to be placed at the retaining wall layout lines, with the slope no flatter than 1.5(H):1(V).
- For retaining walls with design wall height from 3.6 m to 6.1 m, the top of preloading should be no less than two third of the proposed embankment height. The toe of the preloading need to be placed at the heel of retaining wall footing, with the slope no flatter than 1.5(H):1(V).
- For retaining walls with design wall height 3.0 m and lower, preloading is not required.

A schematic diagram for different preloading scenarios is presented below.



- Due to some constraints, Type 5 retaining wall with spread footing foundation was proposed by Structural Design for Southern portion of RW12 from Station 11+68 to Station 11+87 (“B1” line). A factor of safety of more than 5.0 can be achieved for the bearing capacity of the shallow foundation. The global stability criteria can also be satisfied at this part of the retaining wall 12, for both static and pseudo-static conditions.
- Soil samples were obtained and tested for corrosion potential following the guidelines of the Corrosion Technology Branch. Based on the results of the corrosion test, the foundation soils are non-corrosive to reinforced concrete.
- Even though liquefaction potential of the underlying soil is relatively high at the wall locations, ground improvement to mitigate liquefaction potential is not recommended due to substantially higher cost compared with the cost of repair to potential damage caused by liquefaction. The repair of distressed retaining walls and embankment after a major seismic event is feasible, and is more cost-effective.
- At locations where utility lines are less than three times of pile diameter away from the piles, isolation casings are required for driven piles. The isolation casing should start from (but not be connected to) the bottom of the retaining wall footing, and be extended to a depth at least 0.6 m below the bottom of the utility lines. A minimum annular space of 50 mm should be maintained between casing and driven pile. The above annular space should be filled with compressible materials, in order to reduce lateral load and/or vertical drag force on the existing utility lines. Wherever the isolation casing is used to protect utility lines, the design tip of the driven pile should be lowered by no less than half of the length of the isolation casing.

## **CONSTRUCTION CONSIDERATIONS**

- Thirty day waiting period is needed from the end of embankment preloading to the commencement of retaining wall foundation construction. Settlement monitoring device should be installed in the embankments to monitor the settlement rate. The estimated waiting period can be reduced based on settlement measurement with Engineer’s approval.
- Driven piles achieving capacity of more than 1.5 times of pile nominal strength using the Gates Formula outlined in Section 49-1.08 of the Standard Specifications (2006) can be cut off with the Engineer’s approval.

Any question regarding the above recommendations should be directed to the attention of Haitao Liu at (916) 227-0992

Prepared by:



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HAITAO LIU, P.E.  
Transportation Engineer - Civil  
Branch A

cc: R.E. Pending File  
Nancy Pe - District 7  
OGDS-1, Los Angeles  
OGDS-1, Sacramento  
GS File Room

# Memorandum

*Flex your power!  
Be energy efficient!*

**To:** MR. RAMIN RASHEDI  
CHIEF  
Bridge Design Branch 11

**Date:** May 12, 2010

Attn: Mr. Daniel Texler

**File:** 07-LA-05-KP2.9  
07-2159C1  
Carmenita Rd/I-5  
Interchange  
Br. No. 53-3018,  
3018K, 3018S,  
3019K, 3019S

**From:** DEPARTMENT OF TRANSPORTATION  
DIVISION OF ENGINEERING SERVICES  
GEOTECHNICAL SERVICES - MS 5  
OFFICE OF GEOTECHNICAL DESIGN SOUTH - 1

**Subject:** Foundation Report for Carmenita Rd / I-5 Interchange

## 1. SCOPE OF WORK

This report is a revision that supersedes our previous foundation reports, dated September 27 2006, June 22, 2009, and Jan. 22, 2010. This report includes geotechnical recommendations for the main bridge structure and all ramp structures. In addition to the subsurface exploration completed in 2006, more exploratory work was conducted at the subject site from August to September 2008, including drillings and CPT soundings.

These recommendations are based on the review of the General Plan, existing as-built logs of test borings dated May, 1996 for the seismic retrofit of the existing bridge (Carmenita Rd OC), and the recent subsurface exploration of 2004, 2006 and 2008 for the proposed project.

## 2. SUBSURFACE CONDITION

The Site is situated in the Central Basin of the Los Angeles Coastal Plain. The ground surface of the subject site is generally flat.

From existing ground surface to approximately 14 m below ground surface (bgs), soils are mostly medium dense silty sand (SM) and/or poorly graded sand (SP) interbedded with layer(s) of firm to stiff silt to sandy silt with plasticity ranging from low to high. Underlying this soil region, a 1-m to 2.4-m thick stiff lean clay to sandy clay (CL) layer was encountered at most of the boreholes from 14.3 m to 15.2 m bgs. Below the above clay

layer, from 16.5 m to 17.4 m bgs, soils are mostly medium dense to dense clayey sand (SC), silty sand (SM) and sand (SW/SP), interbedded with stiff to hard clay at various depths. Underlying the interbedded sand and clay layer, from about 18 m bgs, there exists a 1.2-m to 4.8-m thick well graded, dense to very dense sand layer, which appears to be continuous across the site.

Bedrock was not encountered during any of the subsurface exploration campaigns.

The job site is reported to be contaminated. Please refer to the report issued by Hazardous Waste Branch, Office of Environmental Engineering and Feasibility Studies, Caltrans District 7, for further information.

### **3. SEISMIC STUDY**

The controlling fault for the site is the Puente Hills Blind Thrust (PHBT) Fault located 4.2 miles northeast of the site. This fault will generate a Maximum Credible Earthquake (MCE) of moment magnitude 7.25 with a peak bedrock acceleration of 0.6g. The soil profile is classified as type "D" under the Department's Seismic Design Criteria (SDC). An acceleration response spectra (ARS) curve for the project site is attached. The recommended ARS curve was obtained by modifying the ARS curve in Figure B.8 of the SDC corresponding to a peak bedrock acceleration of 0.6g. These modifications were introduced to account for the proximity of the controlling seismic source and included a 20% increase in spectral accelerations for periods greater than or equal to 1.0 second. No modifications were introduced for periods less than or equal to 0.5 second. The spectral accelerations for periods between 0.5 and 1.0 second were obtained by linear interpolation.

The site is within a potentially liquefiable zone in the State of California Seismic Hazard Zones mapping program. Liquefaction analysis identified the presence of a liquefiable soil layer from a depth of approximately 9 to 14 m (approximate elev. of 15 m to 10 m) below the existing ground surface. The recommendations presented in this report incorporate the liquefaction potential of the site by neglecting the friction capacity of the bridge foundation from the bottom of the footing to the bottom of liquefiable soil layer.

The potential for ground rupture at this site due to fault movement is considered low since no known fault crosses the project site. The potential for lateral spreading is also low because the relatively deep depth of potential liquefaction zone and the absence of free face.

#### **4. GROUNDWATER**

Based on review of existing well data and recent measurements, the groundwater table elevation at the site has changed substantially over the decades.

Groundwater table was reported to be at Elev. 16.4 m (MSL) in May 1996 and Elev. 14.3 m (MSL) in December 2004 according to respective Log of Test Borings (LOTBs). In recent subsurface exploration performed in July 2008, groundwater was encountered near both ends of the proposed main bridge (BR53-3018). Near Abutment 1, groundwater was encountered at about Elev. 14.3 m (MSL), which is about 9.1 m bgs. Near Abutment 10, groundwater was encountered at Elev. 12.9 m (MSL), which is about 11.6 m bgs.

The encountered water as described above is consider perched water, and does not appear to be continuous across the site. For the convenience of discussion, this perched water is identified as the upper aquifer in the report.

The upper most regional aquifer underlying the site is Gaspur. This aquifer is continuous throughout the site and identified as the lower aquifer in the report. The highest groundwater table elevation of this aquifer over last 17 years is at Elev. 0.7 m (MSL) at Well No. 1051W (LADPW). The measurement was taken after the storm season of 2006. This groundwater elevation is slightly above the groundwater table reported in the log of test borings (LOTBs) of May 1996 for seismic retrofit of the existing bridge, which is at Elev. 0.0 m (MSL), or 24.4 m bgs. During current subsurface exploration performed from July to September of 2008, this lower aquifer was not measured at any of the boreholes, which were advanced to 26.4 m below existing ground surface.

However, measurements from three recently installed monitoring wells near the bridge site indicate that the highest groundwater table was at Elev. 6.2 m (MSL) as of August 21, 2009 to August 24, 2009. The above groundwater table reading is considered to be the highest for the lower aquifer.

#### **5. CORROSION EVALUATION**

Soil samples were obtained at selected borehole locations during site exploration and tested for corrosion potential following the guidelines of the Corrosion Technology Branch. Based on the corrosion tests, the soils at the site are non-corrosive to reinforced concrete.

**Table 1 Corrosion Test Results**

Sample Location	Depth of Sample (m)	pH	Soluble Sulfates	Soluble Chlorides	Minimum Resistivity
Abut 1 (B1 Line)	9.1 - 14.0	8.29	N/A <sup>1</sup>	N/A <sup>1</sup>	1981 ohm-cm
	19.5 - 22.9	7.62	N/A <sup>1</sup>	N/A <sup>1</sup>	3744 ohm-cm
Bent 2 (B1 Line)	Composite	8.56	N/A <sup>1</sup>	N/A <sup>1</sup>	2300 ohm-cm
Bent 6 (B1 Line)	3.0 - 7.6	8.31	N/A <sup>1</sup>	N/A <sup>1</sup>	3548 ohm-cm
Abut 1 (C1 Line)	9.1 - 12.2	8.06	N/A <sup>1</sup>	N/A <sup>1</sup>	1726 ohm-cm
Bent 2 (C3 Line)	12.2 - 17.4	8.16	N/A <sup>1</sup>	N/A <sup>1</sup>	3561 ohm-cm
Abut 3 (C3 Line)	7.6 - 12.2	8.63	N/A <sup>1</sup>	N/A <sup>1</sup>	5000 ohm-cm
Caltrans Criteria for Non-corrosive Soil and Rock		> 5.5	< 2000 PPM	< 500 PPM	> 1000 Ohm-cm

Notes: 1. The tests for sulfate and chloride are usually not conducted unless the resistivity of the sample soil is 1000 Ohm-cm or less. Where resistivity is greater than 1000 Ohm-cm, the soil is considered not corrosive.

## 6. CONTAMINANT

According to District Hazardous Waste branch, subsurface soils and water at the job site are contaminated. Special construction procedure is required to prevent potential cross-contamination introduced by bridge foundation construction activities.

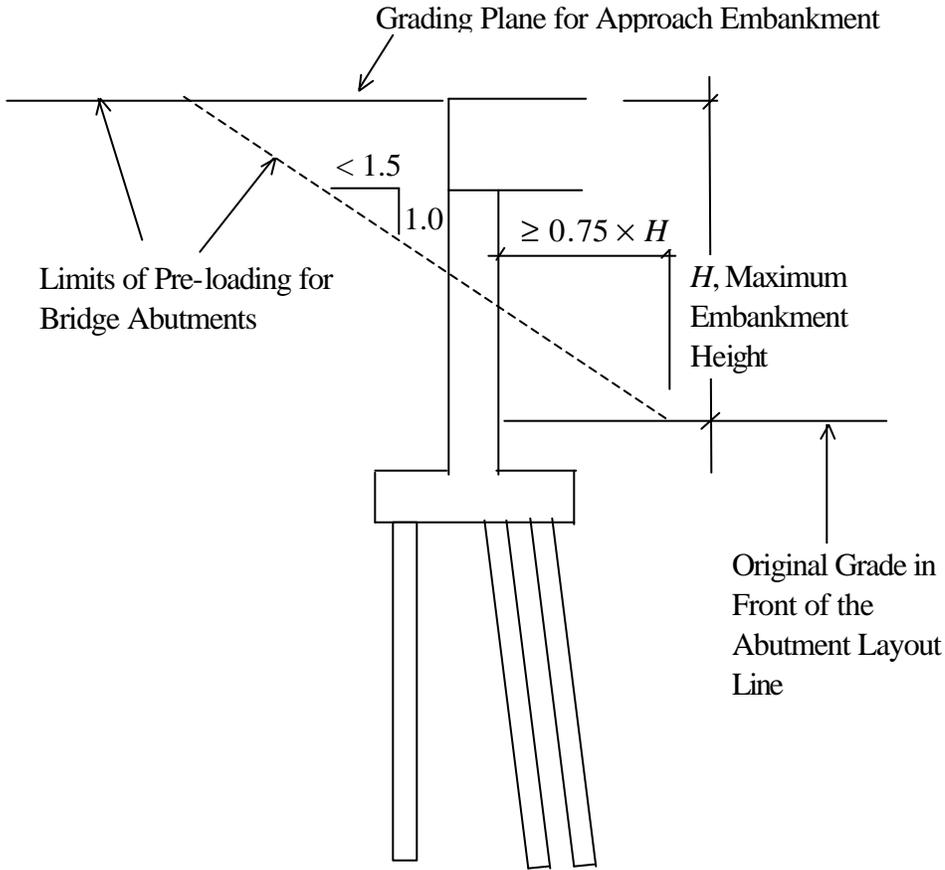
## 7. FOUNDATION DESIGN CONSIDERATION

Due to relatively high liquefaction potential and low density/consistency of the foundation soils, driven pile is recommended as the structural foundation. Open-ended steel pipe pile is selected over displacement piles due to pile drivability issue associated with required small center-to-center pile spacing and presence of very dense soil layer above the lateral and/or tension controlled pile tip elevations.

To prevent cross-contamination by pile driving, special pile installation procedure is needed to facilitate pile installation through the contaminated zone. Advancing casing and removing the contaminants inside the casing before driving a pile is considered viable by the project team. Instruction on the installation of casing and removal of the contaminants is to be provided by District Hazardous Waste branch.

## 8. GEOTECHNICAL RECOMMENDATIONS

- 1) Tables 2 to 6 show the specified design tip elevations for PP 609X12.7 open-ended pipe piles to be used for the bridge foundation. Same pile data table (PDT) can be used for pile driving inside the casing, which will be initiated at or above 14.6 m below ground surface (bgs) following the soil removal from interior of the casing. For pile driving initiated below 14.6 m bgs, correlation tables, Tables 7 and 8, should be used to modify the design tip elevation presented in Tables 2 to 6. Linear interpolation can be used to determine the design pile tip elevations between two adjacent data sets. Depending on the vertical limits of soil removal before pile driving, the nominal driving resistance presented in PDT has to be modified to reflect the reduction of driving resistance.
- 2) Based on subsurface exploration, the soil profile type for the subject bridge is classified as Type D. The recommended ARS Curve is attached to the end of this memo.
- 3) The foundation soils for the bridge are classified as non-corrosive to reinforced concrete according to the corrosion test results of selected soil samples from the field.
- 4) The compressibility of foundation soils at the new approach embankment locations is relatively high. The settlement due to the new embankment will be in the order of 150 mm based on settlement analysis. Most of the settlement is immediate settlement, which should take place during construction. Long-term settlement due to primary consolidation is estimated to be less than 25 mm. To reduce the added stress on piles due to the compression of foundation soils under the new embankment fills, it is recommended that the approach embankment be constructed first to preload the foundation soils, before excavation for abutment footing and pile installation. The toe of the abutment preloading should be in front of abutment layout line by a horizontal distance of no less than 75 percent of the maximum embankment height (measured from O.G.), with the slope at no flatter than 1.5(H): 1(V). The schematic diagram for the abutment preloading is presented below.



**Table 2. Pile Data Table for Carmenita Rd/I-5 Interchange (Main Bridge, BR53-3018)  
 (PP609X12.7 Open-ended Pipe Piles)**

Location	Design Loading (kN)	Nominal Resistance (kN)		Pile Cut-off Elevation (m)	Approx. Finished Grade (m)	Design Tip Elevation** (m)	Specified Tip Elevation (m)	Nominal Driving Resistance* (kN)
		Compression	Tension					
Abut 1	890	1780	700	22.125	23.5	1.2 (1), 5.5 (2)	1.2	3750
Bent 2	890	1780	700	21.625	23.5	1.2 (1), 5.5 (2)	1.2	3750
Bent 3	890	1780	700	22.025	24.0	1.5 (1), 5.5 (2)	1.5	3750
Bent 4	890	1780	700	22.625	24.5	2.0 (1), 6.0 (2)	2.0	3750
Bent 5	700	1400	700	22.625	24.5	3.0 (1), 6.0 (2)	3.0	3350
Bent 6	700	1400	700	22.525	24.5	3.0 (1), 6.0 (2)	3.0	3350
Bent 7	700	1400	700	23.025	25.0	3.0 (1), 6.5 (2)	3.0	3350
Bent 8	700	1400	700	22.875	24.5	3.0 (1), 6.0 (2)	3.0	3350
Bent 9	700	1400	700	19.875	24.5	3.0 (1), 5.5 (2)	3.0	3250
Abut 10	890	1780	700	22.925	24.5	2.0 (1), 6.0 (2)	2.0	3750
Bent C1A	700	1400	700	22.625	24.5	3.0 (1), 6.0 (2)	3.0	3350
Bent C1B	700	1400	700	22.625	24.5	3.0 (1), 6.0 (2)	3.0	3350
Bent C2A	700	1400	700	19.875	24.5	3.0 (1), 5.5 (2)	3.0	3250
Bent C2B	700	1400	700	19.875	24.5	3.0 (1), 5.5 (2)	3.0	3250
Bent C3A	700	1400	700	19.875	24.0	3.0 (1), 5.5 (2)	3.0	3250
Bent C3B	700	1400	700	19.875	24.0	3.0 (1), 5.5 (2)	3.0	3250
Bent C4A	700	1400	700	22.625	24.3	3.0 (1), 6.0 (2)	3.0	3350
Bent C4B	700	1400	700	22.625	24.3	3.0 (1), 6.0 (2)	3.0	3350

Notes: \* "Nominal Driving Resistance" shall only be used for pile driving without casing.  
 \*\*Design tip elevations are based on the following demands: (1) Compression; (2) Tension.

**Table 3.** Pile Data Table for Carmenita Rd/I-5 Interchange (SB Off-ramp, C4, BR53-3018K)  
 (PP609X12.7 Open-ended Pipe Piles)

Location	Design Loading (kN)	Nominal Resistance (kN)		Pile Cut-off Elevation (m)	Finished Grade (m)	Design Tip Elevation** (m)	Specified Tip Elevation (m)	Nominal Driving Resistance* (kN)
		Compression	Tension					
Bent 1	N/A	1400	700	22.565	24.2	3.0 (1), 6.0 (2)	3.0	3350
Bent 2	N/A	1400	600	22.565	24.3	3.0 (1), 6.5 (2)	3.0	3350
Bent 3	N/A	1400	600	22.565	24.4	3.0 (1), 6.5 (2)	3.0	3350
Abut 4	700	N/A	N/A	23.265	24.5	3.0 (1)	3.0	3350

Notes: \* "Nominal Driving Resistance" shall only be used for pile driving without casing.  
 \*\*Design tip elevations are based on the following demands: (1) Compression; (2) Tension.

**Table 4.** Pile Data Table for Carmenita Rd/I-5 Interchange (NB On-ramp, C3, BR53-3018S)  
 (PP609X12.7 Open-ended Pipe Piles)

Location	Design Loading (kN)	Nominal Resistance (kN)		Pile Cut-off Elevation (m)	Finished Grade (m)	Design Tip Elevation** (m)	Specified Tip Elevation (m)	Nominal Driving Resistance* (kN)
		Compression	Tension					
Bent 1	N/A	1350	550	21.925	24.2	3.5 (1), 7.0 (2)	3.5	3300
Bent 2	N/A	1400	500	20.325	24.4	3.3 (1), 7.0 (2)	3.3	3250
Abut 3	600	N/A	N/A	23.725	25.0	4.5 (1)	4.5	3100

Notes: \* "Nominal Driving Resistance" shall only be used for pile driving without casing.  
 \*\*Design tip elevations are based on the following demands: (1) Compression; (2) Tension.

**Table 5.** Pile Data Table for Carmenita Rd/I-5 Interchange (NB Off-ramp, C2, BR53-3019K)  
 (PP609X12.7 Open-ended Pipe Piles)

Location	Design Loading (kN)	Nominal Resistance (kN)		Pile Cut-off Elevation (m)	Finished Grade (m)	Design Tip Elevation** (m)	Specified Tip Elevation (m)	Nominal Driving Resistance* (kN)
		Compression	Tension					
Abut 1	675	N/A	N/A	22.905	24.0	3.0 (1)	3.0	3350
Bent 2	N/A	1350	1100	21.049	24.3	3.3 (1), 5.0 (2)	3.3	3250
Bent 3	N/A	1350	1100	22.080	24.3	3.3 (1), 5.0 (2)	3.3	3250

Notes: \* "Nominal Driving Resistance" shall only be used for pile driving without casing.  
 \*\*Design tip elevations are based on the following demands: (1) Compression; (2) Tension.

**Table 6.** Pile Data Table for Carmenita Rd/I-5 Interchange (SB On-ramp, C1, BR53-3019S)  
 (PP609X12.7 Open-ended Pipe Piles)

Location	Design Loading (kN)	Nominal Resistance (kN)		Pile Cut-off Elevation (m)	Finished Grade (m)	Design Tip Elevation** (m)	Specified Tip Elevation (m)	Nominal Driving Resistance* (kN)
		Compression	Tension					
Abut 1	725	N/A	N/A	22.915	24.0	3.0 (1)	3.0	3400
Bent 2	N/A	1400	600	22.505	24.4	3.0 (1), 6.5 (2)	3.0	3350
Bent 3	N/A	1400	600	22.505	24.5	3.0 (1), 6.5 (2)	3.0	3350

Notes: \* "Nominal Driving Resistance" shall only be used for pile driving without casing.  
 \*\*Design tip elevations are based on the following demands: (1) Compression; (2) Tension.

**Table 7.** Correlations between Depths of Soil Removal and Design Pile Tip  
 (1200-1450 kN nominal resistance or 600-725 kN Design Load Driven Steel Pipe Piles)

Depth of Soil Removal (m, bgs)	14.6	16.0	17.5	19.0	20.5	22.0	23.5	25.0	26.5
Design Tip Elevation Adjustment in PDTs (m)	0.0	-1.0	-2.3	-3.7	-5.0	-6.1	-6.9	-7.6	-8.4

**Table 8.** Correlations between Depths of Soil Removal and Design Pile Tip  
 (1780 kN nominal resistance Driven Steel Pipe Piles)

Depth of Soil Removal (m, bgs)	14.6	16.0	17.5	19.0	20.5	22.0	23.5	25.0	26.5
Design Tip Elevation Adjustment in PDTs (m)	0.0	-1.5	-3.0	-4.6	-6.1	-6.9	-7.6	-8.4	-9.1

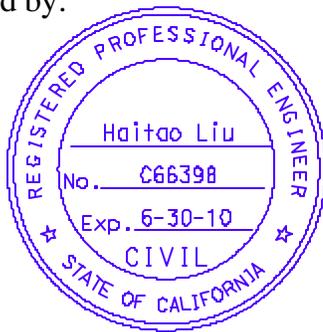
## 9. CONSTRUCTION CONSIDERATIONS

- 1) Acceptance criteria for pile driving should be based on the Gates formula outlined in Section 49-1.08 of the Standard Specifications (May 2006).
- 2) When casing is required for pile installation, this Office should be notified to modify nominal driving resistance.

- 3) The pile tip elevation that determined by lateral capacity has been provided by DES/Structural Design. Specified pile tip elevation must not be raised above the design tip elevations that determined by lateral load demand and nominal tension demand.
- 4) Groundwater is not anticipated during footing excavation.
- 5) Hard driving of the piles is anticipated through dense to very dense sand and gravelly sand layer, which is located at approximately 18 m below the ground surface.
- 6) When casing is used, long section of steel pipe piles will be without lateral support during pile driving due to removal of the soils inside the casing. The contractor must provide adequate equipment and method to maintain pile drivability, and prevent pile buckling.
- 7) A 60-day waiting period is required between the end of approach embankment preloading and the commencement of abutment foundation construction. A schematic diagram for the preloading was presented in Subsection 4) of Section 8. Settlement monitoring device should be installed 2 meters behind the heels of abutment footings along the centerline of the structures. The installation and data collection method of settlement device should be in conformance with California Test Method (CTM) 112. Settlement of subsurface materials below the original grade should be verified by the Engineer prior to installation of abutment piles. The estimated waiting period can be reduced based on settlement measurement with Engineer's approval.

The recommendations contained in this report are based on specific project information regarding structure type, location and design loads that have been provided by the Office of Structure Design. If any conceptual changes are made during final project design, this Office should review those changes to determine if these foundation recommendations are still applicable. Any question regarding the above recommendations should be directed to the attention of Haitao Liu at (916) 227-0992.

Prepared by:



A handwritten signature in blue ink, appearing to read "Haitao Liu".

---

HAITAO LIU, PE

Transportation Engineer – Civil

Office of Geotechnical Design South -1

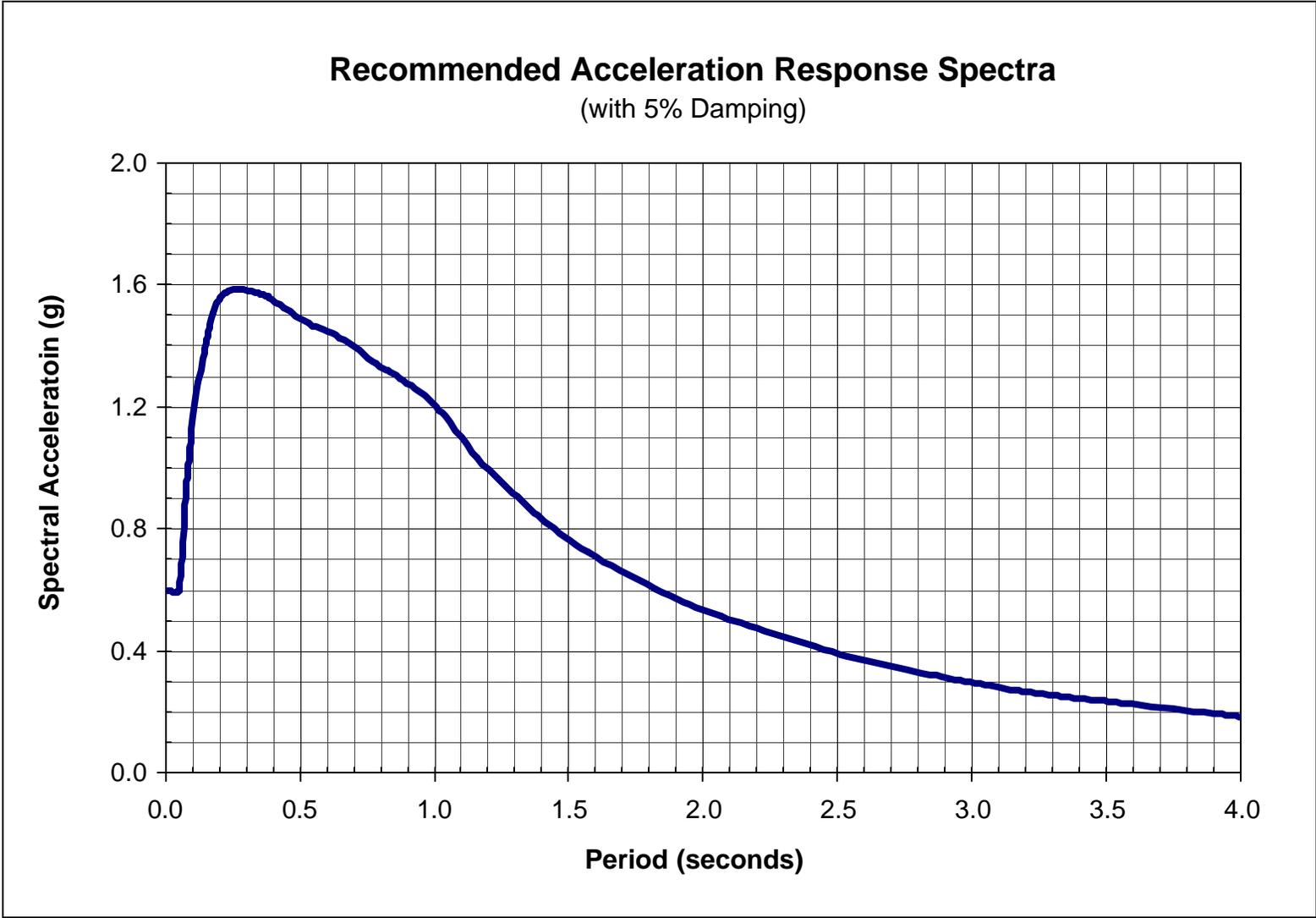
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Steve Chan – District 7  
OGDS -1, Sacramento  
OGDS -1, Los Angeles  
GS - File Room  
R.E. Pending File

# Carmenita Road / I-5 Interchange

EA 07-2159C1

## Recommended Acceleration Response Spectra

(with 5% Damping)



FOR CONTRACT NO.: 07-2159C4

# INFORMATION HANDOUT

## **MATERIALS INFORMATION**

Standard Specification  
For  
Public Works Construction  
(SSPWC)  
2006 Edition

**ROUTE: 07-LA-5, KP 2.9/4.9**

# “GREENBOOK”

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*2006 Edition*

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## *..... By Way Of Explanation*

The Standard Specifications for Public Works Construction, popularly known as the “Greenbook”, was originally published in 1967. The 2006 Edition is the 14<sup>th</sup> edition of this book, which is updated and republished every three years.

The original edition of the Greenbook was the product of almost four years of intensive work by a 400-person task force which then comprised the Joint Cooperative Committee. The City and County of Los Angeles were major contributors to this effort and these two agencies were the first to adopt the Greenbook. To date, more than 200 other cities, counties, and agencies in the area have also adopted it as their standard for public works construction specifications. Interest in the Greenbook has been worldwide, with copies being acquired and studied by public works officials throughout the United States, Canada, and many countries overseas.

Immediately after publication of the Greenbook, a permanent Joint Committee, comprised of representatives from cities, counties, utility companies, and contractors throughout Southern California, was established to carry on the work. The function of this committee is to study and update the provisions of these specifications to reflect the constantly changing technology and advanced thinking of the construction industry.

The first 10 editions of the Greenbook were the product of the Joint Cooperative Committee of the Southern California Chapter of the American Public Works Association, and the Southern California Districts of the Associated General Contractors of California.

In December 1995, the Joint Committee formally ceased operations. In January 1996, Public Works Standards, Inc., a mutual benefit corporation, began producing the Greenbook. The Corporation’s Board of Directors is comprised of nine members – five representing the American Public Works Association, and the other four from the Associated General Contractors of California, the Engineering Contractors Association, the Southern California Contractors Association, and BNi Publications, Inc. The Board appoints a 25-member Greenbook Committee which carries on the tradition and function of the original Joint Committee. This committee convenes regularly on each month to consider new changes.

In each of the two years between publication of a new Greenbook edition, the changes which have been researched and approved by the committee during the preceding year, are published in pamphlet form as amendments to the current edition. This program maintains a “living” document in public works specifications. Stripes in the margin of each new edition point out significant changes in the text adopted since the preceding edition.

The original edition of the Greenbook consisted of three parts: General Provisions, Construction Materials, and Construction Methods.

In 1970, 1991, and 1994, Parts 4, 5 and 6 were added to provide specifications for alternate aggregate materials, pipeline system rehabilitation, and modified asphalt products, respectively.

The Greenbook is designed to aid in furthering uniformity of plans and specifications accepted and used by those involved in public works construction and to take such other steps as are designed to promote more competitive bidding by private contractors. The Greenbook provides specifications that have general applicability to public works projects. The Greenbook does NOT test or approve products. It is the function of public agencies and private project owners that utilize the Greenbook to determine whether products proposed by a contractor satisfy the Greenbook specifications or the Special Provisions.

Interested parties who wish to suggest changes or amendments to this book may communicate with Public Works Standards, Inc., c/o Associated General Contractors of California, 1906 W. Garvey Avenue South, Suite 100, West Covina, CA 91790.

In 1984, a companion to the Greenbook entitled the Standard Plans for Public Works Construction was adopted by the joint committee. Both books are available from BNi Publications, Inc., or other technical bookstores.

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# PART 1

## GENERAL PROVISIONS

### SECTION 1—TERMS, DEFINITIONS, ABBREVIATIONS, UNITS OF MEASURE, AND SYMBOLS

**1-1 TERMS** – Unless otherwise stated, the words *directed, required, permitted, ordered, instructed, designated, considered necessary, prescribed, approved, acceptable, satisfactory*, or words of like meaning, refer to actions, expressions, and prerogatives of the Engineer.

#### 1-2 DEFINITIONS

**Addendum**—Written or graphic instrument issued prior to the opening of Bids which clarifies, corrects, or changes the bidding or Contract Documents. The term Addendum shall include bulletins and all other types of written notices issued to potential bidders prior to opening of Bids.

**Agency**—The legal entity for which the Work is being performed.

**Agreement**—See Contract.

**Assessment Act Contract**—A Contract financed by special assessments authorized under a State Act or procedural ordinance of a City or County.

**Base**—A layer of specified material of planned thickness placed immediately below the pavement or surfacing.

**Bid**—The offer or proposal of the Bidder submitted on the prescribed form setting forth the prices for the Work.

**Bidder**—Any individual, firm, partnership, corporation, or combination thereof, submitting a Bid for the Work, acting directly or through a duly authorized representative.

**Board**—The officer or body constituting the awarding authority of the Agency.

**Bond**—Bid, performance, and payment bond or other instrument of security.

**Cash Contract**—A Contract financed by means other than special assessments.

**Change Order**—A written order to the Contractor signed by the Agency directing an addition, deletion, or revision in the Work, or an adjustment in the Contract Price or the Contract time issued after the effective date of the Contract. A Change Order may or may not also be signed by the Contractor.

**Code**—The terms *Government Code, Labor Code*, etc., refer to codes of the State of California.

**Contract**—The written agreement between the Agency and the Contractor covering the Work.

**Contract Documents** — Including but not limited to; the Contract, any Addendum (which pertain to the contract documents), Notice Inviting Bids, Instructions to Bidders; Bid (including documentation accompanying the Bid and any post-bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Contract, the Bonds, the general conditions, permits from other agencies, the Special Provisions, the Plans, Standard Plans, Standard Specifications, Reference Specifications, and all Modifications issued after the execution of the Contract.

**Contractor**—The individual, partnership, corporation, joint venture, or other legal entity having a Contract with the Agency to perform the Work. In the case of work being done under permit issued by the Agency, the permittee shall be construed to be the Contractor. The term “prime contractor” shall mean Contractor.

**Contract Price**—The total amount of money for which the Contract is awarded.

**Contract Unit Price**—The amount stated in the Bid for a single unit of an item of work.

**County Sealer**—The Sealer of Weights and Measures of the county in which the Contract is let.

**Days**—Days shall mean consecutive calendar’s days unless otherwise specified.

**Electrolier**—Street light assembly complete, including foundation, standard, luminaire arm, luminaire, etc.

**Engineer**—The Chief Engineer of the Agency, or other person designated by the Board, acting either directly or through authorized agents.

**Geotextile**—Synthetic fiber used in civil engineering applications, serving the primary functions of separation and filtration.

**House Connection Sewer**—A sewer, within a public street or right-of-way, proposed to connect any parcel, lot, or part of a lot with a mainline sewer.

**House Sewer**—A sewer, wholly within private property, proposed to connect any building to a house connection sewer.

**Luminaire**—The lamp housing including the optical and socket assemblies (and ballast if so specified).

**Luminaire Arm**—The structural member, bracket, or mast arm, which, mounted on the standard, supports the luminaire.

**Modification**—Includes Change Orders and Supplemental Agreements. A Modification may only be issued after the effective date of the Contract.

**Notice of Award**—The written notice by the Agency to the successful Bidder stating that upon compliance by it with the required conditions, the Agency will execute the Contract.

**Notice to Proceed**—A written notice given by the Agency to the Contractor fixing the date on which the Contract time will start.

**Person**—Any individual, firm, association, partnership, corporation, trust, joint venture, or other legal entity.

**Plans**—The drawings, profiles, cross sections, working drawings, and supplemental drawings, or reproductions thereof, approved by the Engineer, which show the location, character, dimensions, or details of the Work.

**Private Contract**—Work subject to Agency inspection, control, and approval, involving private funds, not administered by the Agency.

**Proposal**—See Bid.

**Reference Specifications**—Those bulletins, standards, rules, methods of analysis or test, codes, and specifications of other agencies, engineering societies, or industrial associations referred to in the Contract Documents. These refer to the latest edition, including amendments in effect and published at the time of advertising the project or issuing the permit, unless specifically referred to by edition, volume, or date.

**Roadway**—The portion of a street reserved for vehicular use.

**Service Connection**—Service connections are all or any portion of the conduit, cable, or duct, including meter, between a utility distribution line and an individual consumer.

**Sewer**—Any conduit intended for the reception and transfer of sewage and fluid industrial waste.

**Special Provisions**—Additions and revisions to the Standard Specifications setting forth conditions and requirements peculiar to the Work.

**Specifications**—Standard Specifications, Reference Specifications, Special Provisions, and specifications in Supplemental Agreements between the Contractor and the Board.

**Standard**—The shaft or pole used to support street lighting luminaire, traffic signal heads, mast arms, etc.

**Standard Plans**—Details of standard structures, devices, or instructions referred to on the Plans or in Specifications by title or number.

**Standard Specifications**—The Standard Specifications for Public Works Construction (SSPWC), the “Greenbook”.

**State**—State of California.

**Storm Drain**—Any conduit and appurtenances intended for the reception and transfer of storm water.

**Street**—Any road, highway, parkway, freeway, alley, walk, or way.

**Subbase**—A layer of specified material of planned thickness between a base and the subgrade.

**Subcontractor**—An individual, firm, or corporation having a direct contract with the Contractor or with any other Subcontractor for the performance of a part of the Work.

**Subgrade**—For roadways, that portion of the roadbed on which pavement, surfacing, base, subbase, or a layer of other material is placed. For structures, the soil prepared to support a structure.

**Supervision**—Supervision, where used to indicate supervision by the Engineer, shall mean the performance of obligations, and the exercise of rights, specifically imposed upon and granted to the Agency in becoming a party to the Contract. Except as specifically stated herein, supervision by the Agency shall not mean active and direct superintendence of details of the Work.

**Supplemental Agreement**—A written amendment of the Contract Documents signed by both parties.

**Surety**—Any individual, firm, or corporation, bound with and for the Contractor for the acceptable performance, execution, and completion of the Work, and for the satisfaction of all obligations incurred.

**Tonne** — Also referred to as “metric ton”. Represents a unit of measure in the International System of Units equal to 1,000 kilograms.

**Utility**—Tracks, overhead or underground wires, pipeline, conduits, ducts, or structures, sewers, or storm drains owned, operated, or maintained in or across a public right of way or private easement.

**Work**—That which is proposed to be constructed or done under the Contract or permit, including the furnishing of all labor, materials, equipment, and services.

### 1-3 ABBREVIATIONS

**1-3.1 General.** The abbreviations herein, together with others in general use, are applicable to these Standard Specifications and to project Plans or other Contract Documents.

All abbreviations and symbols used on Plans for structural steel construction shall conform to those given by the "Manual of Steel Construction" published by the American Institute of Steel Construction, Inc.

#### 1-3.2 Common Usage

<u>Abbreviation</u>	<u>Word or Words</u>		
ABAN .....	Abandon	CONN .....	Connection
ABAND .....	Abandoned	CONST .....	Construct, Construction
ABS .....	Acrylonitrile - butadiene - styrene	COORD .....	Coordinate
AC .....	Asphalt Concrete	CSP .....	Corrugated steel pipe
ACP .....	Asbestos cement pipe	CTB .....	Cement treated base
ACWS .....	Asphalt concrete wearing surface	CV .....	Check valve
ALT .....	Alternate	CY .....	Cubic yard
AMER STD .....	American Standard	D .....	Load of pipe
AWG .....	American Wire Gage (nonferrous wire)	dB .....	Decibels
BC .....	Beginning of curve	DBL .....	Double
BCR .....	Beginning of curb return	DF .....	Douglas fir
BDRY .....	Boundary	DIA .....	Diameter
BF .....	Bottom of footing	DIP .....	Ductile iron pipe
BM .....	Bench mark	DL .....	Dead load
BVC .....	Beginning of vertical curve	DT .....	Drain Tile
B/W .....	Back of wall	DWG .....	Drawing
C/C .....	Center to center	DWY .....	Driveway
CAB .....	Crushed aggregate base	DWY APPR .....	Driveway approach
CAL/OSHA .....	California Occupational Safety and Health Administration	EA .....	Each
CalTrans .....	California Department of Transportation	EC .....	End of curve
CAP .....	Corrugated aluminum pipe	ECR .....	End of curb return
CB .....	Catch Basin	EF .....	Each face
Cb .....	Curb	EG .....	Edge of gutter
CBP .....	Catch Basin Connection Pipe	EGL .....	Energy grade line
CBR .....	California Bearing Ratio	EI .....	Elevation
CCR .....	California Code of Regulations	ELC .....	Electrolier lighting conduit
CCTV .....	Closed Circuit TV	ELT .....	Extra long ton of slurry
CF .....	Curb face	ENGR .....	Engineer, Engineering
CF .....	Cubic foot	EP .....	Edge of pavement
C&G .....	Curb and gutter	ESMT .....	Easement
CFR .....	Code of Federal Regulations	ETB .....	Emulsion-treated base
CIP .....	Cast iron pipe	EVC .....	End of vertical curb
CIPP .....	Cast-in place pipe	EXC .....	Excavation
CL .....	Clearance, center line	EXP JT .....	Expansion joint
CLF .....	Chain link fence	EXST .....	Existing
CMB .....	Crushed miscellaneous base	F .....	Fahrenheit
CMC .....	Cement mortar-coated	F&C .....	Frame and cover
CML .....	Cement mortar-lined	F&I .....	Furnish and install
CO .....	Cleanout (Sewer)	FAB .....	Fabricate
COL .....	Column	FAS .....	Flashing arrow sign
CONC .....	Concrete	FD .....	Floor drain
		FDN .....	Foundation
		FED SPEC .....	Federal Specification

FG.....	Finished grade	MEAS.....	Measure
FH.....	Fire hydrant	MH.....	Manhole, maintenance hole
FL.....	Flow line	MIL SPEC.....	Military specification
FS.....	Finished surface	MISC.....	Miscellaneous
FT-LB.....	Foot-pound	MOD.....	Modified, modify
FTG.....	Footing	MON.....	Monument
FW.....	Face of wall	MULT.....	Multiple
GA.....	Gauge	MVL.....	Mercury vapor light
GALV.....	Galvanized	NRCP.....	Nonreinforced concrete pipe
GIP.....	Galvanized iron pipe	OBS.....	Obsolete
GL.....	Ground line or grade line	OC.....	On center
GM.....	Gas meter	OD.....	Outside diameter
GP.....	Guy pole	OE.....	Outer edge
GR.....	Grade	OPP.....	Opposite
GRTG.....	Grating	ORIG.....	Original
GSP.....	Galvanized steel pipe	PB.....	Pull box
H.....	High or height	PC.....	Point of curvature
HB.....	Hose bib	PCC.....	Portland cement concrete or point of compound curvature
HC.....	House connection	PCVC.....	Point of compound vertical curve
HDWL.....	Headwall	PE.....	Polyethylene
HGL.....	Hydraulic grade line	PI.....	Point of intersection
HORIZ.....	Horizontal	PL.....	Property line
HP.....	Horsepower	PMB.....	Processed miscellaneous base
HPG.....	High pressure gas	POC.....	Point on curve
HPS.....	High pressure sodium (Light)	POT.....	Point on tangent
HYDR.....	Hydraulic	PP.....	Power pole
ID.....	Inside diameter	PRC.....	Point of reverse curve
INCL.....	Including	PRVC.....	Point of reverse vertical curve
INSP.....	Inspection	PSI.....	Pounds per square inch
INV.....	Invert	PT.....	Point of tangency
IP.....	Iron pipe	PVC.....	Polyvinyl chloride
JC.....	Junction chamber	PVMT.....	Pavement
JCT.....	Junction	PVT R/W.....	Private right-of-way
JS.....	Junction structure	Q.....	Rate of flow in cubic feet per second
JT.....	Joint	QUAD.....	Quadrangle, Quadrant
L.....	Length	R.....	Radius
LAB.....	Laboratory	R&O.....	Rock and oil
LAT.....	Lateral	R/W.....	Right-of-way
LB.....	Pound	RA.....	Recycling agent
LD.....	Local depression	RAC.....	Recycled asphalt concrete
LF.....	Linear foot	RAP.....	Reclaimed asphalt pavement
LH.....	Lamp hole	RBAC.....	Rubberized asphalt concrete
LL.....	Live load	RC.....	Reinforced concrete
LOL.....	Layout line	RCB.....	Reinforced concrete box
LONG.....	Longitudinal	RCE.....	Registered civil engineer
LP.....	Lamp post	RCP.....	Reinforced concrete pipe
LPS.....	Low pressure sodium (Light)	RCV.....	Remote control valve
LS.....	Lump sum	REF.....	Reference
LTS.....	Lime treated soil	REINF.....	Reinforced or reinforcement
MAINT.....	Maintenance	RES.....	Reservoir
MAX.....	Maximum	RGE.....	Registered geotechnical engineer
MCR.....	Middle of curb return		

RR.....	Railroad	SY.....	Square yard
RSE.....	Registered structural engineer	TAN.....	Tangent
RTE.....	Registered traffic engineer	TC.....	Top of curb
S.....	Slope	TEL.....	Telephone
SCCP.....	Steel cylinder concrete pipe	TF.....	Top of footing
SD.....	Storm drain	TOPO.....	Topography
SDR.....	Standard thermoplastic pipe dimension ratio (ratio of pipe O.D. to minimum wall thickness)	TR.....	Tract
SE.....	Sand Equivalent	TRANS.....	Transition
SEC.....	Section	TS.....	Traffic signal or transition structure
SF.....	Square foot	TSC.....	Traffic signal conduit
SI.....	International System of Units (Metric)	TSS.....	Traffic signal standard
SPEC.....	Specifications	TW.....	Top of wall
SPPWC.....	Standard Plans for Public Works Construction	TYP.....	Typical
SR.....	Standard ratio	USA.....	Underground Service Alert
SS.....	Sanitary sewer	VAR.....	Varies, Variable
SSB.....	Select sub-base	VB.....	Valve box
SSPWC.....	Standard Specifications for Public Works Construction	VC.....	Vertical curve
ST HWY.....	State highway	VCP.....	Vitrified clay pipe
STA.....	Station	VERT.....	Vertical
STD.....	Standard	VOL.....	Volume
STR.....	Straight	W.....	Wider or width
STR GR.....	Straight grade	WATCH.....	Work Area Traffic Control Handbook
STRUC.....	Structural/Structure	WI.....	Wrought iron
SW.....	Sidewalk	WM.....	Water meter
SWD.....	Sidewalk drain	WPJ.....	Weakened plane joint
		XCONN.....	Cross connection
		XSEC.....	Cross section

### 1-3.3 Institutions.

#### Abbreviation ..... Word or Words

AASHTO.....	American Association of State Highway and Transportation Officials
AISC.....	American Institute of Steel Construction
ANSI.....	American National Standards Institute
API.....	American Petroleum Institute
AREA.....	American Railway Engineering Association
ASTM.....	American Society for Testing and Materials
AWPA.....	American Wood Preservers Association
AWS.....	American Welding Society
AWWA.....	American Water Works Association
GRI.....	Geosynthetic Research Institute
NEMA.....	National Electrical Manufacturers Assn.
NOAA.....	National Oceanic and Atmospheric Administration (Dept. of Commerce)
UL.....	Underwriters' Laboratories Inc.
USGS.....	United States Geological Survey

**1-4 UNITS OF MEASURE.**

**1-4.1 General.** The International System of Units, also referred to as SI or the metric system, is the principal measurement system in these specifications and shall be used for construction, unless otherwise stated in the Contract Documents. U.S. Standard Measures, also called U.S. Customary System, are included in parenthesis. SI units and U.S. Standard Measures in parenthesis may or may not be exactly equivalent. If U.S. Standard Measures are specified for use in the contract documents, then all values used for construction shall be U.S. Standard Measures shown in parenthesis. However, certain material specifications and test requirements contained herein use SI units specifically and conversions to U.S. Standard Measures have not been included in these circumstances. When U.S. Standard Measures are not included in parenthesis, then the SI units shall control.

Reference is also made to ASTM E 380 for definitions of various units of the SI system and a more extensive set of conversion factors.

**1-4.2 Units of Measure and Their Abbreviations.**

<u>U.S. Customary Unit</u> <u>(Abbreviations)</u>	<u>Equal To</u>	<u>SI Unit</u> <u>(Abbreviations)</u>
1 mil (= 0.001 in).....		25.4 micrometer ( $\mu\text{m}$ )
1 inch (in) .....		25.4 millimeter ( mm)
1 inch (in) .....		2.54 centimeter (cm)
1 foot (ft) .....		0.3048 meter (m)
1 yard (yd) .....		0.9144 meter (m)
1 mile (mi).....		1.6093 kilometer (km)
1 square foot (ft <sup>2</sup> ).....		0.0929 square meter (m <sup>2</sup> )
1 square yard (yd <sup>2</sup> ).....		0.8361 square meter (m <sup>2</sup> )
1 cubic foot (ft <sup>3</sup> ).....		0.0283 cubic meter (m <sup>3</sup> )
1 cubic yard (yd <sup>3</sup> ).....		0.7646 cubic meter (m <sup>3</sup> )
1 acre .....		0.4047 hectare (ha)
1 U.S. gallon (gal) .....		3.7854 Liter (L)
1 fluid ounce (fl. oz.).....		29.5735 milliliter (mL)
1 pound mass (lb) (avoirdupois).....		0.4536 kilogram (kg)
1 ounce mass (oz).....		0.02835 kilogram (kg)
1 Ton (= 2000 lb avoirdupois).....		0.9072 Tonne (= 907 kg)
1 Poise .....		0.1 pascal · second (Pa · s)
1 centistoke (cs) .....		1 square millimeters per second ( mm <sup>2</sup> /s)
1 pound force (lbf).....		4.4482 Newton (N)
1 pounds per square inch (psi).....		6.8948 Kilopascal ( kPa)
1 pound force per foot (lbf/ft).....		1.4594 Newton per meter (N/m)
1 foot-pound force (ft-lbf) .....		1.3558 Joules (J)
1 foot-pound force per second ([ft-lbf]/s).....		1.3558 Watt (W)
1 part per million (ppm) .....		1 milligram/liter (mg/L)

**Temperature Units and Abbreviations**

Degree Fahrenheit (°F):

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$$

Degree Celsius (°C):

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$$

**SI Units (abbreviation) Commonly Used in Both Systems**

1 Ampere (A)  
 1 Volt (V)  
 1 Candela (cd)  
 1 Lumen (lm)  
 1 second (s)

**Common Metric Prefixes**

kilo (k)	.....	10 <sup>3</sup>
centi (c)	.....	10 <sup>-2</sup>
milli (m)	.....	10 <sup>-3</sup>
micro (μ)	.....	10 <sup>-6</sup>
nano (n)	.....	10 <sup>-9</sup>
pico (p)	.....	10 <sup>-12</sup>

**1-5 SYMBOLS.**

Δ .....Delta, the central angle or angle between tangents  
 ∠ .....Angle  
 % .....Percent  
 ‘ .....Feet or minutes  
 “ .....Inches or seconds  
<sup>1</sup> .....Number  
 / .....per or (between words)  
 ° .....Degree  
 PL .....Property line  
 CL .....Centerline  
 SL .....Survey line or station line

**SECTION 2 - SCOPE AND CONTROL OF WORK**

**2-1 AWARD AND EXECUTION OF CONTRACT.** Award and execution of Contract will be as provided for in the Specifications, Instruction to Bidders, or Notice Advertising for Bids.

**2-2 ASSIGNMENT.** No Contract or portion thereof may be assigned without consent of the Board, except that the Contractor may assign money due or which will accrue to it under the Contract. If given written notice, such assignment will be recognized by the Board to the extent permitted by law. Any assignment of money shall be subject to all proper withholdings in favor of the Agency and to all deductions provided for in the Contract. All money withheld, whether assigned or not, shall be subject to being used by the Agency for completion of the Work, should the Contractor be in default.

## 2-3 SUBCONTRACTS.

**2-3.1 General.** Each Bidder shall comply with the Chapter of the Public Contract Code including Sections 4100 through 4113. The following excerpts or summaries of some of the requirements of this Chapter are included below for information:

The Bidder shall set forth in the Bid, as provided in 4104:

“(a) The name and location of the place of business of each subcontractor who will perform work or labor or render service to the prime contractor in or about the construction of the work or improvement, or a subcontractor licensed by the State of California who, under subcontract to the prime contractor, specially fabricates and installs a portion of the work or improvement according to detailed drawings contained in the plans and specifications, in an amount in excess of one-half of 1 percent of the prime contractor’s total bid, or, in the case of bids or offers for the construction of streets or highways, including bridges, in excess of one-half of 1 percent of the prime contractor’s total bid or ten thousand dollars (\$10,000), whichever is greater.”

“(b) The portion of the work which will be done by each such subcontractor under this act. The prime contractor shall list only one subcontractor for each such portion as is defined by the prime contractor in his bid.”

If the Contractor fails to specify a Subcontractor, or specifies more than one Subcontractor for the same portion of the work to be performed under the Contract (in excess of one-half of 1 percent of the Contractor’s total Bid), the Contractor shall be qualified to perform that portion itself, and shall perform that portion itself, except as otherwise provided in the Code.

As provided in Section 4107, no Contractor whose Bid is accepted shall substitute any person as Subcontractor in place of the Subcontractor listed in the original Bid, except for causes and by procedures established in Section 4107.5. This section provides procedures to correct a clerical error in the listing of a Subcontractor.

Section 4110 provides that a Contractor violating any of the provisions of the Chapter violates the Contract and the Board may exercise the option either to cancel the Contract or assess the Contractor a penalty in an amount of not more than 10 percent of the subcontract involved, after a public hearing.

**2-3.2 Additional Responsibility.** The Contractor shall give personal attention to the fulfillment of the Contract and shall keep the Work under its control.

“The Contractor shall perform, with its own organization, Contract work amounting to at least 50 percent of the Contract Price except that any designated “Specialty Items” may be performed by subcontract and the amount of any such “Specialty Items” so performed may be deducted from the Contract Price before computing the amount required to be performed by the Contractor with its own organization. “Specialty Items” will be identified by the Agency in the Bid or Proposal. Where an entire item is subcontracted, the value of work subcontracted will be based on the Contract Unit Price. When a portion of an item is subcontracted, the value of work subcontracted will be based on the estimated percentage of the Contract Unit Price. This will be determined from information submitted by the Contractor, and subject to approval by the Engineer.

Before the work of any Subcontractor is started, the Contractor shall submit to the Engineer for approval a written statement showing the work to be subcontracted giving the name and business of each Subcontractor and description and value of each portion of the work to be so subcontracted.

**2-3.3 Status of Subcontractors.** Subcontractors shall be considered employees of the Contractor, and the Contractor shall be responsible for their work.

**2-4 CONTRACT BONDS.** Before execution of the Contract, the Bidder shall file surety bonds with the Agency to be approved by the Board in the amounts and for the purposes noted below. Bonds issued by a surety who is listed in the latest version of U.S. Department of Treasury Circular 570, who is authorized to issue bonds in California, and whose bonding limitation shown in said circular is sufficient to provide bonds in the amount required by the Contract shall be deemed to be approved unless specifically rejected by the Agency. Bonds from all other sureties shall be accompanied by all of the documents enumerated in Code of Civil Procedure 995.660 (a). The Bidder shall pay all bond premiums, costs, and incidentals.

Each bond shall incorporate, by reference, the Contract and be signed by both the Bidder and Surety and the signature of the authorized agent of the Surety shall be notarized.

The Bidder shall provide two good and sufficient surety bonds. The "Payment Bond" (Material and Labor Bond) shall be for not less than 100 percent of the Contract Price, to satisfy claims of material suppliers and mechanics and laborers employed by it on the Work. The bond shall be maintained by the Contractor in full force and effect until the Work is accepted by the Agency and until all claims for materials and labor are paid, and shall otherwise comply with the Civil Code.

The "Performance Bond" shall be for 100 percent of the Contract Price to guaranty faithful performance of all work, within the time prescribed, in a manner satisfactory to the Agency, and that all materials and workmanship will be free from original or developed defects. The bond must remain in effect until the end of all warranty periods set forth in the Contract.

Should any bond become insufficient, the Contractor shall renew the bond within 10 days after receiving notice from the Agency.

Should any Surety at any time be unsatisfactory to the Board, notice will be given the Contractor to that effect. No further payments shall be deemed due or will be made under the Contract until a new Surety shall qualify and be accepted by the Board.

Changes in the Work or extensions of time, made pursuant to the Contract, shall in no way release the Contractor or Surety from its obligations. Notice of such changes or extensions shall be waived by the Surety.

## **2-5 PLANS AND SPECIFICATIONS.**

**2-5.1 General.** The Contractor shall keep at the Work site a copy of the Plans and Specifications, to which the Engineer shall have access at all times.

The Plans, Specifications, and other Contract Documents shall govern the Work. The Contract Documents are intended to be complementary and cooperative. Anything specified in the Specifications and not shown on the Plans, or shown on the Plans and not specified in the Specifications, shall be as though shown on or specified in both.

The Plans shall be supplemented by such working drawings and shop drawings as are necessary to adequately control the Work.

The Contractor shall ascertain the existence of any conditions affecting the cost of the Work through a reasonable examination of the Work site prior to submitting the Bid.

Existing improvements visible at the Work site, for which no specific disposition is made on the Plans, but which interfere with the completion of the Work, shall be removed and disposed of by the Contractor.

The Contractor shall, upon discovering any error or omission in the Plans or Specifications, immediately call it to the attention of the Engineer.

**2-5.2 Precedence of Contract Documents.** If there is a conflict between any of the Contract Documents, the document highest in precedence shall control. The precedence shall be as follows:

- 1) Permits issued by jurisdictional regulatory agencies.
- 2) Change Orders and/or Supplemental Agreements; whichever occurs last.
- 3) Contract/Agreement.

- 4) Addenda.
- 5) Bid/Proposal.
- 6) Special Provisions.
- 7) Plans.
- 8) Standard Plans.
- 9) Standard Specifications.
- 10) Reference Specifications.

Detail drawings shall take precedence over general drawings.

### 2-5.3 Submittals.

**2-5.3.1 General.** Submittals shall be provided, at the Contractor's expense, as required in 2-5.3.2, 2-5.3.3 and 2-5.3.4, when required by the Plans or Special Provisions, or when requested by the Engineer.

Materials shall neither be furnished nor fabricated, nor shall any work for which submittals are required be performed, before the required submittals have been reviewed and accepted by the Engineer. Neither review nor acceptance of submittals by the Engineer shall relieve the Contractor from responsibility for errors, omissions, or deviations from the Contract Documents, unless such deviations were specifically called to the attention of the Engineer in the letter of transmittal. The Contractor shall be responsible for the correctness of the submittals.

The Contractor shall allow a minimum of 20 working days for review of submittals unless otherwise specified in the Special Provisions. Each submittal shall be accompanied by a letter of transmittal.

**2-5.3.2 Working Drawings.** Working drawings are drawings showing details not shown on the Plans which are required to be designed by the Contractor. Working drawings shall be of a size and scale to clearly show all necessary details.

Six copies and one reproducible shall be submitted. If no revisions are required, three of the copies will be returned to the Contractor. If revisions are required, the Engineer will return one copy along with the reproducible for resubmission. Upon acceptance, the Engineer will return two of the copies to the Contractor and retain the remaining copies and the reproducible.

Working drawings are required in the following subsections:

**TABLE 2-5.3.2 (A)**

Item	Section Number	Title	Subject
1	7-10.4.1	Safety Orders	Trench Shoring
2	207-2.5	Joints	Reinforced Concrete Pipe
3	207-8.4	Joints	Vitrified Clay Pipe
4	207-10.2.1	General	Fabricated Steel Pipe
5	300-3.2	Cofferdams	Structure Excavation & Backfill
6	303-1.6.1	General	Falsework
7	303-1.7.1	General	Placing Reinforcement
8	303-3.1	General	Prestressed Concrete Construction
9	304-1.1.1	Shop Drawings	Structural Steel
10	304-1.1.2	Falsework Plans	Structural Steel
11	304-2.1	General	Metal Hand Railings
12	306-2.1	General	Jacking Operations
13	306-3.1	General	Tunneling Operations
14	306-3.4	Tunnel Supports	Tunneling Operations
15	306-6	Remodeling Existing Sewer Facilities	Polyethylene Liner Installation
16	306-8	Microtunneling	Microtunneling Operations
17	307-4.3	Controller Cabinet Wiring Diagrams	Traffic Signal Construction

Working drawings listed above as Items 5, 6, 8, 9, 10, 12, 13, 14 and 16 shall be prepared by a Civil or Structural Engineer registered by the State of California.

**2-5.3.3 Shop Drawings.** Shop drawings are drawings showing details of manufactured or assembled products proposed to be incorporated into the Work. Shop drawings required shall be as specified in the Special Provisions.

**2-5.3.4 Supporting Information.** Supporting information is information required by the Specifications for the purposes of administration of the Contract, analysis for verification of conformance with the Specifications, the operation and maintenance of a manufactured product or system to be constructed as part of the Work, and other information as may be required by the Engineer. Six copies of the supporting information shall be submitted to the Engineer prior to the start of the Work unless otherwise specified in the Special Provisions or directed by the Engineer. Supporting information for systems shall be bound together and include all manufactured items for the system. If resubmittal is not required, three copies will be returned to the Contractor. Supporting information shall consist of the following and is required unless otherwise specified in the Special Provisions:

- 1) List of Subcontractors per 2-3.2.
- 2) List of Materials per 4-1.4.
- 3) Certifications per 4-1.5.
- 4) Construction Schedule per 6-1.
- 5) Confined Space Entry Program per 7-10.4.4.
- 6) Concrete mix designs per 201-1.1.
- 7) Asphalt concrete mix designs per 203-6.1.
- 8) Data, including, but not limited to, catalog sheets, manufacturer's brochures, technical bulletins, specifications, diagrams, product samples, and other information necessary to describe a system, product or item. This information is required for irrigation systems, street lighting systems, and traffic signals, and may also be required for any product, manufactured item, or system.

**2-6 WORK TO BE DONE.** The Contractor shall perform all work necessary to complete the Contract in a satisfactory manner. Unless otherwise provided, the Contractor shall furnish all materials, equipment, tools, labor, and incidentals necessary to complete the Work.

**2-7 SUBSURFACE DATA.** All soil and test hole data, water table elevations, and soil analyses shown on the drawings or included in the Specifications apply only at the location of the test holes and to the depths indicated. Soil test reports for test holes which have been drilled are available for inspection at the office of the Engineer. Any additional subsurface exploration shall be done by Bidders or the Contractor at their own expense.

The indicated elevation of the water table is that which existed on the date when test hole data was determined. It is the Contractor's responsibility to determine and allow for the elevation of groundwater at the date of project construction. A difference in elevation between groundwater shown in soil boring logs and groundwater actually encountered during construction will not be considered as a basis for extra work.

**2-8 RIGHT-OF-WAY.** Rights-of-way, easements, or rights-of-entry for the Work will be provided by the Agency. Unless otherwise provided, the Contractor shall make arrangements, pay for, and assume all responsibility for acquiring, using, and disposing of additional work areas and facilities temporarily required. The Contractor shall indemnify and hold the Agency harmless from all claims for damages caused by such actions.

## **2-9 SURVEYING.**

**2-9.1 Permanent Survey Markers.** The Contractor shall notify the Engineer, or the owner on a Private Contract, at least 7 days before starting work to allow for the preservation of survey monuments, lot stakes (tagged), and bench marks. The Engineer, or the owner at its cost, shall file a Corner Record Form referencing survey monuments subject to disturbance in the Office of the County Surveyor prior to the start of construction and also prior to the completion of construction for the replacement of survey monuments. The Contractor shall not disturb survey monuments, lot stakes (tagged), or bench marks without the consent of the Engineer or the owner on Private Contracts. The Contractor shall bear the expense of replacing any that may be disturbed without permission. Replacement shall be done only under the direction of the Engineer by Registered (licensed) Licensed Land Surveyor or a Registered Civil Engineer authorized to practice land surveying within the state.

When a change is made in the finished elevation of the pavement of any roadway in which a permanent survey monument is located, the Contractor shall adjust the monument cover to the new grade within 7 days of finished paving unless otherwise specified.

**2-9.2 Survey Service.** Except for private contracts, the Engineer will perform and be responsible for the accuracy of surveying adequate for construction. The Contractor shall preserve construction survey stakes and marks for the duration of their usefulness. If any construction survey stakes are lost or disturbed and need to be replaced, such replacement shall be by the Engineer at the expense of the Contractor.

The Contractor shall notify the Engineer in writing at least 2 working days before survey services will be required in connection with the laying out of any portion of the Work. The Contractor shall dig all holes necessary for line and grade stakes.

Unless otherwise specified, stakes will be set and stationed by the Engineer for curbs, headers, sewers, storm drains, structures, and rough grade. A corresponding cut or fill to finished grade (or flowline) will be indicated on a grade sheet.

**2-9.3 Private Engineers.** Surveying by private engineers on the Work shall conform to the quality and practice required by the Engineer.

**2-9.4 Line and Grade.** All work shall conform to the lines, elevations, and grades shown on the Plans.

Three consecutive points set on the same slope shall be used together so that any variation from a straight grade can be detected. Any such variation shall be reported to the Engineer. In the absence of such report, the Contractor shall be responsible for any error in the grade of the finished work.

Grades for underground conduits will be set at the surface of the ground. The Contractor shall transfer them to the bottom of the trench.

**2-10 AUTHORITY OF BOARD AND ENGINEER.** The Board has the final authority in all matters affecting the Work. Within the scope of the Contract, the Engineer has the authority to enforce compliance with the Plans and Specifications. The Contractor shall promptly comply with instructions from the Engineer or an authorized representative.

The decision of the Engineer is final and binding on all questions relating to: quantities; acceptability of material, equipment, or work; execution, progress or sequence of work; and interpretation of the Plans, Specifications, or other drawings. This shall be precedent to any payment under the Contract, unless otherwise ordered by the Board.

**2-11 INSPECTION.** The Work is subject to inspection and approval by the Engineer. The Contractor shall notify the Engineer before noon of the working day before inspection is required. Work shall be done only in the presence of the Engineer, unless otherwise authorized. Any work done without

proper inspection will be subject to rejection. The Engineer and any authorized representatives shall at all times have access to the Work during its construction at shops and yards as well as the project site. The Contractor shall provide every reasonable facility for ascertaining that the materials and workmanship are in accordance with these specifications. Inspection of the Work shall not relieve the Contractor of the obligation to fulfill all conditions of the Contract.

## SECTION 3 - CHANGES IN WORK

### 3-1 CHANGES REQUESTED BY THE CONTRACTOR.

**3-1.1 General.** Changes in the Plans and Specifications, requested in writing by the Contractor, which do not materially affect the Work and which are not detrimental to the Work or to the interests of the Agency, may be granted by the Engineer. Nothing herein shall be construed as granting a right to the Contractor to demand acceptance of such changes.

**3-1.2 Payment for Changes Requested by the Contractor.** If such changes are granted, they shall be made at a reduction in cost or no additional cost to the Agency.

### 3-2 CHANGES INITIATED BY THE AGENCY.

**3-2.1 General.** The Agency may change the Plans, Specifications, character of the work, or quantity of work provided the total arithmetic dollar value of all such changes, both additive and deductive, does not exceed 25 percent of the Contract Price. Should it become necessary to exceed this limitation, the change shall be by written Supplemental Agreement between the Contractor and Agency, unless both parties agree to proceed with the change by Change Order.

Change Orders shall be in writing and state the dollar value of the change or establish the method of payment, any adjustment in the Contract time of completion, and when negotiated prices are involved, shall provide for the Contractor's signature indicating acceptance.

#### 3-2.2 Contract Unit Prices.

**3-2.2.1 General.** If a change is ordered in an item of work covered by a Contract Unit Price, and such change does not involve substantial change in character of the work from that shown on the Plans or specified in the Specifications, then an adjustment in payment will be made. This adjustment will be based upon the increase or decrease in quantity and the Contract Unit Price.

If the actual quantity of an item of work covered by a Contract Unit Price and constructed in conformance with the Plans and Specifications varies from the Bid quantity by 25 percent or less, payment will be made at the Contract Unit Price. If the actual quantity of said item of work varies from the Bid quantity by more than 25 percent, payment will be made per 3-2.2.2 or 3-2.2.3 as appropriate.

If a change is ordered in an item of work covered by a Contract Unit Price, and such change does involve a substantial change in the character of the work from that shown on the Plans or specified in the Specifications, an adjustment in payment will be made per 3-2.4.

**3-2.2.2 Increases of More Than 25 Percent.** Should the actual quantity of an item of work covered by a Contract Unit Price and constructed in conformance with the Plans and Specifications, exceed the Bid quantity by more than 25 percent, payment for the quantity in excess of 125 percent of the Bid quantity will be made on the basis of an adjustment in the Contract Unit Price mutually agreed to by the Contractor and the Agency, or at the option of the Engineer, on the basis of Extra Work per 3-3.

The Extra Work per 3-3, basis of payment, shall not include fixed costs. Fixed costs shall be deemed to have been recovered by the Contractor through payment for 125 percent of the Bid quantity at the Contract Unit Price.

**3-2.2.3 Decreases of More Than 25 Percent.** Should the actual quantity of an item of work covered by a Contract Unit Price, and constructed in conformance with the Plans and Specifications, be less than 75 percent of the Bid quantity, an adjustment in payment will not be made unless so requested in writing by the Contractor. If the Contractor so requests, payment will be made on the basis of an adjustment in the Contract Unit Price mutually agreed to by the Contractor and the Agency, or at the option of the Engineer, on the basis of Extra Work per 3.3; however, in no case will payment be less than would be made for the actual quantity at the Contract Unit Price nor more than would be made for 75 percent of the Bid quantity at the Contract Unit Price.

**3-2.3 Stipulated Unit Prices.** Stipulated Unit Prices are unit prices established by the Agency in the Contract Documents. Stipulated Unit Prices may be used for the adjustment of Contract changes when so specified in the Special Provisions.

**3-2.4 Agreed Prices.** Agreed Prices are prices for new or unforeseen work, or adjustments in Contract Unit Prices per 3-2.2, established by mutual agreement between the Contractor and the Agency. If mutual agreement can not be reached, the Engineer may direct the Contractor to proceed on the basis of Extra Work in accordance per 3-3, except as otherwise specified in 3-2.2.2 and 3-2.2.3.

**3.2.5 Eliminated Items.** Should any Bid item be eliminated in its entirety, payment will be made to the Contractor for its actual costs incurred in connection with the eliminated item prior to notification in writing from the Engineer so stating its elimination.

If material conforming to the Plans and Specifications is ordered by the Contractor for use in the eliminated item prior to the date of notification of elimination by the Engineer, and if the order for that material can not be canceled, payment will be made to the Contractor for the actual cost of the material. In this case, the material shall become the property of the Agency. Payment will be made to the Contractor for its actual costs for any further handling. If the material is returnable, the material shall be returned and payment will be made to the Contractor for the actual cost of charges made by the supplier for returning the material and for handling by the Contractor.

Actual costs, as used herein, shall be computed on the basis of Extra Work per 3-3.

### **3-3 EXTRA WORK.**

**3-3.1 General.** New or unforeseen work will be classified as "extra work" when the Engineer determines that it is not covered by Contract Unit Prices or stipulated unit prices.

#### **3-3.2 Payment.**

**3-3.2.1 General.** When the price for the extra work cannot be agreed upon, the Agency will pay for the extra work based on the accumulation of costs as provided herein.

#### **3-3.2.2 Basis for Establishing Costs.**

(a) **Labor.** The costs of labor will be the actual cost for wages of workers performing the extra work at the time the extra work is done, plus employer payments of payroll taxes, workers compensation insurance, liability insurance, health and welfare, pension, vacation, apprenticeship funds, and other direct costs, resulting from Federal, State, or local laws, as well as assessments or benefits required by lawful collective bargaining agreements.

The use of a labor classification which would increase the extra work cost will not be permitted unless the Contractor establishes the necessity for such additional costs. Labor costs for equipment operators and helpers shall be reported only when such costs are not included in the invoice for equipment rental. The labor cost for foremen shall be proportioned to all of their assigned work and only that applicable to extra work will be paid.

Nondirect labor costs, including superintendence, shall be considered part of the markup of 3-3.2.3 (a).

(b) **Materials.** The cost of materials reported shall be at invoice or lowest current price at which such materials are locally available and delivered to the job site in the quantities involved, plus sales tax, freight, and delivery.

The Agency reserves the right to approve materials and sources of supply, or to supply materials to the Contractor if necessary for the progress of the Work. No markup shall be applied to any material provided by the Agency.

(c) **Tool and Equipment Rental.** No payment will be made for the use of tools which have a replacement value of \$200 or less.

Regardless of ownership, the rates to be used in determining equipment rental costs shall not exceed listed rates prevailing locally at equipment rental agencies, or distributors, at the time the work is performed.

The rental rates paid shall include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs and maintenance of any kind, depreciation, storage, insurance, and all incidentals. Necessary loading and transportation costs for equipment used on the extra work shall be included.

If equipment is used intermittently and, when not in use, could be returned to its rental source at less expense to the Agency than holding it at the Work site, it shall be returned, unless the Contractor elects to keep it at the Work site, at no expense to the Agency.

All equipment shall be acceptable to the Engineer, in good working condition, and suitable for the purpose for which it is to be used. Manufacturer's ratings and approved modifications shall be used to classify equipment and it shall be powered by a unit of at least the minimum rating recommended by the manufacturer.

The reported rental time for equipment already at the Work site shall be the duration of its use on the extra work. This time begins when equipment is first put into actual operation on the extra work, plus the time required to move it from its previous site and back, or to a closer site.

(d) **Other Items.** The Agency may authorize other items which may be required on the extra work, including labor, services, material, and equipment. These items must be different in their nature from those required for the Work, and be of a type not ordinarily available from the Contractor or Subcontractors.

Invoices covering all such items in detail shall be submitted with the request for payment.

(e) **Invoices.** Vendors' invoices for material, equipment rental and other expenditures shall be submitted with the request for payment. If the request for payment is not substantiated by invoices or other documentation, the Agency may establish the cost of the item involved at the lowest price which was current at the time of the report.

### 3-3.2.3 Markup.

(a) **Work by Contractor.** Unless otherwise provided in the Special Provisions, a reasonable allowance for overhead and profit shall be added to the Contractor's costs as determined under 3-3.2.2 and shall constitute the markup for all overhead and profit on work by the Contractor. The

Contractor shall also be compensated for the actual increase in the Contractor's bond premium caused by the extra work.

(b) **Work by Subcontractor.** When any of the extra work is performed by a Subcontractor, the markup established in 3-3.2.3 (a) shall be applied to the Subcontractor's costs as determined under 3-3.2.2. Unless otherwise provided in the Special Provisions, a reasonable allowance for the Contractor's overhead and profit shall be added to the sum of the Subcontractor's costs and markup and shall constitute the markup for all overhead and profit for the Contractor on work by the Subcontractor.

**3-3.3 Daily Reports by Contractor.** When the price for the extra work cannot be agreed upon, the Contractor shall submit a daily report to the Engineer on forms approved by the Agency. Included are applicable delivery tickets, listing all labor, materials, and equipment involved for that day, and other services and expenditures when authorized. Failure to submit the daily report by the close of the next working day may waive any rights for that day. An attempt shall be made to reconcile the report daily, and it shall be signed by the Engineer and the Contractor. In the event of disagreement, pertinent notes shall be entered by each party to explain points which cannot be resolved immediately. Each party shall retain a signed copy of the report. Reports by Subcontractors or others shall be submitted through the Contractor.

The report shall:

1. Show names of workers, classifications, and hours worked.
2. Describe and list quantities of materials used.
3. Show type of equipment, size, identification number, and hours of operation, including loading and transportation, if applicable.
4. Describe other services and expenditures in such detail as the Agency may require.

**3-4 CHANGED CONDITIONS.** The Contractor shall promptly notify the Engineer of the following Work site conditions (hereinafter called changed conditions), in writing, upon their discovery and before they are disturbed:

1. Subsurface or latent physical conditions differing materially from those represented in the Contract;
2. Unknown physical conditions of an unusual nature differing materially from those ordinarily encountered and generally recognized as inherent in work of the character being performed; and
3. Material differing from that represented in the Contract which the Contractor believes may be hazardous waste, as defined in Section 25117 of the Health and Safety Code, that is required to be removed to a Class I, Class II, or Class III disposal site in accordance with provisions of existing law.

The Engineer will promptly investigate conditions which appear to be changed conditions. If the Engineer determines that the conditions are changed conditions and will materially affect costs, a Change Order will be issued adjusting the compensation for such portion of the Work in accordance with 3-2.2. If the Engineer determines that conditions are changed conditions and they will materially affect performance time, the Contractor, upon submitting a written request, will be granted an extension of time subject to the provisions of 6-6.

If the Engineer determines that the conditions do not justify an adjustment in compensation, the Contractor will be notified in writing. This notice will also advise the Contractor of its obligation to notify the Engineer in writing if the Contractor disagrees.

Should the Contractor disagree with the decision, it may submit a written notice of potential claim to the Engineer before commencing the disputed work. In the event of such a dispute, the Contractor shall not be excused from any scheduled completion date provided by the Contract and shall proceed with all

work to be performed under the Contract. However, the Contractor shall retain any and all rights provided by either Contract or law which pertain to the resolution of disputes and protests between the contracting parties. The Contractor shall proceed as provided in 3-5.

The Contractor's failure to give notice of changed conditions promptly upon their discovery and before they are disturbed shall constitute a waiver of all claims in connection therewith.

**3-5 DISPUTED WORK.** If the Contractor and the Agency are unable to reach agreement on disputed work, the Agency may direct the Contractor to proceed with the work. Payment shall be as later determined by mediation or arbitration, if the Agency and Contractor agree thereto, or as fixed in a court of law.

Although not to be construed as proceeding under extra work provisions, the Contractor shall keep and furnish records of disputed work in accordance with 3-3.

## SECTION 4 - CONTROL OF MATERIALS

### 4-1 MATERIALS AND WORKMANSHIP.

**4-1.1. General.** All materials, parts, and equipment furnished by the Contractor in the Work shall be new, high grade, and free from defects. Quality of work shall be in accordance with the generally accepted standards. Material and work quality shall be subject to the Engineer's approval.

Materials and work quality not conforming to the requirements of the Specifications shall be considered defective and will be subject to rejection. Defective work or material, whether in place or not, shall be removed immediately from the site by the Contractor, at its expense, when so directed by the Engineer.

If the Contractor fails to replace any defective or damaged work or material after reasonable notice, the Engineer may cause such work or materials to be replaced. The replacement expense will be deducted from the amount to be paid to the Contractor.

Used or secondhand materials, parts, and equipment may be used only if permitted by the Specifications.

**4-1.2 Protection of Work and Materials.** The Contractor shall provide and maintain storage facilities and employ such measures as will preserve the specified quality and fitness of materials to be used in the Work. Stored materials shall be reasonably accessible for inspection. The Contractor shall also adequately protect new and existing work and all items of equipment for the duration of the Contract.

The Contractor shall not, without the Agency's consent, assign, sell, mortgage, hypothecate, or remove equipment or materials which have been installed or delivered and which may be necessary for the completion of the Contract.

### 4-1.3 Inspection Requirements.

**4-1.3.1 General.** Unless otherwise specified, inspection is required at the source for such typical materials and fabricated items as bituminous paving mixtures, structural concrete, metal fabrication, metal casting, welding, concrete pipe manufacture, protective coating application, and similar shop or plant operations.

Steel pipe in sizes less than 450 mm (18 inches) and vitrified clay and cast iron pipe in all sizes are acceptable upon certification as to compliance with the Specifications, subject to sampling and testing by the Agency. Standard items of equipment such as electric motors, conveyors, elevators, plumbing fixtures, etc., are subject to inspection at the job site only. Special items of equipment such as designed electrical panel boards, large pumps, sewage plant equipment, etc., are subject to inspection at the

source, normally only for performance testing. The Specifications may require inspection at the source for other items not typical of those listed in this section.

**4-1.3.2 Inspection of Materials Not Locally Produced.** When the Contractor intends to purchase materials, fabricated products, or equipment from sources located more than 80 km (50 miles) outside the geographical limits of the Agency, an inspector or accredited testing laboratory (approved by the Engineer), shall be engaged by the Contractor at its expense, to inspect the materials, equipment or process. This approval shall be obtained before producing any material or equipment. The inspector or representative of the testing laboratory shall judge the materials by the requirements of the Plans and Specifications. The Contractor shall forward reports required by the Engineer. No materials or equipment shall be shipped nor shall any processing, fabrication or treatment of such materials be done without proper inspection by the approved agent. Approval by said agent shall not relieve the Contractor of responsibility for complying with the Contract requirements.

**4-1.3.3 Inspection by the Agency.** The Agency will provide all inspection and testing laboratory services within 80 km (50 miles) of the geographical limits of the Agency. For private contracts, all costs of inspection at the source, including salaries and mileage costs, shall be paid by the permittee.

**4-1.4 Test of Materials.** Before incorporation in the Work, the Contractor shall submit samples of materials, as the Engineer may require, at no cost to the Agency. The Contractor, at its expense, shall deliver the materials for testing to the place and at the time designated by the Engineer. Unless otherwise provided, all initial testing and a reasonable amount of retesting will be performed under the direction of the Engineer, and at no expense to the Contractor. If the Contractor is to provide and pay for testing, it will be stated in the Specifications. For private contracts, the testing expense shall be borne by the permittee.

The Contractor shall notify the Engineer in writing, at least 15 days in advance, of its intention to use materials for which tests are specified, to allow sufficient time to perform the tests. The notice shall name the proposed supplier and source of material.

If the notice of intent to use is sent before the materials are available for testing or inspection, or is sent so far in advance that the materials on hand at the time will not last but will be replaced by a new lot prior to use on the Work, it will be the Contractor's responsibility to renotify the Engineer when samples which are representative may be obtained.

**4-1.5 Certification.** The Engineer may waive materials testing requirements of the Specifications and accept the manufacturer's written certification that the materials to be supplied meet those requirements. Materials test data may be required as part of the certification.

**4-1.6 Trade Names or Equals.** The Contractor may supply any of the materials specified or offer an equivalent. The Engineer shall determine whether the material offered is equivalent to that specified. Adequate time shall be allowed for the Engineer to make this determination.

Whenever any particular material, process, or equipment is indicated by patent, proprietary or brand name, or by name of manufacturer, such wording is used for the purpose of facilitating its description and shall be deemed to be followed by the words **or equal**. A listing of materials is not intended to be comprehensive, or in order of preference. The Contractor may offer any material, process, or equipment considered to be equivalent to that indicated. The substantiation of offers shall be submitted as provided in the Contract Documents.

The Contractor shall, at its expense, furnish data concerning items offered by it as equivalent to those specified. The Contractor shall have the material tested as required by the Engineer to determine that the quality, strength, physical, chemical, or other characteristics, including durability, finish, efficiency, dimensions, service, and suitability are such that the item will fulfill its intended function.

Test methods shall be subject to the approval of the Engineer. Test results shall be reported promptly to the Engineer, who will evaluate the results and determine if the substitute item is equivalent. The Engineer's findings shall be final. Installation and use of a substitute item shall not be made until approved by the Engineer.

If a substitute offered by the Contractor is not found to be equal to the specified material, the Contractor shall furnish and install the specified material.

The specified Contract completion time shall not be affected by any circumstance developing from the provisions of this section.

**4-1.7 Weighing and Metering Equipment.** All scales and metering equipment used for proportioning materials shall be inspected for accuracy and certified within the past 12 months by the State of California Bureau of Weights and Measures, by the County Director or Sealer of Weights and Measures, or by a scale mechanic registered with or licensed by the County.

The accuracy of the work of a scale service agency, except as stated herein, shall meet the standards of the California Business and Professions Code and the California Code of Regulations pertaining to weighing devices. A certificate of compliance shall be presented, prior to operation, to the Engineer for approval and shall be renewed whenever required by the Engineer at no cost to the Agency.

All scales shall be arranged so they may be read easily from the operator's platform or area. They shall indicate the true net weight without the application of any factor. The figures of the scales shall be clearly legible. Scales shall be accurate to within 1 percent when tested with the plant shut down. Weighing equipment shall be so insulated against vibration or moving of other operating equipment in the plant area that the error in weighing with the entire plant running will not exceed 2 percent for any setting nor 1.5 percent for any batch.

**4-1.8 Calibration of Testing Equipment.** Testing equipment, such as, but not limited to pressure gages, metering devices, hydraulic systems, force (load) measuring instruments, and strain-measuring devices shall be calibrated by a testing agency acceptable to the Engineer at intervals not to exceed 12 months and following repairs, modification, or relocation of the equipment. Calibration certificates shall be provided when requested by the Engineer.

**4-1.9 Construction Materials Dispute Resolution (Soils, Rock Materials, Concrete, Mortar and Related Materials, Masonry Materials, Bituminous Materials, Rock Products, and Modified Asphalts).** In the interest of safety and public value, whenever credible evidence arises to contradict the test values of materials, the Agency and the Contractor will initiate an immediate and cooperative investigation. Test values of materials are results of the materials' tests, as defined by these Specifications or by the special provisions, required to accept the Work. Credible evidence is process observations or test values gathered using industry accepted practices. A contradiction exists whenever test values or process observations of the same or similar materials are diverse enough such that the work acceptance or performance becomes suspect. The investigation shall allow access to all test results, procedures, and facilities relevant to the disputed work and consider all available information and, when necessary, gather new and additional information in an attempt to determine the validity, the cause, and if necessary, the remedy to the contradiction. If the cooperative investigation reaches any resolution mechanism acceptable to both the Agency and the Contractor, the contradiction shall be considered resolved and the cooperative investigation concluded.

Whenever the cooperative investigation is unable to reach resolution, the investigation may then either conclude without resolution or continue by written notification of one party to the other requesting the implementation of a resolution process by committee. The continuance of the investigation shall be

contingent upon recipient's agreement and acknowledged in writing within 3 calendar days after receiving a request. Without acknowledgement, the investigation shall conclude without resolution. The committee shall consist of three State of California Registered Civil Engineers. Within 7 calendar days after the written request notification, the Agency and the Contractor will each select one engineer. Within 14 calendar days of the written request notification, the two selected engineers will select a third engineer. The goal in selection of the third member is to complement the professional experience of the first two engineers. Should the two engineers fail to select the third engineer, the Agency and the Contractor shall each propose 2 engineers to be the third member within 21 calendar days after the written request notification. The first two engineers previously selected shall then select one of the four proposed engineers in a blind draw.

The committee shall be a continuance of the cooperative investigation and will re-consider all available information and if necessary gather new and additional information to determine the validity, the cause, and if necessary, the remedy to the contradiction. The committee will focus upon the performance adequacy of the material(s) using standard engineering principles and practices and to ensure public value, the committee may provide engineering recommendations as necessary. Unless otherwise agreed, the committee will have 30 calendar days from its formation to complete their review and submit their findings. The final resolution of the committee shall be by majority opinion, in writing, stamped and signed. Should the final resolution not be unanimous, the dissenter may attach a written, stamped, and signed minority opinion.

Once started, the resolution process by committee shall continue to full conclusion unless:

1. Within 7 days of the formation of the committee, the Agency and the Contractor reach an acceptable resolution mechanism; or
2. Within 14 days of the formation of the committee, the initiating party withdraws its written notification and agrees to bear all investigative related costs thus far incurred; or
3. At any point by the mutual agreement of the Agency and the Contractor.

Unless otherwise agreed, the Contractor shall bear and maintain a record for all the investigative costs until resolution. Should the investigation discover assignable causes for the contradiction, the assignable party, the Agency or the Contractor, shall bear all costs associated with the investigation. Should assignable causes for the contradiction extended to both parties, the investigation will assign costs cooperatively with each party or when necessary, equally. Should the investigation substantiate a contradiction without assignable cause, the investigation will assign costs cooperatively with each party or when necessary, equally. Should the investigation be unable to substantiate a contradiction, the initiator of the investigation shall bear all investigative costs. All claim notification requirements of the contract pertaining to the contradiction shall be suspended until the investigation is concluded.

## SECTION 5 - UTILITIES

**5-1 LOCATION.** The Permittee (in the case of Private Contracts) and the Agency (in the case of Cash or Assessment Act Contracts), will search known substructure records and furnish the Contractor with copies of documents which describe the location of utility substructures, or will indicate on the Plans for the project those substructures (except for service connections) which may affect the Work. Information regarding removal, relocation, abandonment, or installation of new utilities will be furnished to prospective bidders.

Where underground main distribution conduits such as water, gas, sewer, electric power, telephone, or cable television are shown on the Plans, the Contractor shall assume that every property parcel will be served by a service connection for each type of utility.

As provided in Section 4216 of the California Government Code, at least 2 working days prior to commencing any excavation, the Contractor shall contact the regional notification center (Underground Service Alert of Southern California) and obtain an inquiry identification number.

The California Department of Transportation is not required by Section 4216 to become a member of the regional notification center. The Contractor shall contact it for location of its subsurface installations.

The Contractor shall determine the location and depth of all utilities, including service connections, which have been marked by the respective owners and which may affect or be affected by its operations. If no pay item is provided in the Contract for this work, full compensation for such work shall be considered as included in the prices bid for other items of work.

**5-2 PROTECTION.** The Contractor shall not interrupt the service function or disturb the support of any utility without authority from the owner or order from the Agency. All valves, switches, vaults, and meters shall be maintained readily accessible for emergency shutoff.

Where protection is required to ensure support of utilities located as shown on the Plans or in accordance with 5-1, the Contractor shall, unless otherwise provided, furnish and place the necessary protection at its expense.

Upon learning of the existence and location of any utility omitted from or shown incorrectly on the Plans, the Contractor shall immediately notify the Engineer in writing. When authorized by the Engineer, support or protection of the utility will be paid for as provided in 3-2.2.3 or 3-3.

The Contractor shall immediately notify the Engineer and the utility owner if any utility is disturbed or damaged. The Contractor shall bear the costs of repair or replacement of any utility damaged if located as noted in 5-1.

When placing concrete around or contiguous to any non-metallic utility installation, the Contractor shall at its expense:

1. Furnish and install a 50 mm (2 inch) cushion of expansion joint material or other similar resilient material; or
2. Provide a sleeve or other opening which will result in a 50 mm (2 inch) minimum-clear annular space between the concrete and the utility; or
3. Provide other acceptable means to prevent embedment in or bonding to the concrete.

Where concrete is used for backfill or for structures which would result in embedment, or partial embedment, of a metallic utility installation; or where the coating, bedding or other cathodic protection system is exposed or damaged by the Contractor's operations, the Contractor shall notify the Engineer and arrange to secure the advice of the affected utility owner regarding the procedures required to maintain or restore the integrity of the system.

**5-3 REMOVAL.** Unless otherwise specified, the Contractor shall remove all interfering portions of utilities shown on the Plans or indicated in the Bid documents as "abandoned" or "to be abandoned in place". Before starting removal operations, the Contractor shall ascertain from the Agency whether the abandonment is complete, and the costs involved in the removal and disposal shall be included in the Bid for the items of work necessitating such removals.

**5-4 RELOCATION.** When feasible, the owners responsible for utilities within the area affected by the Work will complete their necessary installations, relocations, repairs, or replacements before commencement of work by the Contractor. When the Plans or Specifications indicate that a utility installation is to be relocated, altered, or constructed by others, the Agency will conduct all negotiations with the owners and work will be done at no cost to the Contractor, except as provided in 301-1.6. Utilities which are relocated in order to avoid interference shall be protected in their position and the cost of such protection shall be included in the Bid for the items of work necessitating such relocation.

After award of the Contract, portions of utilities which are found to interfere with the Work will be relocated, altered or reconstructed by the owners, or the Engineer may order changes in the Work to avoid interference. Such changes will be paid for in accordance with 3-2.

When the Plans or Specifications provide for the Contractor to alter, relocate, or reconstruct a utility, all costs for such work shall be included in the Bid for the items of work necessitating such work. Temporary or permanent relocation or alteration of utilities requested by the Contractor for its convenience shall be its responsibility and it shall make all arrangements and bear all costs.

The utility owner will relocate service connections as necessary within the limits of the Work or within temporary construction or slope easements. When directed by the Engineer, the Contractor shall arrange for the relocation of service connections as necessary between the meter and property line, or between a meter and the limits of temporary construction or slope easements. The relocation of such service connections will be paid for in accordance with provisions of 3-3. Payment will include the restoration of all existing improvements which may be affected thereby. The Contractor may agree with the owner of any utility to disconnect and reconnect interfering service connections. The Agency will not be involved in any such agreement.

**5-5 DELAYS.** The Contractor shall notify the Engineer of its construction schedule insofar as it affects the protection, removal, or relocation of utilities. Said notification shall be included as a part of the construction schedule required in 6-1. The Contractor shall notify the Engineer in writing of any subsequent changes in the construction schedule which will affect the time available for protection, removal, or relocation of utilities.

The Contractor will not be entitled to damages or additional payment for delays attributable to utility relocations or alterations if correctly located, noted, and completed in accordance with 5-1.

The Contractor may be given an extension of time for unforeseen delays attributable to unreasonably protracted interference by utilities in performing work correctly shown on the Plans.

The Agency will assume responsibility for the timely removal, relocation, or protection of existing main or trunkline utility facilities within the area affected by the Work if such utilities are not identified in the Contract Documents. The Contractor will not be assessed liquidated damages for any delay caused by failure of Agency to provide for the timely removal, relocation, or protection of such existing facilities.

If the Contractor sustains loss due to delays attributable to interferences, relocations, or alterations not covered by 5-1, which could not have been avoided by the judicious handling of forces, equipment, or plant, there shall be paid to the Contractor such amount as the Engineer may find to be fair and reasonable compensation for such part of the Contractor's actual loss as was unavoidable and the Contractor may be granted an extension of time.

**5-6 COOPERATION.** When necessary, the Contractor shall so conduct its operations as to permit access to the Work site and provide time for utility work to be accomplished during the progress of the Work.

## SECTION 6 - PROSECUTION, PROGRESS, AND ACCEPTANCE OF THE WORK

### 6-1 CONSTRUCTION SCHEDULE AND COMMENCEMENT OF WORK.

After notification of award and prior to start of any work, the Contractor shall submit its proposed construction schedule to the Engineer for approval. The construction schedule shall be in the form of a tabulation, chart, or graph and shall be in sufficient detail to show chronological relationship of all activities of the project. These include, but are not limited to: estimated starting and completion dates of various activities, submittal of shop drawings to the Engineer for approval, procurement of materials and scheduling of equipment. The construction schedule shall recognize the requirements of 5-5 and reflect completion of all work under the Contract within the specified time and in accordance with the Specifications.

Unless otherwise provided, the Contract time shall commence upon the date of issuance of a notice to proceed. The Work shall start within 15 days thereafter, and be diligently prosecuted to completion within the time provided in the Specifications.

If the Contractor desires to make a major change in the method of operations after commencing construction, or if the schedule fails to reflect the actual progress, the Contractor shall submit to the Engineer a revised construction schedule in advance of beginning revised operations.

The Engineer may waive these requirements for work constructed under permit.

**6-2 PROSECUTION OF WORK.** To minimize public inconvenience and possible hazard and to restore street and other work areas to their original condition and state of usefulness as soon as practicable, the Contractor shall diligently prosecute the Work to completion. If the Engineer determines that the Contractor is failing to prosecute the Work to the proper extent, the Contractor shall, upon orders from the Engineer, immediately take steps to remedy the situation. All costs of prosecuting the Work as described herein shall be included in the Contractor's Bid. Should the Contractor fail to take the necessary steps to fully accomplish said purposes, after orders of the Engineer, the Engineer may suspend the Work in whole or part, until the Contractor takes said steps.

As soon as possible under the provisions of the Specifications, the Contractor shall backfill all excavations and restore to usefulness all improvements existing prior to the start of the Work.

If Work is suspended through no fault of the Agency, all expenses and losses incurred by the Contractor during such suspensions shall be borne by the Contractor. If the Contractor fails to properly provide for public safety, traffic, and protection of the Work during periods of suspension, the Agency may elect to do so, and deduct the cost thereof from monies due the Contractor. Such actions will not relieve the Contractor from liability.

### 6-3 SUSPENSION OF WORK.

**6-3.1 General.** The Work may be suspended in whole or in part when determined by the Engineer that the suspension is necessary in the interest of the Agency. The Contractor shall comply immediately with any written order of the Engineer. Such suspension shall be without liability to the Contractor on the part of the Agency except as otherwise specified in 6-6.3.

**6-3.2 Archaeological and Paleontological Discoveries.** If discovery is made of items of archaeological or paleontological interest, the Contractor shall immediately cease excavation in the area of discovery and shall not continue until ordered by the Engineer. When resumed, excavation operations within the area of discovery shall be as directed by the Engineer.

Discoveries which may be encountered may include, but not be limited to, dwelling sites, stone implements or other artifacts, animal bones, human bones, and fossils.

The Contractor shall be entitled to an extension of time and compensation in accordance with the provisions of 6-6.

**6-4 DEFAULT BY CONTRACTOR.** If the Contractor fails to begin delivery of material and equipment, to commence the Work within the time specified, to maintain the rate of delivery of material, to execute the Work in the manner and at such locations as specified, or fails to maintain the Work schedule which will insure the Agency's interest, or, if the Contractor is not carrying out the intent of the Contract, the Agency may serve written notice upon the Contractor and the Surety on its Faithful Performance Bond demanding satisfactory compliance with the Contract.

The Contract may be canceled by the Board without liability for damage, when in the Board's opinion the Contractor is not complying in good faith, has become insolvent, or has assigned or subcontracted any part of the Work without the Board's consent. In the event of such cancellation, the Contractor will be paid the actual amount due based on Contract Unit Prices or lump sums bid and the quantity of the Work completed at the time of cancellation, less damages caused to the Agency by acts of the Contractor. The Contractor, in having tendered a Bid, shall be deemed to have waived any and all claims for damages because of cancellation of Contract for any such reason. If the Agency declares the Contract canceled for any of the above reasons, written notice to that effect shall be served upon the Surety. The Surety shall, within 5 days, assume control and perform the Work as successor to the Contractor.

If the Surety assumes any part of the Work, it shall take the Contractor's place in all respects for that part, and shall be paid by the Agency for all work performed by it in accordance with the Contract. If the Surety assumes the entire Contract, all money due the Contractor at the time of its default shall be payable to the Surety as the Work progresses, subject to the terms of the Contract.

If the Surety does not assume control and perform the Work within 5 days after receiving notice of cancellation, or fails to continue to comply, the Agency may exclude the Surety from the premises. The Agency may then take possession of all material and equipment and complete the Work by Agency forces, by letting the unfinished Work to another Contractor, or by a combination of such methods. In any event, the cost of completing the Work shall be charged against the Contractor and its Surety and may be deducted from any money due or becoming due from the Agency. If the sums due under the Contract are insufficient for completion, the Contractor or Surety shall pay to the Agency within 5 days after the completion, all costs in excess of the sums due.

The provisions of this subsection shall be in addition to all other rights and remedies available to the Agency under law.

**6-5 TERMINATION OF CONTRACT.** The Board may terminate the Contract at its own discretion or when conditions encountered during the Work make it impossible or impracticable to proceed, or when the Agency is prevented from proceeding with the Contract by act of God, by law, or by official action of a public authority.

#### **6-6 DELAYS AND EXTENSIONS OF TIME.**

**6-6.1 General.** If delays are caused by unforeseen events beyond the control of the Contractor, such delays will entitle the Contractor to an extension of time as provided herein, but the Contractor will not be entitled to damages or additional payment due to such delays, except as provided in 6-6.3. Such unforeseen events may include: war, government regulations, labor disputes, strikes, fires, floods, adverse weather or elements necessitating cessation of work, inability to obtain materials, labor or equipment, required extra work, or other specific events as may be further described in the Specifications.

No extension of time will be granted for a delay caused by the Contractor's inability to obtain materials unless the Contractor furnishes to the Engineer documentary proof. The proof must be provided in a timely manner in accordance with the sequence of the Contractor's operations and the approved construction schedule.

If delays beyond the Contractor's control are caused by events other than those mentioned above, the Engineer may deem an extension of time to be in the best interests of the Agency. The Contractor will not be entitled to damages or additional payment due to such delays, except as provided in 6-6.3.

If delays beyond the Contractor's control are caused solely by action or inaction by the Agency, such delays will entitle the Contractor to an extension of time as provided in 6-6.2.

**6-6.2 Extensions of Time.** Extensions of time, when granted, will be based upon the effect of delays to the Work. They will not be granted for noncontrolling delays to minor portions of the Work unless it can be shown that such delays did or will delay the progress of the Work.

**6-6.3 Payment for Delays to Contractor.** The Contractor will be compensated for damages incurred due to delays for which the Agency is responsible. Such actual costs will be determined by the Engineer. The Agency will not be liable for damages which the Contractor could have avoided by any reasonable means, such as judicious handling of forces, equipment, or plant. The determination of what damages the Contractor could have avoided will be made by the Engineer.

**6-6.4 Written Notice and Report.** If the Contractor desires payment for a delay as specified in 6-6.3 or an extension of time, it shall file with the Agency a written request and report of cause within 30 days after the beginning of the delay. The request for payment or extension must be made at least 15 days before the specified completion date. Failure by the Contractor to file these items within the times specified will be considered grounds for refusal by the Agency to consider such request.

## **6-7 TIME OF COMPLETION.**

**6-7.1 General.** The Contractor shall complete the Work within the time set forth in the Contract. The Contractor shall complete each portion of the Work within such time as set forth in the Contract for such portion. Unless otherwise specified, the time of completion of the Contract shall be expressed in working days.

**6-7.2 Working Day.** A working day is any day within the period between the start of the Contract time as defined in 6-1 and the date provided for completion, or upon field acceptance by the Engineer for all work provided for in the Contract, whichever occurs first, other than:

1. Saturday,
2. Sunday,
3. any day designated as a holiday by the Agency,
4. any other day designated as a holiday in a Master Labor Agreement entered into by the Contractor or on behalf of the Contractor as an eligible member of a contractor association,
5. any day the Contractor is prevented from working at the beginning of the workday for cause as defined in 6-6.1,
6. any day the Contractor is prevented from working during the first 5 hours with at least 60 percent of the normal work force for cause as defined in 6-6.1.

**6-7.3 Contract Time Accounting.** The Engineer will make a daily determination of each working day to be charged against the Contract time. These determinations will be discussed and the Contractor will be furnished a periodic statement showing allowable number of working days of Contract time, as adjusted, at the beginning of the reporting period. The statement will also indicate the number of working days charged during the reporting period and the number of working days of Contract time remaining. If the Contractor

does not agree with the statement, it shall file a written protest within 15 days after receipt, setting forth the facts of the protest. Otherwise, the statement will be deemed to have been accepted.

**6-8 COMPLETION, ACCEPTANCE, AND WARRANTY.** The Work will be inspected by the Engineer for acceptance upon receipt of the Contractor's written assertion that the Work has been completed.

If, in the Engineer's judgment, the Work has been completed and is ready for acceptance, it will so certify to the Board, which may accept the completed Work. The Engineer will, in its certification to the Board, give the date when the Work was completed. This will be the date when the Contractor is relieved from responsibility to protect the Work.

All work shall be warranted by the Contractor against defective workmanship and materials for a period of 1 year from the date the Work was completed. The Contractor shall replace or repair any such defective work in a manner satisfactory to the Engineer, after notice to do so from the Engineer, and within the time specified in the notice. If the Contractor fails to make such replacement or repairs within the time specified in the notice, the Agency may perform this work and the Contractor's sureties shall be liable for the cost thereof.

**6-9 LIQUIDATED DAMAGES.** Failure of the Contractor to complete the Work within the time allowed will result in damages being sustained by the Agency. Such damages are, and will continue to be, impracticable and extremely difficult to determine. For each consecutive calendar day in excess of the time specified for the completion of Work, as adjusted in accordance with 6-6, the Contractor shall pay to the Agency, or have withheld from monies due it, the sum of \$250, unless otherwise provided in the Specifications.

Execution of the Contract shall constitute agreement by the Agency and Contractor that \$250 per day is the minimum value of the costs and actual damage caused by the failure of the Contractor to complete the Work within the allotted time. Such sum is liquidated damages and shall not be construed as a penalty, and may be deducted from payments due the Contractor if such delay occurs.

**6-10 USE OF IMPROVEMENT DURING CONSTRUCTION.** The Agency reserves the right to take over and utilize all or part of any completed facility or appurtenance. The Contractor will be notified in writing in advance of such action. Such action by the Agency will relieve the Contractor of responsibility for injury or damage to said completed portions of the improvement resulting from use by public traffic or from the action of the elements or from any other cause, except Contractor operations or negligence. The Contractor will not be required to reclean such portions of the improvement before field acceptance, except for cleanup made necessary by its operations. Nothing in this section shall be construed as relieving the Contractor from full responsibility for correcting defective work or materials.

In the event the Agency exercises its right to place into service and utilize all or part of any completed facility or appurtenance, the Agency will assume the responsibility and liability for injury to persons or property resulting from the utilization of the facility or appurtenance so placed into service, except for any such injury to persons or property caused by any willful or negligent act or omission by the Contractor, Subcontractor, their officers, employees, or agents.

## **SECTION 7 - RESPONSIBILITIES OF THE CONTRACTOR**

**7-1 CONTRACTOR'S EQUIPMENT AND FACILITIES.** The Contractor shall furnish and maintain in good condition all equipment and facilities as required for the proper execution and inspection of the Work. Such equipment and facilities shall meet all requirements of applicable ordinances and laws.

## 7-2 LABOR.

**7-2.1 General.** Only competent workers shall be employed on the Work. Any person employed who is found to be incompetent, intemperate, troublesome, disorderly, or otherwise objectionable, or who fails or refuses to perform work properly and acceptably, shall be immediately removed from the Work by the Contractor and not be reemployed on the Work.

**7-2.2 Laws.** The Contractor, its agents, and employees shall be bound by and comply with applicable provisions of the Labor Code and Federal, State, and local laws related to labor.

The Contractor shall strictly adhere to the provisions of the Labor Code regarding minimum wages; the 8-hour day and 40-hour week; overtime; Saturday, Sunday, and holiday work; and nondiscrimination because of race, color, national origin, sex, or religion. The Contractor shall forfeit to the Agency the penalties prescribed in the Labor Code for violations.

In accordance with the Labor Code, the Board has on file and will publish a schedule of prevailing wage rates for the types of work to be done under the Contract. The Contractor shall not pay less than these rates.

Each worker shall be paid subsistence and travel as required by the collective bargaining agreements on file with the State of California Department of Industrial Relations.

The Contractor's attention is directed to Section 1776 of the Labor Code which imposes responsibility upon the Contractor for the maintenance, certification, and availability for inspection of such records for all persons employed by the Contractor or Subcontractor in connection with the project. The Contractor shall agree through the Contract to comply with this Section and the remaining provisions of the Labor Code.

**7-3 LIABILITY INSURANCE.** The Contractor shall furnish the Agency a policy or certificate of liability insurance in which the Agency is the named insured or is named as an additional insured with the Contractor. The policy furnished by the Contractor shall be issued by an insurance company authorized by the Insurance Commissioner to transact business in the State of California. The insurance company shall have a policy holder rating of A or higher and a Financial Class VII or higher as established by A.M. Best, or equivalent or greater rating established by another recognized rating entity such as Moody's. Notwithstanding any inconsistent statement in the policy or any subsequent endorsement, the Agency shall be the insured or named as an additional insured covering the Work, whether liability is attributable to the Contractor or the Agency. The policy shall insure the Agency, its officers, employees, and agents, while acting within the scope of their duties on the Work, against all claims arising out of or in connection with the Work, except as provided in 6-10.

The Contractor may file insurance acceptable to the Agency covering more than one project. The coverage shall provide the following minimum limits:

Bodily Injury.....	\$250,000 each person
	\$500,000 each occurrence
	\$500,000 aggregate products and completed operations.
Property Damage .....	\$100,000 each occurrence
	\$250,000 aggregate.

A combined single limit policy with aggregate limits in the amount of \$1,000,000 will be considered equivalent to the required minimum limits.

Except as provided in 6-10, the Contractor shall save, keep, and hold harmless the Agency, its officers and agents from all damages, costs or expenses in law or equity that may at any time arise or be set up because of damages to property, or of personal injury received by reason of or in the course of performing work, which may be caused by any willful or negligent act or omission by the Contractor, any of the Contractor's employees, or any Subcontractor. The Agency will not be liable for any accident, loss or damage to the Work prior to its completion and acceptance, except as provided in 6-10.

All liability insurance policies shall bear an endorsement or shall have attached a rider whereby it is provided that, in the event of expiration or proposed cancellation of such policies for any reason whatsoever, the Agency shall be notified by registered mail, return receipt requested, giving a sufficient time before the date thereof to comply with any applicable law or statute, but in no event less than 30 days before expiration or cancellation is effective.

The cost of this insurance shall be included in the Contractor's Bid.

**7-4 WORKERS' COMPENSATION INSURANCE.** Before execution of the Contract by the Board, the Contractor shall file with the Engineer the following signed certification:

"I am aware of the provisions of Section 3700 of the Labor Code which require every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with the provisions of that code, and I will comply with such provisions before commencing the performance of the work of this contract."

The Contractor shall also comply with Section 3800 of the Labor Code by securing, paying for, and maintaining in full force and effect for the duration of the contract, complete Workers' Compensation Insurance, and shall furnish a Certificate of Insurance to the Engineer before execution of the Contract. The Agency, its officers, or employees, will not be responsible for any claims in law or equity occasioned by failure of the Contractor to comply with this paragraph.

All compensation insurance policies shall bear an endorsement or shall have attached a rider whereby it is provided that, in the event of expiration or proposed cancellation of such policies for any reason whatsoever, the Agency shall be notified by registered mail not less than 30 days before expiration or cancellation is effective.

**7-5 PERMITS.** The Agency will obtain, at no cost to the Contractor, all encroachment and building permits necessary to perform Contract work in streets, highways, railways or other rights-of-way. The Contractor shall obtain and pay for all costs incurred for permits necessitated by its operations such as, but not limited to, those permits required for night work, overload, blasting, and demolition. For private contracts, the Contractor shall obtain all permits incidental to the Work or made necessary by its operations, and pay all costs incurred by the permit requirements.

The Contractor shall pay all business taxes or license fees that are required for the work.

**7-6 THE CONTRACTOR'S REPRESENTATIVE.** Before starting work, the Contractor shall designate in writing a representative who shall have complete authority to act for it. An alternative representative may be designated as well. The representative or alternate shall be present at the Work site whenever work is in progress or whenever actions of the elements necessitate its presence to take measures necessary to protect the Work, persons, or property. Any order or communication given to this representative shall be deemed delivered to the Contractor. A joint venture shall designate only one representative and alternate. In the absence of the Contractor or its representative, instructions or directions may be given by the Engineer to the superintendent or person in charge of the specific work to which the order applies. Such order shall be complied with promptly and referred to the Contractor or its representative.

In order to communicate with the Agency, the Contractor's representative, superintendent, or person in charge of specific work shall be able to speak, read, and write the English language.

**7-7 COOPERATION AND COLLATERAL WORK.** The Contractor shall be responsible for ascertaining the nature and extent of any simultaneous, collateral, and essential work by others. The Agency, its workers and contractors and others, shall have the right to operate within or adjacent to the Work site during the performance of such work.

The Agency, the Contractor, and each of such workers, contractors and others, shall coordinate their operations and cooperate to minimize interference.

The Contractor shall include in its Bid all costs involved as a result of coordinating its work with others. The Contractor will not be entitled to additional compensation from the Agency for damages resulting from such simultaneous, collateral, and essential work. If necessary to avoid or minimize such damage or delay, the Contractor shall redeploy its work force to other parts of the Work.

Should the Contractor be delayed by the Agency, and such delay could not have been reasonably foreseen or prevented by the Contractor, the Engineer will determine the extent of the delay, the effect on the project, and any extension of time.

### **7-8 PROJECT SITE MAINTENANCE.**

**7-8.1 Cleanup and Dust Control.** Throughout all phases of construction, including suspension of work, and until the final acceptance, the Contractor shall keep the site clean and free from rubbish and debris. The Contractor shall also abate dust nuisance by cleaning, sweeping and sprinkling with water, or other means as necessary. The use of water resulting in mud on public streets will not be permitted as a substitute for sweeping or other methods.

When required by the Plans or Specifications, the Contractor shall furnish and operate a self-loading motor sweeper with spray nozzles at least once each working day for the purpose of keeping paved areas acceptably clean wherever construction, including restoration, is incomplete.

Materials and equipment shall be removed from the site as soon as they are no longer necessary. Before the final inspection, the site shall be cleared of equipment, unused materials, and rubbish so as to present a satisfactory clean and neat appearance. All cleanup costs shall be included in the Contractor's Bid.

Care shall be taken to prevent spillage on haul routes. Any such spillage shall be removed immediately and the area cleaned.

Excess excavated material from catch basins or similar structures shall be removed from the site immediately. Sufficient material may remain for use as backfill if permitted by the Specifications. Forms and form lumber shall be removed from the site as soon as practicable after stripping.

Failure of the Contractor to comply with the Engineer's cleanup orders may result in an order to suspend work until the condition is corrected. No additional compensation will be allowed as a result of such suspension.

**7-8.2 Air Pollution Control.** The Contractor shall not discharge smoke, dust, or any other air contaminants into the atmosphere in such quantity as will violate the regulations of any legally constituted authority.

**7-8.3 Vermin Control.** At the time of acceptance, structures entirely constructed under the Contract shall be free of rodents, insects, vermin, and pests. Necessary extermination work shall be arranged and paid for by the Contractor as part of the Work within the Contract time, and shall be performed by a licensed exterminator in accordance with requirements of governing authorities. The Contractor shall be liable for injury to persons or property and responsible for the elimination of offensive odors resulting from extermination operations.

**7-8.4 Sanitation.** The Contractor shall provide and maintain enclosed toilets for the use of employees engaged in the Work. These accommodations shall be maintained in a neat and sanitary condition. They shall also comply with all applicable laws, ordinances, and regulations pertaining to public health and sanitation of dwellings and camps.

Wastewater shall not be interrupted. Should the Contractor disrupt existing sewer facilities, sewage shall be conveyed in closed conduits and disposed of in a sanitary sewer system. Sewage shall not be permitted to flow in trenches or be covered by backfill.

**7-8.5 Temporary Light, Power, and Water.** The Contractor shall furnish, install, maintain, and remove all temporary light, power, and water at its own expense. These include piping, wiring, lamps, and other equipment necessary for the Work. The Contractor shall not draw water from any fire hydrant (except to extinguish a fire), without obtaining permission from the water agency concerned.

**7-8.6 Water Pollution Control.** The Contractor shall exercise every reasonable precaution to protect channels, storm drains, and bodies of water from pollution. It shall conduct and schedule operations so as to minimize or avoid muddying and silting of said channels, drains, and waters. Water pollution control work shall consist of constructing those facilities which may be required to provide prevention, control, and abatement of water pollution.

**7-8.7 Drainage Control.** The Contractor shall maintain drainage within and through the work areas. Earth dams will not be permitted in paved areas. Temporary dams of sandbags, asphaltic concrete, or other acceptable material will be permitted when necessary. Such dams shall be removed from the site as soon as their use is no longer necessary.

**7-9 PROTECTION AND RESTORATION OF EXISTING IMPROVEMENTS.** The Contractor shall be responsible for the protection of public and private property adjacent to the Work and shall exercise due caution to avoid damage to such property.

The Contractor shall repair or replace all existing improvements within the right-of-way which are not designated for removal (e.g., curbs, sidewalks, driveways, fences, walls, signs, utility installations, pavement, structures, etc.) which are damaged or removed as a result of its operations. When a portion of a sprinkler system within the right-of-way must be removed, the remaining lines shall be capped. Repairs and replacements shall be at least equal to existing improvements and shall match them in finish and dimension.

Maintenance of street and traffic signal systems that are damaged, temporarily removed or relocated shall be done in conformance with 307-1.5.

Trees, lawns, and shrubbery that are not to be removed shall be protected from damage or injury. If damaged or removed due to Contractor's operations, they shall be restored or replaced in as nearly the original condition and location as is reasonably possible. Lawns shall be reseeded and covered with suitable mulch.

The Contractor shall give reasonable notice to occupants or owners of adjacent property to permit them to salvage or relocate plants, trees, fences, sprinklers, and other improvements, within the right-of-way which are designated for removal and would be destroyed because of the Work.

All costs to the Contractor for protecting, removing, and restoring existing improvements shall be included in the Bid.

**7-10 PUBLIC CONVENIENCE AND SAFETY.**

**7-10.1 Traffic and Access.** The Contractor's operations shall cause no unnecessary inconvenience. The access rights of the public shall be considered at all times. Unless otherwise authorized, traffic shall be permitted to pass through the Work, or an approved detour shall be provided.

Safe and adequate pedestrian and vehicular access shall be provided and maintained to: fire hydrants; commercial and industrial establishments; churches, schools and parking lots; service stations and motels; hospitals; police and fire stations; and establishments of similar nature. Access to these facilities shall be continuous and unobstructed unless otherwise approved by the Engineer.

Safe and adequate pedestrian zones and public transportation stops, as well as pedestrian crossings of the Work at intervals not exceeding 90 m (300 feet), shall be maintained unless otherwise approved by the Engineer.

Vehicular access to residential driveways shall be maintained to the property line except when necessary construction precludes such access for reasonable periods of time. If backfill has been completed to the extent that safe access may be provided, and the street is opened to local traffic, the Contractor shall immediately clear the street and driveways and provide and maintain access.

The Contractor shall cooperate with the various parties involved in the delivery of mail and the collection and removal of trash and garbage to maintain existing schedules for these services.

Grading operations, roadway excavation and fill construction shall be conducted by the Contractor in a manner to provide a reasonably satisfactory surface for traffic. When rough grading is completed, the roadbed surface shall be brought to a smooth, even condition satisfactory for traffic.

Unless otherwise authorized, work shall be performed in only one-half the roadway at one time. One half shall be kept open and unobstructed until the opposite side is ready for use. If one-half a street only is being improved, the other half shall be conditioned and maintained as a detour.

The Contractor shall include in its Bid all costs for the above requirements.

**7-10.2 Storage of Equipment and Materials in Public Streets.** Construction materials shall not be stored in streets, roads, or highways for more than 5 days after unloading. All materials or equipment not installed or used in construction within 5 days after unloading shall be stored elsewhere by the Contractor at its expense unless authorized additional storage time.

Construction equipment shall not be stored at the Work site before its actual use on the Work nor for more than 5 days after it is no longer needed. Time necessary for repair or assembly of equipment may be authorized by the Engineer.

Excavated material, except that which is to be used as backfill in the adjacent trench, shall not be stored in public streets unless otherwise permitted. After placing backfill, all excess material shall be removed immediately from the site.

**7-10.3 Street Closures, Detours, Barricades.** The Contractor shall comply with all applicable State, County and City requirements for closure of streets. The Contractor shall provide barriers, guards, lights, signs, temporary bridges, flagpersons, and watchpersons. The Contractor shall be responsible for compliance with additional public safety requirements which may arise. The Contractor shall furnish and install signs and warning devices and promptly remove them upon completion of the Work.

At least 48 hours in advance of closing, partially closing or reopening, any street, alley, or other public thoroughfare, the Contractor shall notify the Police, Fire, Traffic and Engineering Departments, and comply with their requirements. Deviations must first be approved in writing by the Engineer.

The Contractor shall secure approval, in advance, from authorities concerned for the use of any bridges proposed by it for public use. Temporary bridges shall be clearly posted as to load limit, with signs and posting conforming to current requirements covering "signs" as set forth in the Traffic Manual published by the California Department of Transportation. This manual shall also apply to the street closures, barricades, detours, lights, and other safety devices required.

All costs involved shall be included in the Bid.

#### **7-10.4 Safety.**

**7-10.4.1. Safety Orders.** The Contractor shall have at the Work site, copies or suitable extracts of: Construction Safety Orders, Tunnel Safety Orders and General Industry Safety Orders issued by the State Division of Industrial Safety. The Contractor shall comply with provisions of these and all other applicable laws, ordinances, and regulations.

Before excavating any trench 1.5 m (5 feet) or more in depth, the Contractor shall submit a detailed plan to the Agency showing the design of shoring, bracing, sloping, or other provisions to be made for the workers' protection from the hazard of caving ground during the excavation of such trench. If the plan varies from the shoring system standards, the plan shall be prepared by a registered Civil Engineer. No excavation shall start until the Engineer has accepted the plan and the Contractor has obtained a permit from the State Division of Industrial Safety. A copy of the permit shall be submitted to the Engineer.

Payment for performing all work necessary to provide safety measures shall be included in the prices bid for other items of work except where separate bid items for excavation safety are provided, or required by law.

**7-10.4.2 Use of Explosives.** Explosives may be used only when authorized in writing by the Engineer, or as otherwise stated in the Specifications. Explosives shall be handled, used, and stored in accordance with all applicable regulations.

The Engineer's approval of the use of explosives shall not relieve the Contractor from liability for claims caused by blasting operations.

**7-10.4.3 Special Hazardous Substances and Processes.** Materials that contain hazardous substances or mixtures may be required on the Work. A Material Safety Data Sheet as described in Section 5194 of the California Code of Regulations shall be requested by the Contractor from the manufacturer of any hazardous products used.

Material usage shall be accomplished with strict adherence to California Division of Industrial Safety requirements and all manufacturer warnings and application instructions listed on the Material Safety Data Sheet and on the product container label.

The Contractor shall notify the Engineer if a specified product cannot be used under safe conditions.

#### **7-10.4.4 Confined Spaces.**

(a) **Confined Space Entry Program.** The Contractor shall be responsible for implementing, administering and maintaining a confined space entry program (CSEP) in accordance with Sections 5156, 5157 and 5158, Title 8, CCR.

Prior to starting the Work, the Contractor shall prepare and submit its comprehensive CSEP to the Engineer. The CSEP shall address all potential physical and environmental hazards and contain procedures for safe entry into confined spaces, including, but not limited to the following:

1. Training of personnel
2. Purging and cleaning the space of materials and residue
3. Potential isolation and control of energy and material inflow

4. Controlled access to the space
5. Atmospheric testing of the space
6. Ventilation of the space
7. Special hazards consideration
8. Personal protective equipment
9. Rescue plan provisions

The Contractor's submittal shall include the names of its personnel, including subcontractor personnel, assigned to the project who will have CSEP responsibilities, their CSEP training, and their specific assignment and responsibility in carrying out the CSEP.

(b) **Permit-Required Confined Spaces.** Entry into permit-required confined spaces as defined in Section 5157, Title 8, CCR may be required as a part of the Work. All manholes, tanks, vaults, pipelines, excavations, or other enclosed or partially enclosed spaces shall be considered permit-required confined spaces until the pre-entry procedures demonstrate otherwise. The Contractor shall implement a permit space program prior to performing any work in a permit-required confined space. A copy of the permit shall be available at all times for review by Contractor and Agency personnel at the Work site.

(c) **Payment.** Payment for implementing, administering, and providing all equipment and personnel to perform the CSEP shall be included in the bid items for which the CSEP is required.

**7-11 PATENT FEES OR ROYALTIES.** The Contractor shall absorb in its Bid the patent fees or royalties on any patented article or process furnished or used in the Work. The Contractor shall indemnify and hold the Agency harmless from any legal action that may be brought for infringement of patents.

**7-12 ADVERTISING.** The names, addresses and specialties of Contractors, Subcontractors, architects, or engineers may be displayed on removable signs. The size and location shall be subject to the Engineer's approval.

Commercial advertising matter shall not be attached to or painted on the surfaces of buildings, fences, canopies, or barricades.

**7-13 LAWS TO BE OBSERVED.** The Contractor shall keep fully informed of State and National laws and County and Municipal ordinances and regulations which in any manner affect those employed in the Work or the materials used in the Work or in any way affect the conduct of the Work. The Contractor shall at all times observe and comply with such laws, ordinances, and regulations.

**7-14 ANTITRUST CLAIMS.** Section 7103.5 of the Public Contract Code provides:

"In entering into a public works contract or a subcontract to supply goods, services, or materials pursuant to a public works contract, the contractor or subcontractor offers and agrees to assign to the awarding body all rights, title, and interest in and to all causes of action it may have under Section 4 of the Clayton Act (15 U.S.C. Sec 15) or Cartwright Act (Chapter 2 [commencing with Section 16700] of Part 2 of Division 7 of the Business and Professions Code), arising from purchases of goods, services, or materials pursuant to the public works contract or subcontract. The assignment shall be made and become effective at the time the awarding body tenders final payment to the contractor, without further acknowledgment by the parties."

## SECTION 8 - FACILITIES FOR AGENCY PERSONNEL

**8-1 GENERAL.** All facilities provided for Agency personnel shall be at suitable locations approved by the Engineer. Such facilities must be in a room, building, or trailer provided for this purpose with acceptable means for locking.

A Class "A" Field Office in accordance with 8-2.1 shall be provided at any offsite plant facility furnishing pipe subject to Agency inspection during manufacture. A Field Laboratory in accordance with 8-3.1 shall be provided at any offsite or project site plant facility furnishing portland cement concrete or asphalt paving material. Any other facilities for Agency personnel shall be provided only when required by the Specifications.

Offices and laboratories at plants may be used concurrently by inspection personnel of other agencies provided such use does not seriously conflict with Agency use. When facilities are shared in this manner, at least one locker provided with a hasp for a padlock must be available for the exclusive use of Agency inspectors. Otherwise any facilities furnished are for the exclusive use of Agency personnel.

All facilities shall conform to the applicable codes, ordinances, and regulations of the local jurisdiction and of the State of California, and shall conform to current practice. The interior shall be paneled or suitably lined to provide a facility of good appearance.

The Contractor shall provide janitorial and other maintenance services in all types of facilities provided. Such services shall include the supply of the appropriate paper products and dispensers. Trash receptacles shall be provided and emptied by the Contractor at weekly intervals or sooner as required. The trash shall be removed from the project site.

All costs to furnish, maintain, service, and remove the specified facilities at the project site shall be included in the price bid for such facilities. If no bid item is provided in the proposal, costs shall be included in other items for which bids are entered.

The first progress payment will not be approved until all facilities are in place and fully comply with the Specifications.

### 8-2 FIELD OFFICE FACILITIES.

**8-2.1 Class "A" Field Office.** This office shall have a minimum floor space of 16 m<sup>2</sup> (175 ft<sup>2</sup>), at least one door, and window area of not less than 2 m<sup>2</sup> (22 ft<sup>2</sup>). All doors and windows shall be provided with screens.

Furniture shall be provided as follows: one plan table, one standard 1.5 m (5 feet) long double-pedestal desk with a drawer suitable for holding files, two chairs, one drafting stool, and one plan rack.

Electric power shall be provided to include a minimum of four duplex convenience outlets. The office shall be illuminated at the tables and desk. An outdoor lighting fixture with a 300-watt bulb shall be installed.

Heating and air conditioning of sufficient capacity shall be provided at no expense to the Agency. The Contractor shall provide drinking water within the office and integral sanitary facilities directly adjoining. Sanitary facilities shall include a toilet and wash basin with hot and cold running water.

Extended area, non-coin-operated telephone service shall be provided within the office area. The installation shall include sufficient extension cord to serve the plan table and desk.

**8-2.2 Class "B" Field Office.** This office shall be the same as class "A" except that integrated sanitary facilities and air conditioning are not required. A chemical toilet facility shall be provided adjacent to the office.

**8-2.3 Class "C" Field Office.** The office shall be of suitable proportions with 11 m<sup>2</sup> (120 ft<sup>2</sup>) of floor area. It shall be equipped with one 0.9 by 1.5 m (3 by 5 foot) table, four chairs and one plan rack. It shall be adequately heated, ventilated, and lighted and two duplex convenience outlets shall be provided. Air conditioning, telephones, and sanitary facilities are not required.

### 8-3 FIELD LABORATORIES.

**8-3.1 Offsite at Manufacturing Plant.** Field laboratories shall conform to the requirements for a Class "C" Field Office specified in 8-2.3 except for the following:

1. Telephone service per 8-2.1.
2. Chair.
3. Work table, 1.2 by 3.0 m (4 by 10 feet), 0.9 m (3 feet) high.
4. Sieves per 203-6.
5. Scales and weights.
6. Burner plate for heating samples.
7. Thermometer, with 90 to 260°C (200 to 400°F) degree range (Asphalt Plants only).
8. Air meter for all concrete in accordance with ASTM C 231 of the type that indicates percentage of air directly (Precast Concrete Plants only).

All sampling and testing equipment shall be maintained in satisfactory operating condition by Contractor or plant owner. Laboratories shall be located immediately adjacent to and with full view of batching and loading operations.

**8-3.2 At Project Site.** Field laboratories shall be in accordance with 8-3.1, except that sieves, scales, weights, burner plates, sampling devices, pans, and thermometers will be furnished by the Agency at no expense to the Contractor. If air entraining agents are being used in the Concrete on the project, an air meter of the type described in 8-3.1 shall be furnished by the Contractor.

**8-4 BATHHOUSE FACILITIES.** When the Plans or Specifications require bathhouse facilities, the following shall be provided:

1. One lavatory with hot and cold water.
2. One toilet in a stall.
3. One 1 m (3 feet) trough-type urinal.
4. One enclosed shower at least 1 by 1 m (3 by 3 feet) with hot and cold water.
5. One bench, 2 m (6 feet) long.
6. Soap dispensers.
7. Toilet paper holders.
8. Paper towel cabinet.
9. Wastepaper receptacle.

These facilities shall be serviced and provided with necessary sanitary supplies.

These facilities shall be for the exclusive use of Agency personnel. However, a separate building need not be provided for this purpose if such facilities are located in a separate room in a building which includes other facilities.

**8-5 REMOVAL OF FACILITIES.** Field offices, laboratories, and bathhouse facilities at the project site shall be removed upon completion of the Work. Buildings and equipment furnished by the Contractor at the project site under the provisions of this section are the property of the Contractor.

**8-6 BASIS OF PAYMENT.** All costs incurred in furnishing, maintaining, servicing, and removing field offices laboratories, or bathhouse facilities required at the project site shall be included in the bid item for furnishing such facilities. If such facilities are required by the Plans or Specifications and no bid item is provided in the proposal, the costs shall be included in other items for which bids are entered. Such costs incurred in connection with offices and laboratories at plants shall be borne by the plant owners.

## SECTION 9 MEASUREMENT AND PAYMENT

### 9-1 MEASUREMENT OF QUANTITIES FOR UNIT PRICE WORK.

**9-1.1 General.** Unless otherwise specified, quantities of work shall be determined from measurements or dimensions in horizontal planes. However, linear quantities of pipe, piling, fencing and timber shall be considered as being the true length measured along longitudinal axis.

Unless otherwise provided in Specifications, volumetric quantities shall be the product of the mean area of vertical or horizontal sections and the intervening horizontal or vertical dimension. The planimeter shall be considered an instrument of precision adapted to measurement of all areas.

**9-1.2 Methods of Measurement.** Materials and items of work which are to be paid for on basis of measurement shall be measured in accordance with methods stipulated in the particular sections involved.

**9-1.3 Certified Weights.** When payment is to be made on the basis of weight, the weighing shall be done on certified platform scales or, when approved by the Engineer, on a completely automated weighing and recording system. The Contractor shall furnish the Engineer with duplicate licensed weighmaster's certificates showing actual net weights. The Agency will accept the certificates as evidence of weights delivered.

**9-1.4 Units of Measurement.** Measurements shall be in accordance with 1-4.1 and 1-4.2. A metric ton or "tonne" is equal to 1000 kilograms and the unit of liquid measure is a Liter (in U.S. Standard Measures, a pound is an avoirdupois pound; a ton is 2000 pounds avoirdupois; and the unit of liquid measure is a gallon).

**9-2 LUMP SUM WORK.** Items for which quantities are indicated "Lump Sum", "L.S.", or "Job", shall be paid for at the price indicated in the Bid. Such payment shall be full compensation for the items of work and all work appurtenant thereto.

When required by the Specifications or requested by the Engineer, the Contractor shall submit to the Engineer within 15 days after award of Contract, a detailed schedule in triplicate, to be used only as a basis for determining progress payments on a lump sum contract or designated lump sum bid item. This schedule shall equal the lump sum bid and shall be in such form and sufficiently detailed as to satisfy the Engineer that it correctly represents a reasonable apportionment of the lump sum.

### 9-3 PAYMENT

**9-3.1 General.** The quantities listed in the Bid schedule will not govern final payment. Payment to the Contractor will be made only for actual quantities of Contract items constructed in accordance with the Plans and Specifications. Upon completion of construction, if the actual quantities show either an increase or decrease from the quantities given in the Bid schedule, the Contract Unit Prices will prevail subject to the provisions of 3-2.2.1.

The unit and lump sum prices to be paid shall be full compensation for the items of work and all appurtenant work, including furnishing all materials, labor, equipment, tools, and incidentals.

Payment will not be made for materials wasted or disposed of in a manner not called for under the Contract. This includes rejected material not unloaded from vehicles, material rejected after it has been placed, and material placed outside of the Plan lines. No compensation will be allowed for disposing of rejected or excess material.

Payment for work performed or materials furnished under an Assessment Act Contract will be made as provided in particular proceedings or legislative act under which such contract was awarded.

Whenever any portion of the Work is performed by the Agency at the Contractor's request, the cost thereof shall be charged against the Contractor, and may be deducted from any amount due or becoming due from the Agency.

Whenever immediate action is required to prevent injury, death, or property damage, and precautions which are the Contractor's responsibility have not been taken and are not reasonably expected to be taken, the Agency

may, after reasonable attempt to notify the Contractor, cause such precautions to be taken and shall charge the cost thereof against the Contractor, or may deduct such cost from any amount due or becoming due from the Agency. Agency action or inaction under such circumstances shall not be construed as relieving the Contractor or its Surety from liability.

Payment shall not relieve the Contractor from its obligations under the Contract; nor shall such payment be construed to be acceptance of any of the Work. Payment shall not be construed as the transfer of ownership of any equipment or materials to the Agency. Responsibility of ownership shall remain with the Contractor who shall be obligated to store any fully or partially completed work or structure for which payment has been made; or replace any materials or equipment required to be provided under the Contract which may be damaged, lost, stolen or otherwise degraded in any way prior to acceptance of the Work, except as provided in 6-10.

Warranty periods shall not be affected by any payment, but shall commence on the date equipment or material is placed into service at the direction of the Agency. In the event such items are not placed into service prior to partial or final acceptance of the project, warranty periods will commence on the date of such acceptance.

If, within the time fixed by law, a properly executed notice to stop payment is filed with the Agency, due to the Contractor's failure to pay for labor or materials used in the Work, all money due for such labor or materials will be withheld from payment to the Contractor in accordance with applicable laws.

At the expiration of 35 days from the date of acceptance of the Work by the Board, or as prescribed by law, the amount deducted from the final estimate and retained by the Agency will be paid to the Contractor except such amounts as are required by law to be withheld by properly executed and filed notices to stop payment, or as may be authorized by the Contract to be further retained.

**9-3.2 Partial and Final Payment.** The Engineer will, after award of Contract, establish a closure date for the purpose of making monthly progress payments. The Contractor may request in writing that such monthly closure date be changed. The Engineer may approve such request when it is compatible with the Agency's payment procedure.

Each month, the Engineer will make an approximate measurement of the work performed to the closure date and as basis for making monthly payments, estimate its value based on Contract Unit Prices or as provided for in 9-2. When the Work has been satisfactorily completed, the Engineer will determine the quantity of work performed and prepare the final estimate.

From each progress estimate, 10 percent will be deducted and retained by the Agency, and the remainder less the amount of all previous payments will be paid. After 50 percent of the Work has been completed and if progress on the Work is satisfactory, the deduction to be made from remaining progress estimates and from the final estimate may be limited to \$500 or 10 percent of the first half of total Contract amount, whichever is greater.

No progress payment made to the Contractor or its sureties will constitute a waiver of the liquidated damages under 6-9.

As provided in Section 22300 of the California Public Contract Code, the Contractor may substitute securities for any monies withheld by the Agency to ensure performance under the Contract.

**9-3.3 Delivered Materials.** When provided for in the Specifications, and subject to the limitation and conditions therein, the cost of materials and equipment delivered but not incorporated into the Work will be included in the progress estimate.

**9-3.4 Mobilization.** When a bid item is included in the Proposal form for mobilization and subject to the conditions and limitations in the Specifications, the costs of work in advance of construction operations and not directly attributable to any specific bid item will be included in the progress estimate. When no such bid item is provided, payment for such costs will be considered to be included in the other items of work.

# PART 2

## CONSTRUCTION MATERIALS

### SECTION 200 - ROCK MATERIALS

#### 200-1 ROCK PRODUCTS

**200-1.1 General.** Rock products are defined as crushed rock, rock dust, gravel, sand, stone for riprap, or any combination thereof. All rock products shall be clean, hard, sound, durable, uniform in quality, and free of any detrimental quantity of soft, friable, thin, elongated or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

**200-1.1.1 Testing.** Sieve analysis shall be performed in accordance with California Test 202. Sand equivalent tests shall be performed in accordance with California Test 217. Unless otherwise specified, all percentages referred to in this Section 200 shall be determined by weight. All testing shall use the most current test methods.

**200-1.2 Crushed Rock and Rock Dust.** Crushed rock and rock dust shall be the product of crushing rock or gravel. The portion of the material that is retained on a 9.5 mm (3/8 inches) sieve shall contain at least 50 percent of particles having three or more fractured faces. Not over 5 percent shall be pieces that show no such faces resulting from crushing. Of that portion which passes the 9.5 mm (3/8 inches) sieve but is retained on the 4.75 mm (No. 4) sieve, not more than 10 percent shall be gravel particles. Crushed rock will be designated by nominal size and shall conform to the following gradations:

**TABLE 200-1.2 (A)**

Sieve Size	Percentage Passing Sieves		
	25.0 mm (1 in)	19.0 mm (3/4 in)	12.5 mm (1/2 in)
37.5 mm (1-1/2 in)	100	-	-
25.0 mm (1 in)	90-100	100	-
19.0 mm (3/4 in)	30-60	90-100	100
12.5 mm (1/2 in)	0-20	30-60	90-100
9.5 mm (3/8 in)	-	0-20	20-60
4.75 mm (No.4)	0-5	0-5	0-15
2.36 mm (No.8)	-	-	0-5
ASTM C 131 Test Grading	A	B	B

**TABLE 200-1.2 (A) (Continued)**

Sieve Size	9.5 mm (3/8 in)	6.3 mm (1/4 in)	4.75 mm (3/16 in)	Rock Dust
12.5 mm (1/2 in)	100	-	-	-
9.5 mm (3/8 in)	90-100	-	-	100
6.3 mm (1/4 in)	-	100	-	-
4.75 mm (No.4)	30-60	75-100	100	90-100
2.36 mm (No.8)	0-10	0-25	40-75	-
1.18 mm (No.16)	-	0-5	0-10	-
600 μm (No.30)	-	-	-	20-60
75 μm (No.200)	-	0-2	0-2	5-20
ASTM C 131 Test Grading	C	D	D	-

Crushed rock shall meet the following requirements:

**TABLE 200-1.2 (B)**

Test	Test Method No.	Requirements in percent
Percentage Wear	ASTM C 131	
100 Revolutions		15 Max.
500 Revolutions		52 Max.

**200-1.2.1 Screenings.** Screenings when used as a cover aggregate for asphalt emulsion chip seals in accordance with 302-2.5, shall be composed of crushed rock and will be designated by the name of the size of screenings and shall conform to the following gradations in Table 200-1.2.1 (A):

All screenings in 200-1.2.1 and 600-2.6.1 shall meet the following requirements:

**TABLE 200-1.2.1 (A)**

Sieve Size	Percentage Passing Sieve			
	Coarse 12.5 x 4.75 mm (1/2 in x No.4)	Medium 9.5 x 3.35 mm (3/8 in x No.6)	Medium Fine 8.0 x 2.36 mm (5/16 in x No.8)	Fine 6.3 x 2.00 mm (1/4 in x No.10)
19.0 mm (3/4 in)	100			
12.5 mm (1/2 in)	90-100	100	-	-
9.5 mm (3/8 in)	50-80	90-100	100	100
4.75 mm (No.4)	0-15	5-30	30-60	60-85
2.36 mm (No.8)	0-5	0-10	0-15	0-25
1.18 mm (No.16)	-	0-5	0-5	0-5
600 µm (No.30)	-	-	0-3	0-3
75 µm (No.200)	0-2	0-2	0-2	0-2

**TABLE 200-1.2.1 (B)**

Tests	Test Method No.	Requirements
Percentage Wear (100 revolutions)	ASTM C 131	12 Maximum
Percentage Wear (500 revolutions)	ASTM C 131	35 Maximum
Film Stripping	California 302	25 Maximum
Cleanness Value	California 227	80 Maximum
California Durability	California 229	52 Maximum

**200-1.3 Gravel.** Gravel shall be composed entirely of particles that have no more than one fractured face.

**200-1.4 Coarse Aggregate for Portland Cement Concrete.** Concrete aggregate shall be composed of gravel, crushed rock, or a blended mixture. All concrete aggregate shall be washed before delivery to the batching plant and shall conform to the following:

**TABLE 200-1.4 (A)**

Tests	Tests Method No.	Requirements
Cleanness Value	California 227	75 Minimum
Percentage Wear	ASTM 131	
100 revolutions		15 Maximum
500 revolutions		52 Maximum
Specific Gravity (Bulk saturated surface dry)	ASTM C 127	2.58 Minimum <sup>1</sup>

1. Not more than 15 percent by weight shall be particles with a bulk specific gravity below 2.50.

Concrete aggregate will be designated by number and shall conform to the following gradations:

TABLE 200-1.4 (B)

Sieve Size	Percentage Passing Sieve		
	No. 2	No. 3	No.4
50 mm (2 in)	100	-	-
37.5 mm (1-1/2 in)	90-100	100	-
25.0 mm (1 in)	5-40	90-100	-
19.0 mm (3/4 in)	0-15	55-85	100
9.5 mm (3/8 in)	0-5	8-20	85-100
4.75 mm (No.4)	-	0-5	0-30
2.36 mm (No. 8)	-	0-5	0-10
75 µm (No. 200)	0-2	0-2	0-2
ASTM C 131 Test Grading	A	B	C

### 200-1.5 Sand.

**200-1.5.1 General.** Sand shall consist of natural or manufactured granular material, or a combination thereof, free of deleterious amounts of organic material, mica, loam, clay, and other substances not suitable for the purpose intended.

**200-1.5.2 Sand for Asphalt Concrete.** The sand shall conform to the gradation specified for asphalt concrete in 200-1.5.5.

**200-1.5.3 Sand for Portland Cement Concrete.** Sand for portland cement concrete shall be washed and shall conform to the gradation specified for portland cement concrete in 200-1.5.5 and the following quality requirements:

TABLE 200-1.5.3 (A)

Tests	Test Method No.	Requirements in percent
Organic Impurities	ASTM C 40	Satisfactory <sup>1</sup>
Mortar Strength Relative to Ottawa Sand	California 515	100 Minimum
Sand Equivalent		
Individual Test Result	California 217	70 Minimum
Average of Tests on 3 samples		75 Minimum
Percent Clay, Silt, Loam	ASTM C 117	3 Maximum
Soundness <sup>2</sup>	California 214	10 Maximum

1. The resultant color of the testing solution shall not be darker than the ASTM C 40 standard.

2. The soundness requirement will be waived, provided that the durability index, Df, is 60 or greater, when determined by California Test 229.

**200-1.5.4 Sand For Air-Placed Concrete.** Sand for air-placed concrete shall be washed and conform to the gradation for portland cement concrete in 200-1.5.5. The amount of deleterious substances shall not exceed the limits prescribed in ASTM C 33.

**200-1.5.5 Sand Gradations.** The sand shall conform to the following gradations:

**TABLE 200-1.5.5 (A)**

Sieve Size	Percentage Passing Sieve		
	Asphalt Concrete	Portland Cement Concrete	Mortar
9.5 mm (3/8 in)	100	100	-
4.75 mm (No.4)	-	95-100	100
2.36 mm (No.8)	75-100	75-90	95-100
1.18 mm (No.16)	-	55-75	70-95
600 µm (No.30)	-	30-50	35-70
300 µm (No.50)	-	10-25	5-35
150 µm (No.100)	-	2-10	0-10
75 µm (No. 200)	0-8 <sup>1</sup>	0-5	0-5

1. May be exceeded to permit a maximum of 12 percent, provided the sand equivalent of the asphalt concrete sand is 35 or greater.

### 200-1.6 Stone for Riprap.

**200-1.6.1 General.** Stone for riprap shall be quarystone or cobblestone. Quarystone shall be angular and cobblestone shall be rounded. Stone shall be of such shape as to form a stable protection structure of the required section. Cobblestone shall not be used on slopes steeper than 1 vertical to 2 horizontal. Flat or elongated shapes will not be accepted unless the thickness of the individual pieces is at least one-third of the length.

Unless otherwise designated, for application greater than 180 tonnes (200 tons), design parameters including filter, foundation, and gradation with supporting calculations by a registered Civil Engineer, shall be submitted to the Engineer for approval.

Stone shall be sound, durable, hard, resistant to abrasion and free from laminations, weak cleavage planes, and the undesirable effects of weathering. It shall be of such character that it will not disintegrate from the action of air, water, or the conditions to be met in handling and placing. All material shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings.

**200-1.6.2 Grading Requirements.** Stone for riprap shall be designated by class and conform to the following gradations:

**TABLE 200-1.6 (A)**

Rock Size	Percentage Larger Than			
	225 kg (500 lb) Class	170 kg (375 lb) Class	90 kg (Light) Class	35 kg (Facing) Class
450 kg (1000 lb)	0-5	-	-	-
320 kg (700 lb)	-	0-10	-	-
225 kg (500 lb)	50-100	10-50	0-5	-
90 kg (200 lb)	-	85-100	50-100	0-5
35 kg (75 lb)	90-100	95-100	90-100	50-100
10 kg (25 lb)	95-100	-	95-100	90-100
1 kg (2.2 lb)	-	-	-	95-100

**Note:** The amount of material smaller than the smallest size shown in the table for any class shall not exceed the percentage limit as determined on a weight basis. Compliance with the percentage limits shown in the table for all other sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified size compared to the total number of individual pieces larger than the smallest size listed in the table for that class.

**200-1.6.3 Quality Requirements.** Visual evaluation of the quarry, including examination of blast samples and diamond drill core samples, suitable tests and service records may be used to determine the acceptability of the stone. The Contractor shall notify the Agency in writing of the intended source of stone at least 60 days prior to use. To ensure the required quality, stone may be subject to petrographic analysis or X-ray diffraction.

The material shall conform to the following requirements:

**TABLE 200-1.6 (B)**

Tests	Test Method No.	Requirements in percent
Apparent Specific Gravity	ASTM C 127	2.50 Minimum
Absorption <sup>1</sup>	California 206	4.20 Maximum
Durability <sup>1</sup>	California 229	52 Minimum
Percentage Wear	ASTM C 131	45 Maximum

1. Based on the formula below, absorption may exceed 4.2 percent if the Durability Absorption Ratio (DAR) is greater than 10. Durability may be less than 52 if DAR is greater than 24.

$$\text{DAR} = \frac{\text{Coarse Durability Index}}{\% \text{ Absorption} + 1}$$

## 200-2 UNTREATED BASE MATERIALS

**200-2.1 General.** Materials for use as untreated base or subbase shall be classified in the order of preference as follows:

- Crushed Aggregate Base
- Crushed Miscellaneous Base
- Processed Miscellaneous Base
- Select Subbase

When base material without further qualification is specified, the Contractor shall supply crushed aggregate base. When a particular classification of base material is specified, the Contractor may substitute any higher classification, following the order of preference listed above, of base material for that specified. All processing or blending of materials to meet the grading requirement will be performed at the plant or source. The materials shall compact to a hard, firm, unyielding surface and shall remain stable when saturated with water.

### 200-2.2 Crushed Aggregate Base.

**200-2.2.1 General.** Crushed aggregate base shall consist entirely of crushed rock and rock dust conforming to the requirements of 200-1.1 and 200-1.2.

**200-2.2.2 Grading.** The aggregate shall be uniformly graded and shall conform to the following gradation:

**TABLE 200-2.2.2**

Sieve	Percentage Passing Sieve
37.5 mm (1-1/2 in)	100
19.0 mm (3/4 in)	90-100
9.5 mm (3/8 in)	50-80
4.75 mm (No.4)	35-55
600 μm (No.30)	10-30
75 μm (No.200)	2-9
ASTM C 131 Test Grading	B

**200-2.3 (Not Used)****200-2.4 Crushed Miscellaneous Base.**

**200-2.4.1 General.** Crushed miscellaneous base shall consist of broken and crushed asphalt concrete or portland cement concrete and may contain crushed aggregate base or other rock materials. The material shall be free of any detrimental quantity of deleterious material as defined in 200-1.1. Material retained on the 4.75 mm (No. 4) sieve shall contain no more than 15 percent gravel particles as defined in 200-1.3. The material may contain no more than 3 percent brick by weight as determined by California test method 202 as modified: Brick material retained on a 4.75 mm (No. 4) sieve shall be identified visually and separated manually. Brick quantification shall be based on total weight of dry sample.

**200-2.4.2 Grading.** The material shall be uniformly graded and shall conform to one of the following gradations:

**TABLE 200-2.4.2 (A)**

Sieve Size	Percentage Passing Sieve	
	Coarse	Fine
50.0 mm (2 in)	100	
37.5 mm (1-1/2 in)	85-100	100
19.0 mm (3/4 in)	50-85	85-100
9.5 mm (3/8 in)		55-75
4.75 mm (No.4)	25-45	35-60
600 μm (No.30)	10-25	10-30
75 μm (No.200)	2-9	2-9
ASTM C 131 Test Grading	A	B

When there is a difference in specific gravity (bulk saturated surface dry per ASTM C 127) of 0.2 or more between that portion retained and that portion passing a 4.75 mm (No. 4) sieve, the grading will be modified by California Test 105.

**200-2.4.3 Quality Requirements.** This material shall conform to the following:

**TABLE 200-2.4.3 (A)**

Tests	Test Method No.	Requirements
R-value <sup>1</sup>	California 301	78 Minimum
Sand Equivalent	California 217	35 Minimum
Percentage Wear	ASTM C 131	
100 revolutions		15 Maximum
500 revolutions		52 Maximum

1. The R-value requirement may be waived, provided the material has an SE of 40 or more.

The Engineer may waive the percentage wear requirements, provided the material has a minimum durability of 40 in accordance with California Test 229.

**200-2.5 Processed Miscellaneous Base.**

**200-2.5.1 General.** Processed miscellaneous base shall consist of broken or crushed asphalt concrete, portland cement concrete, railroad ballast, glass, crushed porcelain material, crushed rock, rock dust, or natural material. The material that is retained on a 4.75 mm (No. 4) sieve shall contain no more than 75 percent gravel particles as defined in 200-1.3. The material shall be free of any detrimental quantity of deleterious material as defined in 200-1.1. The material may contain no more than 3 percent brick by weight as determined by California Test 202 as modified: Brick material retained on a 4.75mm

(No. 4) sieve shall be identified visually and separated manually. Brick quantification shall be based on total weight of dry sample.

**200-2.5.2 Grading.** The material shall be uniformly graded and shall conform to 200-2.4.2 Grading.

**200-2.5.3 Quality Requirements.** This material shall conform to the following in Table 200-2.4.3 (A):

The Engineer may waive the percentage wear requirements, provided the material has a minimum durability of 35 in accordance with California Test 229.

**200-2.6 Select Subbase.**

**200-2.6.1 General.** Select subbase shall consist of soil, mineral aggregates, asphalt concrete, portland cement concrete, or blends of these.

**200-2.6.2 Grading.** The material shall be uniformly graded and shall conform to one of the following gradations:

**TABLE 200-2.6.2 (A)**

Sieve Size	Percentage Passing Sieve	
	Coarse	Fine
37.5 mm (1-1/2 in)	100	-
25.0 mm (1 in)	-	100
4.75 mm (No.4)	55-75	70-100
1.18 mm (No.16)	30-75	40-90
300 $\mu$ m (No.50)	15-40	20-60
75 $\mu$ m (No.200)	0-25	0-30

**200-2.6.3 Quality Requirements.** The material shall also conform to the following requirements:

**TABLE 200-2.6.3 (A)**

Tests	Test Method No.	Requirements
R-value <sup>1</sup>	California 301	60 Minimum
Sand Equivalent	California 217	20 Minimum

1. The R-value requirement may be waived, provided the material has an SE of 30 or more.

**200-2.7 Disintegrated Granite.**

**200-2.7.1 General.** Disintegrated granite shall be free from vegetable matter and other deleterious substances and shall be of such nature that it can be compacted readily under water and rolling to form a firm, stable base.

Disintegrated granite shall be any igneous rock, which has been weathered in place, or any sedimentary material principally derived from igneous rock.

**200-2.7.2 Grading.** The percentage composition by weight shall conform to Table 200-2.7.2(A).

**TABLE 200-2.7.2 (A)**

Sieve Size	Percent Passing
37.5 mm (1-1/2 in.)	100
25.0 mm (1 in.)	90-100
4.75 mm (No. 4)	50-100
600 $\mu$ m (No. 30)	25-55
75 $\mu$ m (No. 200)	5-18

**200-2.7.3 Quality Requirements.** Disintegrated granite shall also conform to Table 200-2.7.3 (A).

**TABLE 200-2.7.3 (A)**

Test	California Test	Requirements
R-value	California 301	73 Min.
Sand Equivalent	California 217	30 Min.

### 200-2.8 Pulverized Miscellaneous Base

**200-2.8.1 General.** Pulverized miscellaneous base shall consist of asphalt concrete or Portland cement concrete pavement that has been pulverized in place to the dimensions shown on the Plans. Pulverized miscellaneous base may contain underlying base material or subgrade soil. The material shall be free of any detrimental quantity of deleterious material as specified in 200-1.1.

Pulverized miscellaneous base, if produced in place, shall only be produced through the operation of a machine specifically designed for pulverizing, stabilizing and blending of this material. Pulverized miscellaneous base shall not be produced by the operation of self-propelled drop hammers ("stompers"), breakers, steel padded rollers, or by ripping or excavation equipment.

**200-2.8.2 Testing.** The Agency will collect samples of the pulverized material in conformance with California Test 125. The Agency will perform a minimum of one gradation and one sand equivalent test per 500 cubic yards of material pulverized. The Contractor shall allow the Agency a minimum of 48 hours to complete each test and inform the Contractor of the results.

**200-2.8.3 Grading.** The material shall be uniformly graded and shall conform to Table 200-2.8.2 (A):

**TABLE 200-2.8.2 (A)**

Sieve Size	Percentage Passing Sieves
50 mm (2.0")	100
25 mm (1.0")	-
19 mm (3/4")	85-100
9.5 mm (3/8")	55-80
4.75 mm (No. 4)	35-60
600 um (No. 30)	10-30
75 um (No. 200)	2-9
ASTM C 131 Grading	B

If, after testing by the Agency, the pulverized material does not conform to the gradation specified in Table 200-2.8.2 (A), a maximum of 35 percent rock products conforming to 200-1 may be blended into the pulverized material to correct the gradation. The Contractor shall determine the amount of rock products to be blended. The rock products shall be uniformly spread and blended over the area requiring correction of the gradation. The equipment used for blending shall conform to 200-2.8.1. The rock products shall be supplied, and blended at no additional cost to the Agency. The Agency will retest the corrected area in conformance with 200-2.8.2.

When there is a difference in specific gravity (bulk saturated surface dry conforming to ASTM C 127) of 0.2 or more between that portion retained and that portion passing a No. 4 sieve, a modified grading will be required. The grading will be modified in accordance with California Test 105. The Agency will provide the Contractor with the modified grading required.

**200-2.8.4 Quality Requirements.** This material shall conform to the following:

**TABLE 200-2.8.3 (A)**

Tests	Test Method No.	Requirements
Sand Equivalent	California Test 217	40 Minimum
Percentage Wear	ASTM C 131	
100 Rev		15 Maximum <sup>1</sup>
500 Rev		52 Maximum <sup>1</sup>
R-Value	California Test 301	78 Minimum <sup>2</sup>

(1) The Engineer may waive the percentage wear requirements, provided the material has a minimum durability of 40 in accordance with California Test 229.

(2) The R-Value may be waived if the SE is 45 or greater.

## SECTION 201 - CONCRETE, MORTAR, AND RELATED MATERIALS

### 201-1 PORTLAND CEMENT CONCRETE.

#### 201-1.1 Requirements.

**201-1.1.1 General.** Concrete shall consist of portland cement, concrete aggregates, water, and when required or approved for use, admixture and/or fly ash and/or reclaimed concrete material in accordance with these provisions. Concrete will be specified by class, by alternate class, by special exposure, or by compressive strength. When concrete is specified by class, alternate class, or special exposure, a mix design shall be submitted to the Engineer for approval. The mix design shall show the aggregate, water, and where applicable, fly ash, admixtures, and reclaimed concrete material. The mix design submittal shall also include the size and source of aggregate, the type and source of portland cement and fly ash, the brand and designation of admixtures, slump requirement, and the type of construction for which the concrete is to be used.

Concrete specified by compressive strength shall be designed by the Contractor in accordance with 201-1.1.4.

Approved admixtures shall be used in accordance with 201-1.2.4 and 201-1.2.5 and at the manufacturer's recommended dosage rate. Additional portland cement or cementitious material is permitted to obtain high early strength in concrete, except that the total amount of portland cement shall not exceed 415 kg per m<sup>3</sup> (700 lbs. per yd<sup>3</sup>) unless approved by the Engineer.

Reclaimed concrete material may be incorporated into concrete mixtures when approved by the Engineer in accordance with section 201-1.2.6.

**201-1.1.2 Concrete Specified by Class and Alternate Class.** When specified by class the concrete will be designated by a number, one or two letters, and a number. The first number is the weight of portland cement conforming to 201-1.2.1 in kg per m<sup>3</sup> (lb. per yd<sup>3</sup>), the first letter is the combined aggregate gradation conforming to 201-1.3.2, and the second letter (W) designates the required use of a water reducing admixture conforming to 201-1.2.4. The last number is the minimum compressive strength at 28 days in MPa (psi). A water reducing admixture conforming to 201-1.2.4 may be used in any concrete specified by class and is required in all 28 Mpa (4000 psi) compressive strength concrete specified by class.

When specified by alternate class the concrete will be designated by a number, three letters, and a number. The first number is the weight of cementitious material in kg per m<sup>3</sup> (lb. per yd<sup>3</sup>) which consists of 85% portland cement conforming to 201-1.2.1 and 15% fly ash by weight. The first letter is the combined aggregate gradation, conforming to 201-1.3.2, the second letter (F) designates the required use of fly ash conforming to 201-1.2.5, and the third letter (W) designates the required use of a water reducing admixture conforming to 201-1.2.4. The last number is the minimum compressive strength at 28 days in MPa (psi).

The concrete class, alternate class, and maximum slump for the various types of construction shall be as designated in Table 201-1.1.2(A).

TABLE 201-1.1.2 (A)

Type of Construction	Concrete Class <sup>7</sup> Metric Units (U.S. Standard Measures)	Alternate Class Metric Units (U.S. Standard Measures)	Maximum Slump Millimeters (Inches)
<b>Street Surface Improvements</b>			
Concrete Pavement (not integral with curb)	310-A-17 (520-A-2500)	295-AFW-17 (494-AFW-2500)	75 (3)
Curb, Integral Curb and Pavement, Gutter, Walk, Alley Aprons	310-C-17 (520-C-2500)	295-CFW-17 (494-CFW-2500)	100 (4)
	310-C-17P <sup>1</sup> (520-C-2500P <sup>1</sup> )	295-CFW-17P <sup>1</sup> (494-CFW-2500P <sup>1</sup> )	100 (4)
	310-D-17 (520-D-2500)	295-DFW-17 (494-DFW-2500)	50 (2)
Extruded Curb, Curb and Gutter	310-C-17 (520-C-2500)	295-CFW-17 (494-CFW-2500)	50 (2)
<b>Sewer<sup>2</sup> &amp; Storm Drainage Facilities</b>			
Pipe Collars, Beam Support for Pipe, Pre-Cast Manhole Components, Catch Basins, Sidewalk Culverts	330-C-23 <sup>3</sup> (560-C-3250 <sup>3</sup> )	315-CFW-23 <sup>3</sup> (532-CFW-3250 <sup>3</sup> )	125 (5)
	335-C-23P <sup>1</sup> (565-C-3250P <sup>1</sup> )	320-CFW-23P <sup>1</sup> (537-CFW-3250P <sup>1</sup> )	100 (4)
	295-C-17 (500-C-2500)	280-CFW-17 (475-CFW-2500)	75 (3)
Sidehill Surface Drainage Facilities	310-C-17P <sup>1</sup> (520-C-2500P <sup>1</sup> )	295-CFW-17P <sup>1</sup> (494-CFW-2500P <sup>1</sup> )	100 (4)
	330-E-17P <sup>1</sup> (560-E-2000P <sup>1</sup> )	315-EFW-17P <sup>1</sup> (532-EFW-2000P <sup>1</sup> )	100 (4)
	265-C-14 <sup>3</sup> (450-C-2000 <sup>3</sup> )		100 (4)
	335-E-14P <sup>1</sup> (565-E-2000P <sup>1</sup> )	320-EFW-14P <sup>1</sup> (537-EFW-2000P <sup>1</sup> )	150 (6)
Pipe Bedding and Encasement Anchors and Thrust Blocks, Wall Support for Pipe <sup>4</sup>	285-C-14 (480-C-2000)		125 (5)
Tunnel Backfill <sup>5</sup>	290-C-14P <sup>1</sup> (490-C-2000P <sup>1</sup> )		125 (5)
	60-E-0.7 (100-E-100)		125 (5)
Trench Backfill Slurry <sup>5</sup>			125 (5)
<b>Reinforced Structures</b>			
Bridges, Buildings, Retaining Walls and Tunnels	330-C-23 <sup>3</sup> (560-C-3250 <sup>3</sup> )	315-CFW-23 <sup>3</sup> (532-CFW-3250 <sup>3</sup> )	100 (4)
	335-C-23P <sup>1</sup> (565-C-3250P <sup>1</sup> )	320-CFW-23P <sup>1</sup> (537-CFW-3250P <sup>1</sup> )	100 (4)
	385-CW-28 <sup>7</sup> (650-CW-4000 <sup>7</sup> )	370-CFW-28 (618-CFW-4000)	100 (4)
	390-CW-28P <sup>1,7</sup> (660-CW-4000P <sup>1,7</sup> )	370-CFW-28P <sup>1</sup> (618-CFW-4000P <sup>1</sup> )	100 (4)
	330-C-23 <sup>3</sup> (560-C-3250 <sup>3</sup> )	315-CFW-23 <sup>3</sup> (532-CFW-3250 <sup>3</sup> )	100 (4)
	335-C-23P <sup>1</sup> (565-C-3250P <sup>1</sup> )	320-CFW-23P <sup>1</sup> (537-CFW-3250P <sup>1</sup> )	100 (4)
	330-B-23 (560-B-3250)	315-BFW-23 (532-BFW-3250)	100 (4)
Channels and Boxes, Inverts	335-B-23P <sup>1</sup> (565-B-3250P <sup>1</sup> )	320-BFW-23P <sup>1</sup> (537-BFW-23P <sup>1</sup> )	100 (4)
	385-BW-28 <sup>7</sup> (650-BW-4000 <sup>7</sup> )	370-BFW-28 (618-BFW-4000)	100 (4)
	390-CW-28P <sup>1,7</sup> (660-CW-4000P <sup>1,7</sup> )	375-CFW-28P <sup>1</sup> (627-CFW-4000P <sup>1</sup> )	100 (4)
	330-C-23 (560-C-3250)	315-CFW-23 (532-CFW-3250)	125 (5)
	335-C-23P <sup>1</sup> (565-C-3250P <sup>1</sup> )	320-CFW-23P <sup>1</sup> (537-CFW-3250P <sup>1</sup> )	125 (5)
	385-CW-28 <sup>7</sup> (650-CW-4000 <sup>7</sup> )	370-CFW-28 (618-CFW-4000)	100 (4)
	390-CW-28P <sup>1,7</sup> (660-CW-4000P <sup>1,7</sup> )	375-CFW-28P <sup>1</sup> (627-CFW-4000P <sup>1</sup> )	100 (4)
Walls and Deck	330-C-23 (560-C-3250)	315-CFW-23 (532-CFW-3250)	125 (5)
	335-C-23P <sup>1</sup> (565-C-3250P <sup>1</sup> )	320-CFW-23P <sup>1</sup> (537-CFW-3250P <sup>1</sup> )	125 (5)
	385-CW-28 <sup>7</sup> (650-CW-4000 <sup>7</sup> )	370-CFW-28 (618-CFW-4000)	100 (4)
	390-CW-28P <sup>1,7</sup> (660-CW-4000P <sup>1,7</sup> )	375-CFW-28P <sup>1</sup> (627-CFW-4000P <sup>1</sup> )	100 (4)

**TABLE 201-1.1.2 (A) Continued**

Type of Construction	Concrete Class <sup>7</sup> Metric Units (U.S. Standard Measures)	Alternate Class Metric Units (U.S. Standard Measures)	Maximum Slump Millimeters (Inches)
<b>Miscellaneous</b>			
Street Light and Traffic Signal Foundations, Survey Monuments	330-C-23 (560-C-3250)	315-CFW-23 (532-CFW-3250)	100 (4)
Fence and Guardrail Post Foundations	295-C-17 (500-C-2500)	280-CFW-17 (475-CFW-2500)	125 (5)
Concrete Not Otherwise Specified	330-C-23 (560-C-3250)	315-CFW-23 (532-CFW-3250)	125 (5)
	335-C-23P <sup>1</sup> (565-C-3250P <sup>1</sup> )	320-CFW-23P <sup>1</sup> (537-CFW-3250P <sup>1</sup> )	100 (4)
	385-D-23P <sup>1</sup> (650-D-3250P <sup>1</sup> )	370-DFW-23P <sup>1</sup> (618-DFW-3250P <sup>1</sup> )	100 (4)
	385-E-23P <sup>1</sup> (650-E-3250P <sup>1</sup> )	370-EFW-23P <sup>1</sup> (618-EFW-3250P <sup>1</sup> )	100 (4)
Air Placed Concrete Method B (E gradation only)	385-D-23P <sup>1</sup> (650-D-3250P <sup>1</sup> ) 385-E-23P <sup>1</sup> (650-E-3250P <sup>1</sup> )	370-DFW-23P <sup>1</sup> (618-DFW-3250P <sup>1</sup> ) 370-EFW-23P <sup>1</sup> (618-EFW-3250P <sup>1</sup> )	100 (4) 100 (4)
Coarse Masonry Grout	360-E-14G <sup>6</sup> (610-E-2000G <sup>6</sup> )	345-EFW-14G <sup>6</sup> (580-EFW-2000G <sup>6</sup> )	250 (10)

- Concrete mixes followed by a "P" have been designed to accommodate placement by a concrete pump. A pump mix may be substituted for a similar class or alternate class mix and placed utilizing standard placement methods by the Contractor at its option. Said substitution, if made, shall be at the Contractor's expense.
- The Engineer should consider sulfide resistance of mix prior to use in sewers or appurtenant structures.
- Use B Aggregate gradation when placing conditions permit.
- Use limited to bedding concrete over which backfill will be placed not less than 40 hours after placement. For backfill after 24 hours, add 31 milliliters per kilogram of cement (3 pints per 100 pounds of cement) of calcium chloride. For backfill after 16 hours and removal of sheeting after 18 hours, use 390-C-26 (660-C-3750) with 31 milliliters per kilogram of cement (3 pints per 100 pounds of cement) calcium chloride solution.
- Controlled Low Strength Material (CLSM) conforming to Section 201-6 may be used when approved by the Engineer, except the maximum slump requirement in the table does not apply.
- Concrete mixes followed by a "G" have been designed to accommodate the grout requirements of Section 202, Masonry Materials.
- A water reducing admixture conforming to 201-1.2.4 may be used in any concrete specified by class and is required in all 28 Mpa (4000 psi) compressive strength concrete specified by class.

**201-1.1.3 Concrete Specified by Special Exposure.** When specified by exposure the concrete shall be designated by a number, followed by three letters, and a number. The first number is the minimum weight of cementitious material in kg per m<sup>3</sup> (lb. Per yd<sup>3</sup>) as prescribed in Table 201-1.1.3 (A). The first letter is the combined aggregate gradation per 201-1.3.2. The second and third letters (LE, ME, or SE) designates the level of exposure (Low Exposure, Moderate Exposure or Severe Exposure). The last number is the minimum compressive strength at 28 days in MPa (psi).

Special Exposure mixes should be proportioned in accordance with ACI 318, Chapter 4, Durability Requirements. Air entraining admixtures may be incorporated into the concrete mix at manufacturer's suggested rates to produce a 4% ± 1% air content in the concrete mix to help reduce permeability. Admixtures containing calcium chloride are prohibited for use in concrete exposed to sulfates. The Engineer shall identify the exposure condition and presence of chemicals that the concrete may contact during its performance life. These include sulfates in soils, chloride ions, sewage, and other corrosive materials. The Engineer must then specify the method and level of protection for the concrete. Special Exposure mixtures of greater severity may be substituted for a mixture of lesser severity.

All Special Exposure Concrete shall contain fly ash conforming to 201-1.2.5 and a water-reducing admixture conforming to 201-1.2.4, and shall comply with water-cementitious ratio per Table 201-1.1.3(A).

TABLE NO. 201-1.1.3 (A)

Special Exposure Mixes	Maximum Water – Cementitious Ratio <sup>2</sup>	Special Exposure Metric Units (U.S. Standard Measures)	Cementitious Material Requirement
LOW EXPOSURE – (% water soluble SO <sub>4</sub> in soil samples 0.10 to 0.20) (Sulfate SO <sub>4</sub> in water samples, PPM – 150 to 1500)	0.50	370-BLE-28P <sup>1</sup> (618-BLE-4000P <sup>1</sup> ) 370-CLE-28P <sup>1</sup> (618-CLE-4000P <sup>1</sup> ) 440-DLE-28P <sup>1</sup> (740-DLE-4000P <sup>1</sup> )	80% Type II or V portland cement with 20% Class F fly ash.
MODERATE EXPOSURE – (% water soluble SO <sub>4</sub> in soil sample 0.20 to 2.00) (Sulfate SO <sub>4</sub> in water samples, PPM – 1500 to 10,000)	0.45	390-BME- P <sup>1</sup> (658-BME-4500P <sup>1</sup> ) 390-CME-31P <sup>1</sup> (658-CME-4500P <sup>1</sup> ) 480-DME-31P <sup>1</sup> (815-DME-4500P <sup>1</sup> )	80% Type II or V portland cement with 20% Class F fly ash.
SEVER EXPOSURE – (% water soluble SO <sub>4</sub> in soil sample 2.00 or more) (Sulfate SO <sub>4</sub> in water samples, PPM – 10,000 or more)	0.40	450-BSE-35P <sup>1</sup> (750-BSE-5000P <sup>1</sup> ) 450-CSE-35P <sup>1</sup> (750-BSE-5000P <sup>1</sup> ) 520-DSE-35P <sup>1</sup> (875-DSE-5000P <sup>1</sup> )	80% Type V portland cement with 20% Class F fly ash.

1. Concrete mixes followed by a "P" have been designated to accommodate placement by a concrete pump.
2. Maximum slump is determined by placement conditions so long as water-cementitious ratio is not exceeded.

**201-1.1.4 Concrete Specified by Compressive Strength.** The Contractor shall determine the mix proportions of concrete specified on the Plans by its 28-day compressive strength within the minimum cement, maximum size coarse aggregate, and admixture limitations designed herein or in the Specifications. The concrete shall contain not less than 330 kg of cement or cement and fly ash per m<sup>3</sup> (560 pounds of cement or cement and fly ash per cubic yard), in accordance with 201-1.2.5, for concrete strengths of 23 MPa (3,250 psi) or greater. The Contractor may submit mix designs specified by compressive strength in excess of 28 days with the approval of the Engineer. Submittals designated by compressive strength in excess of 28 days are not subject to the fly ash limitations of 201-1.2.5.

Calcium chloride may be used only with the approval of the Engineer. Admixtures proposed for use shall be evaluated in accordance with 201-1.2.4.

The proposed mix design shall be evaluated from tests of a field trial batch conforming to the size of load, materials, proportions, slump, mixing and placing equipment, and procedures to be used in the actual work or, with the approval of the Engineer, tests of a laboratory trial batch conforming to the materials, proportions, and slump to be used in the actual work. The trial batch procedure may be waived when test data of prior performance of the proposed mix design is presented by the Contractor and approved by the Engineer. The Contractor may utilize any strength data on file with the Agency for this purpose.

When approved by the Engineer, field trial batches may be placed in the Work at designated locations where concrete of a lower quality is specified. Concrete so placed will be considered for purpose of payment to be the type of concrete specified at that location.

Ten test cylinders shall be molded from the trial batch containing the maximum water content indicated by the mix design. Five of the cylinders shall be tested at 7 days in order to establish 7-day average compressive strength information, and the remaining five cylinders shall be tested at no more than 28 days after molding. The average compressive strength of the five 28 day cylinders for field trial tests shall be at

least 4 MPa (600 psi) greater than the specified strength. The average compressive strength of the five 28 day cylinders for laboratory trial batch tests shall be at least 7 Mpa (1000 psi) greater than the specified strength for specified strengths less than 21 Mpa (3000 psi), 8 Mpa (1200 psi) greater than the specified strength for specified strengths between 21 Mpa and 36 Mpa (3000 psi and 5000 psi), and 10 Mpa (1400 psi) greater than the specified strength for specified strengths greater than 36 Mpa (5000 psi). The minimum strength of any one cylinder shall not be less than the specified strength.

The placing of concrete specified by compressive strength shall not begin until the mix design has qualified in accordance with the aforesaid test criteria. Should the source of materials or established procedures change, new trial batches may be required.

**201-1.1.5 Test for Portland Cement Concrete.** Portland cement concrete shall be sampled and tested in accordance with the following ASTM and California Tests:

- 1) Sampling Fresh Concrete ..... C 172
- 2) Obtaining Drilled Cores ..... C 42
- 3) Molding and Curing Specimens..... C 31
- 4) Compressive Strength ..... C 39
- 5) Flexural Strength..... C 78
- 6) Slump ..... C 143
- 7) Air Content ..... C 173 or C 231
- 8) Unit Weight Yield..... C 138
- 9) Setting of Mortar..... C 191 or C 266
- 10) Mortar Cube Test..... California Test 515
- 11) Drying Shrinkage (with admixture) ..... California Test 530

A compressive strength test shall consist of the average strength of two cylinders fabricated from a single load of concrete, except that if any cylinder shows evidence of improper handling, molding, or testing, it shall be discarded and the strength test shall consist of the strength of the remaining cylinder.

The Engineer will determine the frequency of sampling. The Contractor shall afford the Engineer all reasonable access, without charge, for the procurement of samples of fresh concrete at time of placement.

Concrete compressive strength tests representing concrete that has been placed shall attain the following 28-day strength: The average of any three consecutive strength tests shall be equal to or greater than the specified 28-day strength. Not more than 10 percent of the tests shall be less than the specified 28-day strength. No test shall be less than 85 percent of the specified 28-day strength.

Concrete represented by compressive strength tests that fail to meet the requirements of this subsection shall be removed from the Work. However, with the approval of the Engineer, the concrete represented by the failing compressive strength tests may be cored for strength testing. Coring shall commence within 5 days of notification by the Engineer. Drilled cores shall be obtained by the Contractor in the presence of the Engineer and tested at the Contractor's expense in accordance with ASTM C 42 by a laboratory acceptable to the Engineer. A minimum of three cores shall be taken in each area represented by the failing 28-day compressive strength tests. If the average of three cores is at least 85 percent of the specified 28-day strength and no single core is less than 75 percent of the specified 28-day strength, the concrete represented may be accepted with no further action required. Additional testing of cores extracted from locations represented by erratic core strength results shall be permitted by the Engineer.

**201-1.2 Materials.**

**201-1.2.1 Portland Cement.** All cement to be used or furnished shall be:

- (a) Type II portland cement, or Type V portland cement conforming to ASTM C 150. Additionally, Type II and Type V portland cements shall meet the optional requirements of ASTM C 150, Table 2 for maximum equivalent alkalis ( $\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$ ) of 0.60 percent, or Type IP (MS) portland-pozzolan cement conforming to ASTM C 595, unless otherwise specified. Type IP (MS) cement shall meet the optional mortar expansion requirements of ASTM C 595, Table 2 and contain no more than 20 percent pozzolan, which shall be inter-ground with clinker.
- (b) Type III low alkali portland cement conforming to the standard requirements of ASTM C 150 with the additional optional requirements of ASTM C 150, Table 2 for maximum equivalent alkalis ( $\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$ ) of 0.60 percent may be used when approved by the Engineer.
- (c) Rapid-hardening hydraulic cement may be used when approved by the Engineer. When used, the concrete mix shall conform to the requirements of ASTM C 928 and admixtures may be used when approved by the Engineer.

The Contractor shall furnish a Certificate of Compliance signed by the manufacturer identifying the cement and confirming compliance. Supporting test data will be furnished upon request by the Engineer.

Whenever suitable facilities are available for handling and weighing bulk cement, they shall be used. Otherwise, cement shall be delivered in original unopened sacks marked with brand, type, and weight.

Cement shall be stored in such a manner as to permit ready access for inspection and sampling and suitably protected against contamination and moisture. Should any cement show evidence of contamination or be otherwise unsuitable, the Engineer may reject it and require that it be removed from the site.

All portland cement used in concrete for any individual structure shall be of the same brand and type unless otherwise approved by the Engineer.

**201-1.2.2 Aggregates.** Aggregates shall conform to the requirements prescribed in 200-1 and shall be approved by the Engineer prior to use. Aggregate shall be of such character that it will be possible to produce workable concrete within the limits of slump and water content in 201-1.1.2 and 201-1.3.3.

Methods of handling materials resulting in segregation, degradation, or the combining of materials which results in failure to meet specifications shall not be permitted. The free moisture content of sand shall not exceed 8 percent at the time of batching.

Aggregates shall be nonreactive when tested in accordance with ASTM C 289 and evaluated in accordance with Appendix X-1 of ASTM C 33. Aggregates found to be potentially reactive may be used only upon written approval of the Engineer.

**201-1.2.3 Water.** Water used for concrete shall not contain deleterious substances. Water shall not contain an amount of impurities that will cause a change in the time of setting of portland cement of more than 25 percent nor a reduction in relative mortar strength at 7 and 28 days of more than 10 percent compared to results obtained with distilled water.

In conventionally reinforced concrete work, water shall not contain more than 1,000 mg/L (ppm) of chlorides calculated as Cl, nor more than 1,000 mg/L (ppm) of sulfates calculated as  $\text{SO}_4$ .

In prestressed concrete work, water shall not contain more than 650 mg/L (ppm) of chlorides calculated as Cl, nor more than 800 mg/L (ppm) of sulfates calculated as  $\text{SO}_4$ .

In nonreinforced concrete work, water shall not contain more than 2,000 mg/L (ppm) of chlorides calculated as Cl, nor more than 1,500 mg/L (ppm) of sulfates calculated as  $\text{SO}_4$ .

**201-1.2.4 Chemical Admixtures.** Chemical admixtures specified or approved by the Engineer shall conform to ASTM standards unless otherwise specified. Chemical admixtures shall be compatible with all other ingredients of the concrete mixture. Attention should be given to the instructions provided by the manufacturer of the admixture. The chemical admixture shall be dispensed in liquid form, using an approved measuring device. The quantity dispensed shall not vary more than 5 percent from the quantity specified. Approval to use an admixture shall not relieve the Contractor of the designated concrete requirements, including strength. Use of chemical admixtures shall conform to the requirements of 201-1.1.4, Concrete Specified by Compressive Strength, except for concrete specified by class, by alternate class, or by special exposure.

**(a) Water-Reducing, Set-Retarding Admixtures.**

Water-reducing (Type A) and water-reducing, set-retarding (Type D) admixtures shall conform to ASTM C 494, and shall be approved by the Engineer prior to use.

**(b) Accelerating Admixtures.** When calcium chloride is approved for use, it shall conform to ASTM D 98. Calcium chloride shall not be used in concrete containing prestressing steel. Calcium chloride shall not be used in concrete containing any reinforcing metal products, unless approved by the Engineer. Other accelerating admixtures shall conform to ASTM C 494, accelerating (Type C), or water-reducing and accelerating (Type E) admixtures, and shall be approved by the Engineer prior to use.

**(c) High Range, Water-Reducing Admixtures.** High range, water-reducing admixtures (HRWRA), i.e., superplasticizers, shall conform to ASTM C 494, water-reducing, high range admixtures (Type F), or water-reducing, high range, and retarding admixtures (Type G). The use of HRWRA shall conform to the manufacturer's recommendation for dosage, redose, and point of addition for each specific admixture. HRWRA may be added at the batch plant or jobsite, as approved by the Engineer. Any HRWRA shall be approved by the Engineer prior to use.

**(d) Air-Entraining Admixtures.** Air-entraining admixtures shall conform to ASTM C 260. Concrete containing air-entraining admixtures shall be field tested using test methods ASTM C 173 or ASTM C 231. The air content of the concrete, at the point of discharge, when sampled from the transportation unit, shall be within a tolerance of 1.5 percent of the value specified in ASTM C 94. Any air-entraining admixture shall be approved by the Engineer prior to use.

**201-1.2.5 Fly Ash.** Fly ash is specified in alternate class and special exposure mixes. Fly ash may be used in any other mix when approved by the Engineer. The amount of fly ash and portland cement used shall be based upon trial batches in accordance with 201-1.1.4. Fly ash may be used with Type IP (MS) or Type III portland cement when approved by the Engineer.

The Contractor shall furnish a certification per 4-1.5 signed by the supplier identifying the type of fly ash and stating that the fly ash complies with ASTM C 618 and these specifications. Supporting test data shall be furnished when requested by the Engineer. All testing and sampling procedures shall conform with ASTM C 311.

Separate silo storage facilities shall be provided. Suitable facilities shall be provided to discharge the fly ash into the cement hopper in accordance with 201-1.3.1. Fly ash shall be stored in such a manner as to permit ready access for the purpose of inspection and sampling and be suitably protected against contamination or moisture. Should any fly ash show evidence of contamination or be otherwise unsuitable, the Engineer may reject it and require that it be removed from the site.

All fly ash used in concrete for any individual structure shall be from the same source and of the same class unless otherwise approved by the Engineer.

(a) **Class F Fly Ash.** Class F fly ash shall conform to ASTM C 618 and the following specifications:

Loss on ignition	4% maximum
SO <sub>3</sub> content	3% maximum
Moisture content	1% maximum
R-Factor* (Only required where Sulfate Resistant Concrete is specified)	0.75% maximum

$$*R = \frac{(\% \text{ CaO} - 5)}{\% \text{ Fe}_2\text{O}_3} \quad \text{from fly ash oxide analysis}$$

Class F fly ash, as a percent by weight of total cementitious material, may exceed 20 percent, when approved by the Engineer.

(b) **Class C Fly Ash.** Class C fly ash shall conform to ASTM C 618 and the following specifications:

Loss on ignition	2% maximum
SO <sub>3</sub> content	4% maximum
Moisture content	1% maximum

Class C Fly Ash, as a percent by weight of total cementitious material, shall not exceed 30 percent, unless otherwise approved by the Engineer.

Class C fly ash shall not be used where sulfate resistant concrete is required.

**201-1.2.6 Reclaimed Concrete Material.** Reclaimed concrete material may be used in concrete mixtures in accordance with this section when approved by the Engineer. Reclaimed concrete material may be either:

1.) Reclaimed plastic portland cement concrete (RPPCC)

or

2.) Reclaimed non-plastic portland cement concrete materials

The contractor is required to maintain suitable equipment to classify reclaimed concrete material and document its use in the proportioning of concrete mixtures. The addition and characteristics of reclaimed concrete material will be monitored to ensure the final portland cement concrete composite conforms to the specifications for its Class and use.

All mixtures incorporating reclaimed concrete material will be represented by mix designs in accordance with section 201-1.1.1. The contractor shall evaluate all mix designs by laboratory or field trial batches. Each trial batch shall conform to the materials, proportions, and slump as proposed by the mix design. When approved by the Engineer, field trial batches may be placed in the Work at designated locations where concrete of lower quality is specified. Concrete so placed will be considered for the purpose of payment to be the type of concrete specified at that location. A minimum of ten test cylinders shall be molded from the trial batch containing the maximum water content indicated by the mix design. Five of the cylinders shall be tested at 7 days to establish 7-day average compressive strength information. The remaining five cylinders shall be tested at no more than 28 days after molding. For field trial batches the average 28 day compressive strength shall be at least 4 Mpa (600 psi) greater than the specified strength. For laboratory trial batches the average 28-day compressive strength shall be at

least 7 Mpa (1000 psi) greater for specified strengths less than 21 Mpa (3000 psi), 8 Mpa (1200 psi) greater for specified strengths between 21 Mpa and 36 Mpa (3000 psi and 5000 psi) and 10 Mpa (1400 psi) greater for specified strengths greater than 36 Mpa (5000 psi). The minimum strength of any one cylinder shall not be less than the specified strength. Changes in the source of materials or established procedures may require new trial batches. Changes in the quality of materials or failure to comply with the compressive strength requirements of 201-1.1.4 shall require new trial batches unless otherwise approved by the Engineer.

Reclaimed concrete material may not be used in special exposure mixtures and is not normally recommended for use in portland cement concrete where architectural aesthetics are a concern.

(a) **Reclaimed Plastic Portland Cement Concrete (RPPCC).** A maximum of 15% by volume of reclaimed plastic portland cement concrete conforming to this section may be incorporated into fresh portland cement concrete. Each weighmaster certificate shall show the exact volume of RPPCC in addition to the weighmaster certificate requirements of section 201-1.4.3.

RPPCC may be any un-hardened portland cement concrete provided its design strength is 2000 psi or greater, its constituent material conforms to section 201-1.2, and it has not attained or has been delayed from attaining initial set either by time or by the incorporation of set-delaying chemical admixtures. When set-delaying chemical admixtures are used, they will be used at the manufacturers recommended dosage rates and have a proven history of specifically maintaining and extending both plasticity and set. The contractor will maintain process documentation, mix designs, and supportive concrete test data and shall provide the information to the Engineer upon request.

RPPCC will be proportioned by volume in accordance with section 201-1.3. RPPCC may be added at any point during the proportioning process that results in a consistent, uniform, and homogeneous final product. For design and proportioning purposes, all RPPCC will be considered as a 2000 psi mixture, consisting of 280 kg (470 pounds) of cementitious material. Additional portland cement will be added to achieve the minimum portland cement content and/or strength as required for a mixture's Class and use. The quantity and/or constituent materials of the RPPCC shall be monitored and proportioned such that the final portland cement concrete gradation conforms to the requirements of section 201-1.3.2.

(b) **Reclaimed Non-Plastic Portland Cement Concrete Materials.** Non-Plastic Portland Cement Concrete Materials shall consist of an individual amount of or a combination of materials resulting from the reclaiming of portland cement concrete. Before reclamation, these materials shall conform to section 201-1.2. The materials shall be designated as either reclaimed aggregates (RA) or reclaimed water (RW).

When crushed portland cement concrete is used as aggregate it shall, when combined with the non-reclaimed aggregate at the proposed percentage of use, conform to section 201-1.2.2. A maximum of 30% RA by weight of total aggregate may be incorporated into fresh portland cement concrete. RA shall consist of crushed and graded concrete aggregates and/or a reclaimed naturally occurring aggregate. Reclaimed naturally occurring aggregates may contain minor residual amounts of portland cement concrete components as a result of reclamation. When 15% or less RA by weight of total aggregate is used, the requirements of 201-1.2.2 may be waived by the Engineer provided the final portland cement concrete gradation conforms to the requirements of section 201-1.3.2.

RW may consist of non-deleterious amounts of hydrated and un-hydrated portland cement, admixtures, minor amounts of fly ash and fine aggregate. The reclamation process for RW shall include a mechanism to ensure uniformity and homogeneity of the RW. A maximum of 35% RW by weight of batch water may be incorporated into fresh portland cement concrete.

RA and RW will be proportioned by weight in accordance with section 201-1.3. RA and RW may be added at any point during the proportioning process that results in a consistent, uniform, and homogeneous final product. The quantity and/or constituent materials of the RA shall be monitored and proportioned such that the final portland cement concrete gradation conforms to the requirements of section 201-1.3.2.

### **201-1.3 Proportioning.**

**201-1.3.1 General.** Aggregates and cement shall be proportioned by weight except that when the amount of concrete required for any one contract is 8 cubic meters (10 cubic yards) or less, the materials may be measured by volume. Materials that are proportioned by volume shall be measured in containers of known capacity.

Weigh hoppers shall be charged from bins located directly over them or from conveyor belts. When conveyor belts are used, there shall be a separate belt for each size aggregate. There shall be a moisture meter installed, accurate within 1 percent of actual moisture content, to indicate moisture in the sand.

Bulk cement shall be weighed in an individual hopper and kept separate from the aggregates until ingredients are released for discharge. The cement hopper shall be attached to a separate scale for individual weighing.

The amount of water added to the mixture shall be measured into the mixing drum through a valve with a positive cutoff. When water is measured by weight, it shall be weighed on a separate scale.

Whenever a portable batch plant is set up at a new location the scale assemblies shall be inspected and certified regardless of the date the scales were last tested.

Scales utilized in proportioning shall be either springless dial, multiple beam, or solid-state digital strain gage transducer. Scale graduation shall be no greater than the following:

Aggregate Scales .....10 kg (25 lbs.)

Cement Scales .....2 kg (5 lbs.)

Water Scales .....2 kg (5 lbs.)

If a multiple beam type scale is used, the scale shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight. The indicator shall be so designed that it will operate during the addition of the last 200 kg (400 pounds) of any weighing. The over travel of the indicator hand shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust.

Weighing equipment shall be insulated against vibration and movement of other operating equipment in the plant. When the entire plant is running, the scale reading at cutoff shall not vary from the weight designated by more than 1 percent for cement, 1 percent for water, 1-1/2 percent for any size of aggregate, nor 1 percent for the total aggregate in any batch.

**201-1.3.2 Combined Aggregate Gradings.** If the combined aggregate grading conforms to the grading of its designated class, the individual grading required by 200-1.4 and 200-1.5 may be waived. The combined aggregates shall conform to the gradings specified in the following table:

TABLE 201-1.3.2 (A)

Sieve Size	Percentage Passing Sieves				
	Grading	Grading	Grading	Grading	Grading
	A	B	C	D	E
50 mm (2 in)	100	100	-	-	-
37.5 mm (1-1/2 in)	95-100	95-100	100	-	-
25.0 mm (1 in)	64-80	80-96	95-100	-	-
19.0 mm (3/4 in)	55-71	64-80	77-93	100	100
9.5 mm (3/8 in)	37-53	40-52	50-70	92-100	90-100
4.75 mm (No. 4)	32-42	35-46	39-51	42-60	60-80
2.36 mm (No. 8)	25-35	28-38	31-41	33-47	50-70
1.18 mm (No. 16)	18-28	21-31	22-32	22-38	33-53
600 µm (No. 30)	10-18	10-20	12-22	17-25	19-35
300 µm (No. 50)	3-9	3-10	3-15	6-15	5-15
150 µm (No. 100)	0-4	0-4	0-5	1-6	2-7
75 µm (No. 200)	0-2	0-2	0-2	0-3	0-4

**201-1.3.3 Concrete Consistency.** The amount of water added at the mixer shall be regulated to take into account the free water in aggregates. Free water is defined as the total water minus the water absorbed by the aggregate in a saturated surface-dry condition.

The amount of water used in the mixture shall not exceed the amount necessary to permit practical placement and consolidation of the concrete. Total free water in the mixture shall not exceed an amount producing the maximum slump specified in 201-1.1.2, and shall not exceed amounts shown in the following:

TABLE 201-1.3.3 (A)

Aggregate Grading <sup>1</sup>	Kilograms (Pounds) Per Cubic Meter (Cubic Yard) of Concrete				
	Slump Millimeters (Inches)				
	25 mm (1 in)	50 mm (2 in)	75 mm (3 in)	100 mm (4 in)	125 mm (5 in)
A	160 (270)	166 (280)	172 (290)	178 (300)	184 (310)
B	163 (275)	169 (285)	175 (295)	181 (305)	187 (315)
C	172 (290)	178 (300)	184 (310)	190 (320)	196 (330)
D	190 (320)	199 (335)	208 (350)	216 (365)	222 (375)
E	199 (335)	208 (350)	216 (365)	225 (380)	234 (395)

1. When the coarse aggregate is composed solely of crushed rock, the above values may be increased up to 12 kilograms (20 pounds) of water per cubic meter (cubic yard).

When adverse or difficult conditions affect the placement of concrete, the Engineer may authorize a greater slump to be used, provided the cement is increased. Water shall be added at a ratio not to exceed 32 percent of added cement per cubic meter (cubic yard) of concrete, and such additional water and cement shall be provided at the Contractor's expense.

#### 201-1.4 Mixing.

**201-1.4.1 General.** Machine mixing will be required in all cases other than those in which it would obviously prove to be impractical, in which case hand mixing is permitted. Mixing shall be commenced as soon as possible after the cement is placed in contact with the aggregates, but in no event shall the intervening period exceed 30 minutes.

All concrete mixers shall be of such design and construction and so operated to provide a properly mixed concrete with uniform distribution of ingredients. Mixers shall be maintained properly and be in working order and not have any aluminum parts which will have direct contact with concrete.

**201-1.4.2 Paving and Stationary Mixers.** Paving and stationary mixers shall be equipped with an accurate automatic timing device so designed and constructed as to lock the discharge lever. The regulation setting of this device shall be under the supervision of the Engineer. Water control equipment shall also be provided with each concrete mixer.

The proper proportions of aggregate, cement, and water for each batch of concrete shall be placed in the mixer and mixed for a period of not less than 1 minute (1-1/2 minutes for reinforced concrete).

The rotating speed at which the mixer shall be operated shall conform to that recommended by the manufacturer. The total volume of materials in any one batch shall not exceed the water level capacity of the mixer or the manufacturer's specified capacity of the mixer.

**201-1.4.3 Transit Mixers.** The type, capacity, and manner of operation of the mixing and transporting equipment for ready-mix concrete shall conform to the current "Standards for Operation of Truck Mixers and Agitators of the National Ready-Mixed Concrete Association" and the "Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau." Transit mix concrete trucks shall be equipped with an automatic device for recording the number of revolutions of the drum during the mixing period. Each mixer and agitator shall have attached thereto in a prominent place, a metal plate or plates, installed by the manufacturer. The plate(s) shall be plainly marked with the manufacturer's designated capacity of the drum in terms of the volume of mixed concrete and the speed of rotation for the agitating and mixing speeds of the mixing drum or blades.

Each mixer shall have an identification number painted on it that can be easily read from the batching platform.

The total volume of materials introduced into the mixer shall not exceed the manufacturer's specified mixing capacity. If the concrete so mixed does not meet the uniformity requirements of 210-1.4.1, the amount of materials introduced into the mixer shall be reduced.

The drum of the mixer shall be completely emptied of any previously mixed load. The proper proportions of the required ingredients for each load of concrete shall be placed in the mixer and shall be mixed between 70 and 100 revolutions at the manufacturer's designated mixing speed unless otherwise approved by the Engineer. Additional revolutions of the drum shall be at the manufacturer's designated agitating speed.

When concrete is produced for pavement or concrete structures, all wash water shall be emptied from the mixer before any portion of the succeeding load is introduced, unless it has been measured. For all other work, the mixer shall be empty or may carry up to 40 liters (10 gallons) of water in the drum. This amount may be exceeded if the water is measured to an accuracy of 1% of the required total mixing water. Adequate control of ready-mixed concrete may require additional added water mixed into the batch at the discharge point. This water shall be mixed for a minimum of 30 revolutions at the manufacturer's designated mixing speed. Water shall not be added to the load during transit.

The total elapsed time between introduction of water at the batch plant and completely discharging the load shall not exceed 90 minutes. The Engineer may waive this limitation if the concrete is of such slump after the 90 minute time limit has been reached that it can be placed without the addition of water to the batch. Under conditions contributing to quick stiffening of the concrete a time limit less than 90 minutes may be specified by the Engineer.

The Engineer shall be provided with a legible certified weighmaster certificate which shall contain the following information:

- 1) Name of vendor
- 2) Name of Contractor
- 3) Work location
- 4) Number of cubic yards in the load
- 5) Concrete Class, Alternate Class, or Special Exposure mix designation
- 6) Amount of water added at the plant (including water in fine aggregates)
- 7) Maximum allowable water
- 8) Time and date of batching

When concrete is specified by compressive strength, or when required by the Engineer, the certificate shall contain the following additional information:

- 9) Actual weights of cementitious materials and of each size of aggregate
- 10) Brand and type of cement
- 11) Brand, type and amount of admixture.

Space shall be provided on the certificate so that amount of water added at the work site may be indicated.

**201-1.4.4 Hand Mixing.** Hand mixing is permitted when the amount of concrete required is less than 1 cubic meter (cubic yard). Hand-mixed concrete shall be mixed on a watertight platform or in a mortar box in batches not to exceed 1/3 cubic meter (cubic yard) each. The aggregates shall be spread in a uniform layer over which the required quantity of cement shall be evenly distributed. The entire batch shall be turned with shovels until the ingredients are thoroughly blended before adding water. After adding the proper amount of water, the batch shall again be turned with shovels until a uniform consistency is obtained. Methods of hand mixing which allow the loss of mixing water will not be permitted.

**201-1.5 Transporting Batched Materials and Mixed Concrete.** The compartments of trucks or other equipment used for the purpose of transporting proportioned dry aggregate and cement, or mixed concrete, shall be suitably constructed to protect and prevent loss or leakage of contents during charging, transit, or discharging.

## **201-2 REINFORCEMENT FOR CONCRETE.**

**201-2.1 General.** Reinforcement for concrete specified or approved by the Engineer shall conform to the appropriate ASTM standard. Bar, wire, and wire mesh reinforcement shall conform to dimensions and details indicated on the Plans or otherwise prescribed. Before placed in any concrete work, it must be thoroughly cleaned. When steel, glass or synthetic fibers are used, the quantity and material type shall conform to details indicated on the Plans or in the Specifications, as approved by the Engineer. Approval to use any reinforcement shall not relieve the Contractor of the specified concrete requirements, including strength.

### **201-2.2 Steel Reinforcement**

**201-2.2.1 Reinforcing Steel.** Unless otherwise specified, reinforcing steel shall be either Grade 300 (40) or Grade 400 (60) billet steel conforming to ASTM A 615/615M. Steel bending processes shall conform to the requirements of Manual of Standard Practice of the Concrete Reinforcing Steel Institute. Bending or straightening shall be accomplished so that the steel will not be damaged. Kinked bars shall not be used.

**201-2.2.2 Wire Reinforcement.** Wire reinforcement shall in all respects fulfill requirements prescribed in ASTM A 82.

**201-2.2.3 Wire Mesh Reinforcement.** Mesh reinforcement shall conform to ASTM A 185. The gage of the wire and the dimensions of the mesh shall be as shown on the Plans or in the Specifications. The wire mesh reinforcements shall be so constructed as to retain its original shape and form during necessary handling. The effective cross-sectional area of the wire shall be equal to that specified or indicated on the Plans.

**201-2.3 Fiber Reinforcement.** Fiber-Reinforced Concrete or Air-Placed Concrete, Type B shall conform to ASTM C1116 material requirements and classifications. Concrete containing fibers shall conform to Section 201-1.1.4. Fiber Type (Type I, II, or III), fiber manufacturer and addition rate of fibers per cubic yard shall be included in the mix design approved by the Engineer. Type II and Type III fibers shall not be used to replace structural reinforcement, and shall be added at the batch plant.

**201-2.3.1 Type I.** Steel Fiber-Reinforced Concrete or Air-Placed Concrete, Type B. Type I shall contain stainless steel, alloy steel, or carbon steel fibers.

**201-2.3.2 Type II.** Glass Fiber-Reinforced Concrete or Air-Placed Concrete, Type B. Type II shall contain alkali-resistant glass fibers.

**201-2.3.3 Type III.** Synthetic Fiber-Reinforced Concrete or Air-Placed Concrete, Type B. Type III shall contain virgin homopolymer polypropylene fibers or other synthetic fibers.

**201-2.4 Samples for Testing.**

**201-2.4.1 General.** No reinforcing steel will be accepted until it has been approved by the Engineer. Samples shall be taken from bars selected by the Engineer and cut in the Engineer's presence. The Contractor shall furnish a certified mill test report for each heat or size of steel when required by the Engineer.

**201-2.4.2 Reinforcing Steel Bars.** Two sample bars, cut from different bars and 1 m (3 ft) in length for sizes 10 M (No. 3) through 16M (No. 5) and 1.5 m (5 ft) in length for size 19M (No. 6) and larger, shall be taken from each bar size and heat number delivered to the job site on a cumulative tonnage basis in accordance with the following schedule:

**TABLE 201-2.4.2 (A)**

Bar Sizes (U.S. Standard Sizes)	Bar Size Delivered To Job Site Tonnes (Tons)
6M (2)	0.5 (1/2)
10M (3)	1 (1)
13M (4)	2 (2)
16M (5)	3 (3)
19M (6)	4 (4)
22M (7)	5 (5)
25M (8)	6 (7)
29M (9)	8 (9)
32M (10)	10 (11)
36M (11)	12 (13)
43M (14)	18 (20)
57M (18)	32 (35)

**Note:** At least two sample bars shall be taken from each bar size.

**201-2.4.3 Wire Reinforcement.** One sample consisting of two pieces, each 1 m (3 feet) long, shall be taken from each lot of 2 tonne (2 tons) or less for each size of wire delivered to the job site.

**201-2.4.4 Wire Mesh Reinforcement.** Two samples of a size suitable for testing shall be taken from each 280 m<sup>2</sup> (3,000 square feet) of fabric or fraction thereof.

### **201-3 EXPANSION JOINT FILLER AND JOINT SEALANTS.**

**201-3.1 General.** This section specifies joint fillers and sealants to be used for treating joints in portland cement concrete.

All joints which are to be sealed shall be formed with filler. The filler shall be placed in correct position before concrete is placed against it. Holes or joints in the filler shall be filled with mastic to prevent the passage of mortar or concrete from one side of the joint to the other.

**201-3.2 Premolded Joint Filler.** Premolded joint filler material shall consist of premolded strips of a durable resilient material.

Unless otherwise specified, premolded joint filler shall be one of the following:

Preformed Expansion Joint Filler (Bituminous) ASTM D 994

Nonextruding and Resilient Filler (Bituminous) ASTM D 1751

Nonextruding and Resilient Filler (Non-bituminous) ASTM D 1752

**201-3.3 Polystyrene Joint Filler.** Commercial quality expanded polystyrene foam blocks and planks shall be furnished by the Contractor and installed in place as shown on the Plans. The foam shall be composed of non-interconnecting cells. Expanded polystyrene shall have a flexural strength of 240 kPa (35 psi) and a compressive yield strength of between 110 kPa and 275 kPa (16 and 40 psi) at 5 percent compression.

Surfaces of expanded polystyrene against which concrete is to be placed shall be faced with hardboard. Hardboard shall be 3 mm (1/8 inch) minimum thickness conforming to Federal Specifications LLL-B-810, any type. Other facing materials may be used, provided they furnish equivalent protection. All boards shall be held in place by nails, waterproof adhesive, or other means approved by the Engineer.

**201-3.4 Type "A" Sealant (Two-Part Polyurethane Sealant).** The sealant shall be a polyurethane sealant furnished and placed in accordance with the Specifications for "Two-Component Machine-Mixed Polyurethane Sealant" (State Specification 8030-61J-01).

Polyethylene foam shall be commercial quality, with a continuous impervious, glazed top surface, suitable for retaining the liquid polyurethane sealant in the joint while hardening.

A primer, furnished by the manufacturer of the sealant, shall be applied to the sides of the groove and to all exposed vertical surfaces in the joint prior to placing the polyurethane sealant. The primer shall be dry prior to placing sealant. Contamination of the completed primer with foreign material will be cause for rejection of the primed surface.

**201-3.5 Type "B" Sealant (Preformed Elastomeric Sealant).** The sealant shall be a preformed elastomeric joint seal conforming to specifications of ASTM D 268 and the following requirements:

The manufacturer shall designate the minimum uncompressed width of each size of seal to be furnished. Any seal which has a minimum uncompressed width, measured at any point in the height of the seal, less than that designated by the manufacturer shall not be used.

Seals delivered to the job that have dimensional or shape tolerances of such magnitude that the seal will not function as specified shall not be used.

The seal shall consist of a multi-channel, nonporous, homogeneous material furnished in a finished extruded form, and shall be furnished full length for each joint with no more than one shop splice in any 18 m (60 foot) length of seal. Field splices shall not be used.

The adhesive used to splice the seal shall be an effective bonding agent and shall be resistant to water and ozone. The lubricant adhesive shall conform to State Specification 701-80-30. All abutting surfaces of shop splices shall be bonded together with adhesive. Shop splices shall have no visible evidence of bond failure.

After the seal has been installed in the joint, shop splices shall have no visible offset of the exterior surfaces and there shall be no evidence of bond failure at the abutting surfaces of the splices.

At all open ends of the seal, each cell of the elastomeric joint seal shall be filled to a depth of 100 mm (4 inches) with commercial quality open cell polyurethane foam, or closed by other methods subject to Engineer approval.

Tests of elastomeric joint seals will be conducted in accordance with California Test 673.

**201-3.6 Type "C" Sealant (Asphalt-Latex Emulsion Joint Sealant).** Asphalt-latex emulsion joint sealant shall be designated for mixing and application by hand methods and shall be suitable for use at temperatures above 10°C (50°F). The sealing compound shall be an emulsion consisting of paving asphalt, Grade AR-1000, conforming to requirements of 203-1 emulsified with rubber latex in a suitable emulsifying agent. Rubber latex shall be natural rubber or synthetic latex containing approximately 40 percent solids. The resulting emulsion shall consist of a minimum of 55 percent paving asphalt and a minimum of 36 percent rubber latex.

A setting agent shall be provided in the form of a paste to be added at the rate of approximately 25 mL/L (3 fluid ounces per gallon) of emulsion.

The joint sealant shall comply with the requirements of Table 201-3.6 (A).

**TABLE 201-3.6 (A)**

Determination	Test Method No.	Requirements	Remarks
Furl Viscosity at 25°C (77°F)	ASTM D 88	80-250 Secs.	Before adding setting agent.
Sieve Test	ASTM D 244	1% Max.	Before adding setting agent.
Penetration <sup>1</sup> at 25°C (77°F)	California 418	50-150	Immediately after mixing, the material is poured into a 175 mL (6-ounce) deep ointment can and the specimen allowed to stand in air at a temperature of 25° ± 1°C (77° ± 2°F) for a period of 24 hours. It is then penetrated with a grease cone under a total load of 150 g in accordance with ASTM D 217.
Elasticity <sup>1</sup>	California 418	70% Min.	Immediately after mixing, the material is placed in an aluminum pan and cured for 24 hours at 46° ± 1°C (115° ± 2°F). Specimen shall be tested in modified ductility mold per test method.
Total Solids <sup>2</sup>	California 418	70% Min.	3 to 5 g of freshly mixed material is placed in an aluminum pan and dehydrated in a suitable oven maintained at a temperature of 93° ± 2°C (200° ± 3°F) for a period of three hours.
Setting Time <sup>2</sup>	California 418	60 Min. Max.	Material is poured into a 175 mL (6-ounce) deep ointment can and penetration checked each 15 minutes. Time is recorded when penetration is less than 200.

1. Mixing ratio of material: Add 10 ± 0.1 g. of sodium fluosilicate powder to 200 g. of emulsion component.

2. Mixing ratio of material: Add 12 mL of setting agent component of 24 mL (8 fluid ounces) of emulsion component.

**201-3.7 Type “D” Joint Sealant (Hot-Poured Rubber-Asphalt Joint Sealant).** Hot-poured rubber asphalt joint sealants shall conform to requirements of ASTM D 1190. They shall be applied in accordance with the manufacturer’s recommendation and 303-1.8.7.

**201-3.8 Type “E” Joint Sealant (Polysulfide Polymer and Rubber Rod).** Polysulfide polymer type joint sealant shall be a two-component, plastic, rubber-like, cold-applied joint sealant. This material shall resist the intrusion of foreign materials into the joint throughout repeated cycles of expansion and contraction.

The joint sealant shall be packaged in sealed containers identified by the name of the manufacturer, lot number, and date, and bear instructions for mixing and application. Accelerator containers shall be marked “A”, and polysulfide containers shall be marked “B”. The weight of component “A” in the mixture shall not be less than 10 percent of component “B”. Minimum polysulfide content of the mixture shall be 20 percent by weight.

Upon opening the container, component “B” shall not exhibit more than a slight degree of “skinning” on the surface of the material.

The joint sealant shall comply with the following requirements when laboratory mixed materials are tested in accordance with California Test 413:

**TABLE 201-3.8 (A)**

Determination	Requirements
Viscosity, 5 minutes after mixing Pa·s (poises)	20 to 35 (200 to 350)
Application time (pot life or time to reach 200 Pa·s [2000 poises] at 25°C [77°F], hours minimum)	1
Penetration at 25°C (77°F) after aging 24 hours at 25°C (77°F)	150 max.
Nonvolatile content, percent	88 min.

The following tests are to be performed on the mixed material after 96 hours of aging at 25°C (77°F):

**TABLE 201-3.8 (B)**

Determination	Requirements
Penetration at 25°C (77°F)	50 to 120
Penetration at 70°C (158°F)	175 max.
Resilience at 25°C (77°F), percent	70 min., 60 min. <sup>1</sup>
Resilience at 70°C (158°F), percent	60 min., 50 min. <sup>1</sup>
Bond to concrete, 100% extension, dry at - 29°C (- 20°F)	No failure
Bond to concrete, 50% extension, wet at - 29°C (- 20°F)	No failure

The following test is to be performed on the sample from the resilience test above, oven-aged for 7 days at 70°C (158°F):

**TABLE 201-3.8 (C)**

Determination	Requirements
Resilience of oven-aged sample after 7 days at 25°C (77°F), percent	70 min., 60 min. <sup>1</sup>

1. This requirement applied if the penetration at 25°C (77°F), after 96 hours aging at 25°C (77°F) is 100 to 129

The rubber rod shall be a cellular synthetic rubber, either butyl or neoprene, of circular cross section with continuous skin impervious to water. It must comply with the following requirements:

**TABLE 201-3.8 (D)**

Determination	Requirements
Specific gravity (Bulk)	0.30 to 0.50
Surface hardness, Durometer (Fig. 1) ASTM D 2240	60 to 85
Water absorption, by weight, 25.4 mm (one inch) head at 24°C (75°F), for 24 hours, percent	5 max.
Resistance to ozone, ASTM D 470, except 30 minutes exposure, at 70 ± 10 mg/L ozone, at 29°C (85°F)	No cracks

**201-3.9 Test Report and Certification.** When requested by the Engineer, the Contractor shall provide at delivery time, certified copies of the vendor's test report. This shall indicate the vendor name, type of joint sealant, date and point of delivery, quantity, ticket number, lot number, and results of the required test. The test report shall be signed by an authorized representative of the vendor. The certified test reports and testing required in connection therewith shall be without cost to the Agency.

#### **201-4 CONCRETE CURING MATERIALS.**

##### **201-4.1 Membrane Curing Compounds**

**201-4.1.1 General.** Curing compound shall consist of a liquid which, when applied to fresh concrete, will form a continuous membrane over the exposed surfaces of the concrete.

Curing compounds shall conform to the requirements of ASTM C 309 Class B (Resin Type Only), except the loss of water shall not exceed 0.15 kilogram per square meter in 24 hours nor 0.45 kilogram per square meter in 72 hours when tested in accordance with ASTM C 156.

Concrete curing compounds are designated by type as follows:

Type 1 - Clear or translucent without dye.

Type 1-D - Clear or translucent with fugitive dye.

Type 2 - White pigmented

Unless otherwise stated on the Plans or in the Specifications, Type 1-D shall be used, except that Type 2 shall be used for the top surface of bridge decks. Curing compounds which contain such coloration as to be easily visible following application shall be considered as meeting the fugitive dye requirement.

All compounds shall be furnished by the Contractor and shall be delivered ready-mixed in sealed original containers labeled in accordance with ASTM C 309 and with the date of the manufacture. At the time of use, pigmented curing compounds shall be maintained in a thoroughly mixed condition. Containers of curing compound shall remain air-tight when not in use.

**201-4.1.2 Application.** Curing compound shall be applied in two coats according to manufacturer's directions and 303-1.10. The direction of application of the second coat shall be perpendicular to the first. The second coat shall be applied when the first coat is dry to the touch, but not later than 4 hours after the first coat was applied.

The rate of application shall be such that the compound forms a continuous, unbroken film when applied to the work and shall not be less than the rate used when tested for water retention.

Application of the curing compound to the concrete shall commence as soon as the finished surface of the concrete reaches a uniformly damp appearance with no free water on the surface. At any point, the

application rate shall be within 1.2 m<sup>2</sup>/L (50 square feet per gallon) of the nominal rate and the average application rate shall be within 0.6 m<sup>2</sup>/L (25 square feet per gallon) of the nominal rate specified when tested in accordance with California Test 535.

#### 201-4.2 Sheet Curing Materials.

**201-4.2.1 General.** Sheet curing materials are designated by type as follows:

- Type 1 - Waterproof Paper
- Type 2 - Polyethylene Film
- Type 3 - White-Burlap-Polyethylene Sheet
- Type 4 - Burlap

Types 1, 2, and 3 sheet curing materials shall conform to the requirements of ASTM C 171, Standard Specification for Sheet Materials for Curing Concrete.

**201-4.2.2 Burlap.** Burlap shall weigh not less than 305 g/m<sup>2</sup> (10 ounces per linear yard, 40 inches wide).

**201-4.3 Test Report and Certification.** The Contractor shall provide, when requested by the Engineer, certified copies of the vendor's test report showing compliance with ASTM C 309 and these specifications. The testing and the report required shall be supplied without cost to the Agency.

#### 201-5 CEMENT MORTAR

**201-5.1 General.** Cement mortar shall consist of portland cement, sand, and water. Cement and sand shall first be combined in the proper proportions, and then thoroughly mixed with the required amount of water.

Cement mortar shall be designated by class and proportioned by loose volume as shown in Table 201-5.1 (A).

TABLE 201-5.1 (A)

Mortar Designation Class	Proportions	
	Parts Cement	Parts Sand
A	1	1
B	1	1-½
C	1	2
D	1	2-½
E	1	3
F	1	3-½

The quantity of water to be used in the preparation of mortar shall be only that required to produce a mixture sufficiently workable for the purpose intended.

Mortar shall be used as soon as possible after mixing and shall show no visible signs of setting prior to use. Retempering of mortar will not be permitted.

**201-5.2 Cement.** Portland cement shall conform to 201-1.2.1. Plastic (masonry) cement shall conform to ASTM C 91.

**201-5.3 Sand.** Sand shall conform to requirements of 200-1.5.3. In proportioning the sand it shall be measured loose (without shaking or compacting) in measuring boxes or other suitable containers of known capacity.

**201-5.4 Water.** Water shall conform to 201-1.2.3.

**201-5.5 Admixtures.** No admixture shall be used in mortar unless approved by the Engineer.

## 201-6 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

### 201-6.1 Requirements

**201-6.1.1 General.** At the approval of the Engineer, Controlled Low Strength Material (CLSM) may be used as a trench backfill, structural backfill, pipe bedding, or pipe backfill. CLSM shall consist of portland cement, aggregates, water, and fly ash. Chemical admixtures and other mineral admixtures may be used when approved by the Engineer.

The actual mix proportions and flow characteristics shall be determined by the producer of the CLSM to meet jobsite conditions and shall be approved by the Engineer. The mixture shall be workable and non-segregating. When air-entrainment is specified, it shall be evaluated with the actual materials to be used on the project.

CLSM that is to be hand excavatable, shall contain aggregate no larger than 9.5 mm (3/8 in) and the 9.5 mm (3/8 in) aggregate shall comprise no more than 30 percent of the total aggregate content.

When minimum and/or maximum compressive strength is required, the strength shall be as shown on the project plans.

### 201-6.2 Materials

**201-6.2.1 Portland Cement.** Portland cement shall conform to the requirements of Section 201-1.2.1.

**201-6.2.2 Aggregates.** Aggregates shall conform to the requirements of Section 201-1.2.2, except as noted below. Aggregates shall be pretested in CLSM mixtures similar to those anticipated for the work, confirming their ability to perform as required for the specific application. Aggregates not in conformance with Section 201-1.2.2 may be used when approved by the Engineer, providing the material has a minimum sand equivalent of 20, the percentage passing the 75 $\mu$ m (No.200) sieve does not exceed 12 percent, and the fines are non-plastic.

**201-6.2.3 Water.** Water shall conform to the requirements of Section 201-1.2.3.

**201-6.2.4 Admixtures.** Chemical admixtures shall conform to the requirements of Section 201-1.2.4, and may consist of air-entraining agents, water-reducing admixtures, and other chemical additives. Chemical admixtures shall be approved by the Engineer.

Mineral admixtures other than fly ash may be used when approved by the Engineer.

**201-6.2.5 Fly Ash.** Fly ash shall conform to the requirements of 201-1.2.5, except it shall not be limited to 20 percent by weight of the total cementitious material. Class C fly ash shall not be used.

### 201-6.3 Proportioning

**201-6.3.1 General.** Proportioning shall conform to requirements of Section 201-1.3.1. When CLSM is used underneath a paved public right of way, the mixture shall contain a minimum of 15 kilograms per cubic meter (25 pounds per cubic yard) of cement when using washed concrete sand.

### 201-6.4 Mixing

**201-6.4.1 General.** Mixing shall conform to the requirements of Section 201-1.4, except the ninety minute time limit specified in Section 201-1.4 shall not apply. Unless otherwise specified, under conditions contributing to quick setting the Engineer may specify a time limit, not to exceed 2-1/2 hours.

**201-6.5 Testing.** CLSM shall be tested for plastic unit weight. Plastic unit weight shall not deviate more than  $\pm 10$  percent of theoretical unit weight shown on the approved mix design. Unit weight shall be determined in accordance with ASTM C 138. When a compressive strength is specified on the plans, a compressive strength test shall be performed as directed by the Engineer.

### 201-6.6 Placement.

**201-6.6.1 General.** CLSM may be placed by chutes, conveyors, buckets, pumps or tremies depending upon the application and accessibility.

For trench backfill, CLSM shall be placed continuously. To contain CLSM when filling long open trenches or open-ended structures in stages, the end points shall be adequately bulkheaded to prevent movement. Methods may include bulkheading with sandbags, earth dams, forms, or stiffer mixtures of CLSM.

For bedding, CLSM shall be placed in a manner to prevent flotation or displacement of the embedded item. Methods of preventing flotation or displacement may include placement of CLSM in lifts or, at strategic locations, placing sandbags, straps anchored into soil, faster setting CLSM, or lower slump CLSM over the embedded item.

### 201-6.7 Replacing Pavement.

**201-6.7.1 General.** Pavement may be placed directly upon the CLSM as soon as the surface will withstand the paving process without displacement or disruption. If the placement of the CLSM is not completed in time to allow permanent paving to be completed the same day, the Contractor shall prevent traffic contact with the CLSM until paving is completed.

### 201-7 NON-MASONRY GROUT

**201-7.1 General.** Non-masonry grouts are composed of hydraulic cement, fine aggregate, and other ingredients. Quick-setting grouts may be used for setting posts and anchors in concrete or masonry. Non-shrink grout is typically used for setting bearing plates.

**201-7.2 Quick-Setting Grout.** Quick-setting grout shall be a high strength nonstaining grout approved by the Engineer. It shall reach an initial set within 90 minutes at 21°C (70°F) and reach minimum compressive strength of 17.2 Mpa (2,500 psi) within 24 hours. Shrinking shall be less than 0.1 percent when tested, using the test procedures of ASTM C 596. The grout shall be mixed, handled and placed in accordance with manufacturer's instructions.

**201-7.3. Non-Shrink Grout.** Non-shrink grout shall be a high strength nonstaining grout approved by the Engineer and meeting the requirements of ASTM C 1107. The grout shall be mixed, handled and placed in accordance with the manufacturer's instructions.

## SECTION 202 - MASONRY MATERIALS

### 202-1 BRICK.

**202-1.1 General.** Brick shall be whole, sound, hard, burned, give a clear ringing sound when struck together, and be uniform in quality. They shall be culled or sorted before delivery to the worksite.

**202-1.2 Manhole Brick.** Sewer manhole brick shall conform to ASTM C 62, Grade MW, with the following exceptions:

- 1) Average compressive strength of five bricks shall not be less than 27.6 MPa (4,000 psi) and compressive strength of any individual brick shall not be less than 24.1 MPa (3,500 psi).
- 2) The absorption of any individual brick shall not be more than 16 percent when submerged 24 hours in cold water.
- 3) Brick shall conform to following dimensions:

TABLE 202-1.2 (A)

	Depth mm (in)	Width mm (in)	Length mm (in)
Standard Size	63.5 (2-1/2)	98.4 (3-7/8)	209.6 (8-1/4)
Allowable Variation	± 6.4 (± 1/4)	± 9.5 (± 3/8)	± 12.7 (± 1/2)

**202-1.3 Building Brick.** Building brick shall conform to requirements of ASTM C 62, Grade MW. The size and texture shall be as shown on the Plans or as approved by the Engineer.

**202-1.4 Facing Brick.** Facing brick shall conform to requirements of ASTM C 216, Grade MW, Type FBS. The size, color, and texture shall be as shown on the Plans or as approved by the Engineer.

**202-1.5 Mortar, Grout, Water, and Plaster.**

**202-1.5.1 Mortar.** Mortar used in brick construction shall be Class "D" as specified in 201-5.1 to which 1/4 to 1/2 part hydrated lime or lime putty has been added to portland cement mixtures, and no more than 1/10 part hydrated lime or lime putty has been added to plastic (masonry) cement mixtures. Mortar shall attain a minimum compressive strength of 13 MPa (1,800 psi) in 28 days.

**202-1.5.2 Grout.**

**(a) General.**

- 1) Fine grout shall be used in spaces less than 50 mm (2 inches) clear in any dimension.
- 2) Coarse Grout shall be used in spaces 50 mm (2 inches) or larger in all horizontal directions.
- 3) Grout shall attain a minimum compressive strength of 14 MPa (2,000 psi) in 28 days.
- 4) Grout shall be tested in accordance with ASTM C1019, Sampling and Testing Grout.

**(b) Site-mixed Grout.**

- 1) Site-mixed grout shall be proportioned by volume.
- 2) Fine grout shall be 1 part portland cement and 2-1/4 to 3 parts sand to which 1/10 part hydrated lime may be added.
- 3) Coarse grout shall be 1 part portland cement, 2 to 3 parts sand, and not more than 2 parts No. 4 Concrete Aggregate.

**(c) Ready-mixed Grout.**

- 1) Ready-mixed grout shall conform to 201-1.
- 2) One cubic meter (cubic yard) of fine grout shall consist of a minimum of 445 kg (750 pounds) portland cement, sand, and sufficient water to achieve a 250 mm (10 inch) slump. Admixtures may be used as specified or as approved by the Engineer.
- 3) Coarse grout shall conform to Concrete Class 360-E-14G (610-E-2000G).

**202-1.5.3 Water.** Water shall conform to the requirements of 201-1.2.3. The quantity of water to be used in the preparation of the mortar or grout shall be the minimum required to produce a mixture sufficiently workable for the purpose intended.

**202-1.5.4 Plaster.** Plaster for brick sewer structures shall be class "D" mortar as specified in 201-5.1.

**202-2 CONCRETE BLOCK.**

**202-2.1 Masonry Units.** Masonry units shall be made with sand-gravel aggregate and conform to ASTM C 90 for Type 1 Units. The net size of units shall be as indicated on the Plans. Unless otherwise specified, all units shall be of the normal weight classification [oven-dry weight of concrete 2000 kg/m<sup>3</sup> (125 pounds per cubic foot) or more]. Lightweight aggregates for use in concrete masonry units shall be

manufactured from expanded clay, expanded shale, scoria, pumice, or a combination thereof, and shall conform to ASTM C 331.

### **202-2.2 Mortar, Grout, and Water.**

**202-2.2.1 Mortar.** Mortar used in concrete block construction shall be Class "D" or "E" as specified in 201-5.1 to which 1/4 to 1/2 part hydrated lime or lime putty has been added to portland cement mixtures, and no more than 1/10 part hydrated lime or lime putty has been added to plastic (masonry) cement mixtures. Mortar shall attain a minimum compressive strength of 13 MPa (1,800 psi) in 28 days.

#### **202-2.2.2 Grout.**

##### **(a) General.**

- 1) Fine grout shall be used in spaces less than 100 mm (4 inches) clear in any dimension.
- 2) Coarse grout shall be used in spaces 100 mm (4 inches) or larger in all horizontal directions.
- 3) Grout shall attain a minimum compressive strength of 14 MPa (2,000 psi) in 28 days.
- 4) Grout shall be tested in accordance with ASTM C 1019, Sampling and Testing Grout.

##### **(b) Site-mixed Grout.**

- 1) Site-mixed grout shall be proportioned by volume.
- 2) Fine grout shall be 1 part portland cement and 2-1/4 to 3 parts sand to which 1/10 part hydrated lime may be added.
- 3) Coarse grout shall be 1 part portland cement and 2 to 3 parts sand, and 1-3/4 to 2 parts No. 4 Concrete Aggregate.

##### **(c) Ready-mixed Grout.**

- 1) Ready-mixed grout shall conform to 201-1.
- 2) One cubic meter (cubic yard) of fine grout shall consist of a minimum of 445 kg (750 pounds) portland cement, sand, and sufficient water to achieve a 250 mm (10 inch) slump. Admixtures may be used as specified or as approved by the Engineer.
- 3) Coarse grout shall conform to Concrete Class 360-E-14G (610-E-2000G).

**202-2.2.3 Water.** Water shall conform to the requirements of 201-1.2.3. The quantity of water to be used in the preparation of the mortar or grout shall be the minimum required to produce a mixture sufficiently workable for the purpose intended.

## **SECTION 203 - BITUMINOUS MATERIALS**

### **203-1 PAVING ASPHALT.**

**203-1.1 General.** Paving asphalt shall be a steam-refined asphalt produced from crude asphaltic petroleum or a mixture of refined liquid asphalt and refined solid asphalt. It shall be homogeneous and free from water and residues from distillation of coal, coal tar, or paraffin oil.

**203-1.2 Testing Requirements.** Asphalts shall be specified by viscosity grade and shall conform to the requirements in Table 203-1.2 (A).

**TABLE 203-1.2 (A)**

Specification Designation	ASTM Test No.	VISCOSITY GRADE				
		AR 1000	AR 2000	AR 4000	AR 8000	AR 16000
<b>TESTS ON RESIDUE FROM RTFO PROCEDURE Test Method No. California 346<sup>1</sup></b>						
Dynamic viscosity at 60° (140°F), 10 <sup>-1</sup> Pa·s (poise)	D 2171	750-1250	1500-2500	3000-5000	6000-10000	12000-20000
Kinematic viscosity (minimum) at 135°C (275°F), mm <sup>2</sup> /s (centistokes)	D 2170	140	200	275	400	550
Penetration (min.) at 25°C (77°F), 5 sec. at 100 gm, 0.1 mm	D 5	65	40	25	20	20
Percent of original penetration at 25°C (77°F), (minimum)	D 5	—	40	45	50	52
Ductility at 25°C (77°F), mm (minimum)	D 113	1000 <sup>2</sup>	1000 <sup>2</sup>	750	750	750
<b>TESTS ON ORIGINAL ASPHALT</b>						
Flash Point, Cleveland Open Cup °C (°F) (minimum)	D 92	205 (400)	215 (425)	225 (440)	230 (450)	235 (460)
Solubility in trichloroethylene, % (minimum)	D 2042	99	99	99	99	99

1. TFO may be used but RTFO shall be the reference method. Test on residue from RTFO procedure. California Test 346.

2. If the ductility at 25°C (77°F) is less than 1000 mm., the material will be acceptable if its ductility at 15°C (60°F) is more than 1000 mm.

**203-1.3 Test Reports and Certification.** At delivery time, the supplying vendor will deliver to the purchaser certified copies of the test report. This report shall indicate the vendor's name, type and grade of asphalt delivered, date and point of delivery, quantity delivered, ticket number, purchase order number, and results of specified tests. The certified test reports and the testing required in connection with the reports shall be at no cost to the Agency.

Until the certified test reports and samples of the material have been checked by the Engineer to determine their conformity with the prescribed requirements, the material to which such report relates and any work in which it may have been incorporated as an integral component, will be only tentatively accepted by the Agency. Final acceptance will be dependent upon the determination by the Engineer that the material involved fulfills prescribed requirements.

**203-1.4 Temperatures.** Asphalt shall not be heated during its manufacture, storage, or during construction so as to cause formation of carbonized particles. At no time shall the temperature be higher than 5°C (10°F) below the actual flash point of the asphalt, nor shall it be raised above 190°C (375°F) after loading into a tank car or truck for transport.

Unless otherwise specified, the various grades of asphalt shall be applied at a temperature range as indicated in the following table:

TABLE 203-1.4 (A)

ASPHALT GRADE	PUGMILL MIXING TEMPERATURE °C (°F)		DISTRIBUTION APPLICATION TEMPERATURE °C (°F)	
	Minimum	Maximum	Minimum	Maximum
	AR 16000	150 (300)	175 (350)	140 (285)
AR 8000	135 (275)	160 (325)	140 (285)	175 (350)
AR 4000	135 (275)	160 (325)	140 (285)	175 (350)
AR 2000	135 (275)	160 (325)	140 (285)	175 (350)
AR 1000	95 (200)	150 (300)	125 (260)	160 (325)

Asphalt shall be heated in such a manner that no steam or hot oils will be introduced into the asphalt during heating. The Contractor shall furnish and keep on the site an accurate thermometer suitable for determining the temperature of the asphalt.

**203-1.5 Distributing Equipment.** Distributing equipment shall meet the requirements of 203-2.5.

**203-1.6 Measurement and Payment.** For all volumetric quantities to be paid for at a Contract Price, the unit of measurement shall be the liter (U.S. gallon) at a temperature of 15°C (60°F).

In converting weight to volume, computations shall be based on the following:

TABLE 203-1.6 (A)

Grade of Material	Liters Per Tonne At 15°C (Gallons Per Ton At 60°F)	Grams Per Liter At 15°C (Lbs. Per Gallon At 60°F)
AR 16000	981 (235)	1020 (8.51)
AR 8000	981 (235)	1020 (8.51)
AR 4000	981 (235)	1020 (8.51)
AR 2000	989 (237)	1011 (8.44)
AR 1000	997 (239)	1002 (8.36)

## 203-2 LIQUID ASPHALT.

**203-2.1 General.** Liquid asphalt shall conform to the following classifications:

- 1) Slow curing products, designated by the letters SC, shall consist of natural crude oils or residual oils from refining of crude asphaltic petroleum, or products resulting from fluxing of a paving asphalt with a light oil.
- 2) Medium curing products, (MC), shall consist of a paving asphalt conforming to provisions in 203-1, fluxed or blended with a kerosene-type solvent.
- 3) Rapid curing products (RC), shall consist of a paving asphalt conforming to provisions in 203-1, fluxed or blended with a naphtha solvent.

**203-2.2 Test Reports and Certifications.** Test reports and certifications will be furnished in accordance with 203-1.3.

**203-2.3 Temperatures.** The asphalt shall not be heated during its manufacture, storage, or during construction so as to cause the formation of carbonized particles.

At no time after loading for transportation from the refinery to the purchaser, unless authorized by the Engineer, shall the temperature of the asphalt be raised above that given in the last column of the following table and in no case shall the temperature be higher than 5°C (10°F) below flash point. Unless authorized by the Engineer, no asphalt, except tack coats, shall be applied when the air temperature is lower than 5°C (40°F).

Unless otherwise specified, the various grades of asphalt shall be applied at a temperature range as indicated in table 203-2.3 (A):

TABLE 203-2.3 (A)

All Type of Liquid Asphalt	Pugmill Mixing Temp. for MC & SC Liquid Asphalts, °C (°F)		Distributor Application Temperature, °C (°F)	
	Minimum	Maximum	Minimum	Maximum
70	30 (90)	70 (155)	40 (105)	80 (175)
250	50 (125)	90 (200)	60 (140)	110 (225)
800	70 (160)	105 (225)	80 (175)	125 (225)
3000	95 (200)	125 (260)	100 (215)	145 (290)

The asphalt shall be heated in such a manner that no steam or hot oils will be introduced into the asphalt. The Contractor shall furnish and keep on the site an accurate thermometer suitable for determining the temperature of the asphalt.

**203-2.4 Test Requirements.** Liquid asphalt shall conform to the requirements in the following tables:

TABLE 203-2.4 (A)  
SLOW CURING PRODUCTS

Test Description	ASTM Test No.	GRADE			
		SC 70	SC 250	SC 800	SC 3000
Flash Point, C.O.C. °C (°F), Min.	D 92	65 (150)	80 (175)	90 (200)	105 (225)
Viscosity at 60°C (140°F) Kinematics, mm <sup>2</sup> /s (cSt)	D 2170	70-140	250-500	800-1600	3000-6000
Distillation Total Dist. to 360°C (680°F) Vol. %	D 402	10-30	4-20	2-12	0-5
Kinematic Viscosity on Residue at 60°C (140°F) mm <sup>2</sup> /s (cSt)	D 2170	400-7000	800-8500	2002-14000	4000-35000
Asphalt Residue of 100 Pen., % Min.	D 243	50	60	70	80
Ductility of Asphalt Residue at 25° (77°F) mm, Min.	D 113	1000	1000	1000	1000
Solubility in trichloroethylene, % Min.	D 2042	99.5	99.5	99.5	99.5
Water, % Max.	D 95	0.5	0.5	0.5	0.5
Heptane Xylene Equivalent, % Max. (AASHTO T-102)		35	35	35	35

**TABLE 203-2.4 (B)**  
**MEDIUM CURING PRODUCTS**

Test Description	ASTM Test No.	GRADE			
		MC 70	MC 250	MC 800	MC 3000
Flash Point (Tag Open Cup) °C (°F) Min.	D 3143	40 (100)	65 (150)	65 (150)	65 (150)
Viscosity at 60 °C (140 °F) Kinematic, mm <sup>2</sup> /s (cSt)	D 2170	70-140	250-500	800-1600	3000-6000
Distillation Distillate [% of total distillate to 360°C (680°F)]	D 402				
To 225°C (437°F)		0-20	0-10	0-3	0-2
To 260°C (500°F)		20-60	15-55	0-35	0-75
To 315°C (600°F)		65-90	60-87	45-80	15-75
Residue from distillation to 360°C (680°F) Volume percent by difference, Min.		55	67	75	80
Tests on Residue from Distillation Penetration at 25°C (77°F), 0.1 mm	D 5	120-250	120-250	120-250	120-250
Ductility, 25°C (77°F) mm, Min. <sup>1</sup>	D 113	1000	1000	1000	1000
Solubility in trichloroethylene, % Min.	D 2042	99.5	99.5	99.5	99.5
Water, % Max.	D 95	0.2	0.2	0.2	0.2
Heptane Xylene Equiv., % Max. (AASHTO T-102)	—	35	35	35	35

1. If penetration of residue is more than 200 and its ductility at 25°C (77°F) is less than 1000, the material will be acceptable if the ductility at 15°C (60°F) is greater than 1000 mm.

**TABLE 203-2.4 (C)**  
**RAPID CURING PRODUCTS**

Test Description	ASTM Test No.	GRADE			
		RC 70	RC 250	RC 800	RC 3000
Flash Point (Tag Open Cup) °C (°F), Min.	D 3143	—	27 (80)	27 (80)	27 (80)
Viscosity at 60°C (140°F) Kinematic mm <sup>2</sup> /s (cSt)	D 2170	70-140	250-500	800-1600	3000-6000
Distillation Distillate [% of total distillate to 360°C (680°F), Min.] To 190°C (374°F)	D 402				
To 225°C (437°F)		10	—	—	—
To 260°C (500°F)		50	35	15	—
To 315°C (600°F)		70	60	45	25
		85	80	75	70
Residue from Distillation to 360°C (680°F) Volume percent by difference, Min.		55	65	75	80
Tests on Residue from Distillation Penetration at 25°C (77°F), 0.1 mm	D 5	80-120	80-120	80-120	80-120
Ductility, 25°C (77°F) mm, Min. <sup>1</sup>	D 113	1000	1000	1000	1000
Solubility in trichloroethylene, % Min.	D 2042	99.5	99.5	99.5	99.5
Water, % Max.	D 95	0.2	0.2	0.2	0.2
Heptane Xylene Equiv., % Max. (AASHTO T-102)	—	35	35	35	35

**203-2.5 Distributing Equipment.** Distributors shall be of the pressure type with insulated tanks and shall be equipped with the following:

- 1) A tachometer of the auxiliary wheel type which registers speed in meters (feet) per minute.
- 2) Charts and devices to provide for accurate and rapid determination and control of the amount of asphalt being applied.
- 3) A hose and nozzle attachment to be used for areas inaccessible to the spray bar.
- 4) A pressure gage for determining application pressure.
- 5) A thermometer for determining temperature of the asphalt.

Distributors and booster tanks shall be so maintained as to prevent dripping of asphalt from any part of the equipment.

Spray bars shall have a minimum length of 2.7 m (9 feet). Spray bars and extensions shall be the full circulating type and be adjustable to permit varying height above the surface to be treated.

The nozzles attached to the bar shall be either conical or flat slotted. The distance center to center shall not exceed 150 mm (6 inches). The valves which control the flow from nozzles shall be of a positive acting design so as to provide a uniform unbroken spread of asphalt. Valves shall be operated so that all may be simultaneously opened or closed. Each valve shall also be capable of similar independent control.

Spreading equipment shall be so designed and articulated that uniform application of the asphalt may be made ranging from 0.1 L/m<sup>2</sup> to 4.5 L/m<sup>2</sup> (0.02 to 1.0 gallon per square yard) of surface and with a range of pressure from 170 to 515 kPa (25 to 75 psi).

Equipment which fails to produce a satisfactory distribution of asphalt, as determined by the Engineer, shall not be used.

Application of asphalt will not be permitted when, as determined by the Engineer, the surface to be treated is damp or weather conditions are unsuitable.

**203-2.6 Measurement and Payment.** For all volumetric quantities to be paid for at Contract Unit Price, the unit measure shall be the liter (U.S. gallon) at a temperature of 15°C (60°F).

In converting weight to volume, computations are based on the following:

**TABLE 203-2.6 (A)**

Grade of Material	Liters per Tonne (Gallons per Ton) @ 15°C (60°F)	Grams per Liter (Pounds per Gallon) @ 15°C (60°F)
70	1056 (253)	947 (7.90)
250	1039 (249)	962 (8.03)
800	1022 (245)	978 (8.16)
3000	1006 (241)	995 (8.30)

All types SC, MC, and RC of the same grade shall be considered to have equal weights per volume.

### **203-3 EMULSIFIED ASPHALT.**

**203-3.1 General.** Emulsified asphalt shall be composed of a paving asphalt base uniformly emulsified with water. It shall be homogeneous throughout and, when stored, shall show no separation within 30 days after delivery.

**203-3.2 Testing Requirements.** Emulsified asphalt shall conform to the requirements of Tables 203-3.2 (A) and (B).

**TABLE 203-3.2 (A) – ANIONIC EMULSIONS**

Test Description	ASTM Test Method No.	Rapid Setting <sup>4</sup>				Slow Setting			
		RS-1		RS-2		SS-1		SS-1h	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Furl Viscosity at 25°C (77°F), sec.	D 244	20	100			20	100	20	100
Furl Viscosity at 50° (122°F), sec.	D 244			75	400				
Settlement <sup>1</sup> 5 days, %	D 244		5		5		5		5
Storage Stability <sup>2</sup> 1 day	D 244		1		1		1		1
Demulsibility <sup>3</sup> (5mL 0.02N CaCl <sub>2</sub> ) %	D 244	60		60					
Sieve Test (Retained on 850 µm [No.20]), %	D 244		0.10		0.10		0.10		0.10
Cement Mixing Test, %	D 244						2.0		2.0
Residue from distillation, %	D 244	55		63		57		57	
Penetration of residue at 25°C (77°F), 0.1 mm	D 5	100	200	100	200	100	200	40	90
Solubility of residue, %	D 2042	97.5		97.5		97.5		97.5	
Ductility of residue at 25°C (77°F), mm	D 113	400		400		400		400	

1. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.
2. The 24-hour (1-day) storage stability test may be used instead of the 5-day settlement test.
3. The demulsibility test shall be made within 30 days from the date of shipment.
4. A harder base asphalt meeting current paving asphalt specifications may be specified with the provision that the test requirements on the Residue from Distillation be waived.

TABLE 203-3.2 (B) – CATIONIC EMULSIONS

TEST DESCRIPTION	ASTM Test No.	Rapid Setting <sup>4</sup>		Medium Setting			Slow Setting	
		CRS-1 Min. Max.	CRS-2 Min. Max.	CRS-2S Min. Max.	CMS-2 Min. Max.	CMS-2h Min. Max.	CSS-1 Min. Max.	CSS-1h Min. Max.
Furl Viscosity at 25°C (77°F), sec.	D 244						20 100	20 100
Furl Viscosity at 50°C (122°F), sec.	D 244	20 100	100 400	50 450	50 450	50 450		
Settlement <sup>1</sup> , 5 days, %	D 244	5	5	5	5	5	5	5
Storage Stability Test <sup>2</sup> 1 day	D 244	1	1	1	1	1	1	1
Demulsibility <sup>3</sup> 35 mL 0.8% sodium dioctyl sulfosuccinate, %	D 244	40	40					
Sieve Test (Retained on 850 µm [No. 20]), %	D 244	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Coating ability and water resistance:	D 244							
Coating, dry aggregate				Good	Good	Good		
Coating, after spraying				Fair	Fair	Fair		
Coating, wet aggregate				Fair	Fair	Fair		
Coating, after spraying				Fair	Fair	Fair		
Particle Charge Test	D 244	Positive	Positive	Positive	Positive	Positive	Positive	Positive <sup>5</sup>
Cement Mixing Test, %	D 244						2.0	2.0
Oil distillate by vol. of emulsion, %	D 244	3	3	20	12	12		
Residue from distillation, %	D 244	60	65	60	65	65	57	57
Penetration of residue at 25°C (77°F), 0.1 mm	D 5	100 250	100 250	100 250	100 250	40 90	100 250	40 90
Solubility of residue, %	D 2042	97.5	97.5	97.5	97.5	97.5	97.5	97.5
Ductility of residue 25°C (77°F), mm	D 113	400	400	400	400	400	400	400

1. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the purchaser may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.

2. The 24-hour (1-day) storage stability test may be used instead of the 5-day settlement test.

3. The demulsibility test shall be made within 30 days from the date of shipment.

4. A harder base asphalt meeting current paving asphalt specifications may be specified with the provision that the test requirements on the Residue from Distillation be waived.

5. Must meet a pH requirement of 6.7 maximum (ASTM E-70) if the Particle Charge Test result is inconclusive.

**203-3.3 Test Reports and Certification.** Test reports and certification shall be made in accordance with 203-1.3.

**203-3.4 Temperatures.** Emulsified asphalt may be reheated, but at no time after loading for transportation from the refinery to the purchaser shall the temperature of the emulsion be raised above 70°C (160°F). During reheating, the emulsified asphalt shall be agitated to prevent localized overheating. Emulsified asphalt shall not be permitted to cool to a temperature less than 5°C (40°F).

Unless otherwise specified, emulsified asphalts shall be applied at temperatures within the limits specified below:

TABLE 203-3.4 (A)

Grade of Emulsified Asphalt	Mixing Temperatures of Pug Mill °C (°F)		Application Temperature °C (°F)	
	Min.	Max.	Min.	Max.
RS-1, CRS-1			25 (75)	55 (130)
RS-2, CRS-2			45 (110)	70 (160)
SS-1, CSS-1	10 (50)	55 (130)	25 (75)	55 (130)
SS-1h, CSS-1h	10 (50)	55 (130)	25 (75)	55 (130)
CMS-2, CMS-2S, CMS-2h	15 (60)	60 (140)	40 (100)	70 (160)

Emulsified asphalt shall be heated in such a manner that no steam or hot oils will be introduced into the asphalt. The Contractor shall furnish and keep on the site an accurate thermometer suitable for determining the temperature of the emulsified asphalt.

**203-3.5 Distributing Equipment.** Distributing equipment shall be the same as specified in 203-2.5 except that hand spraying by means of hose or bar through a gear pump or air tank will be acceptable for applications to  $0.45 \text{ L/m}^2$  (0.10 gal per square yard) for flat work or tacking of vertical edges. Uniform coverage will be required.

**203-3.6 Measurement and Payment.** For all volumetric quantities to be paid for at Contract Unit Price, the unit of measurement shall be the liter (U.S. gallon) at a temperature of  $15^\circ\text{C}$  ( $60^\circ\text{F}$ ).

In converting weight to volume, computations shall be based on the following, for all grades:

Liters per Tonne = 1002 (Gallons per ton = 240)

Liters per Tonne = 998 (Pounds per gallon = 8.33)

#### 203-4 AIR-REFINED ASPHALT.

**203-4.1 General.** Air-refined asphalt is intended for use in subsealing existing concrete pavements. It shall be a mixture of refined liquid asphalt and refined solid asphalt prepared from crude asphaltic petroleum. It shall be homogeneous and free from water and residues.

**203-4.2 Testing Requirements.** Air-refined asphalt shall conform to the following requirements:

TABLE 203-4.2 (A)

Test Description	ASTM Test Method No.	Requirement
Penetration of Original Sample at $25^\circ\text{C}$ ( $77^\circ\text{F}$ ), 0.1 mm	D 5	10-25
Flash Point, C.O.C. $^\circ\text{C}$ ( $^\circ\text{F}$ ), Min.	D 92	230 (450)
Loss on heating, 5 hrs. at $163^\circ\text{C}$ ( $325^\circ\text{F}$ ), % Max.	D 1754	1
Penetration after loss at $163^\circ\text{C}$ ( $325^\circ\text{F}$ ), % of Original Pen., Min.	D 5	75
Softening Point $^\circ\text{C}$ ( $^\circ\text{F}$ )	D 36	82-93 (180-200)
Ductility at $25^\circ\text{C}$ ( $77^\circ\text{F}$ ) mm, Min.	D 113	10
Solubility in trichloroethylene, %, Min.	D 2042	97
Solubility in $\text{CS}_2$ , % Min.	D 4	98

**203-4.3 Test Reports and Certification.** Test reports and certification shall be made in accordance with 203-1.3.

**203-4.4 Delivery and Pumping.** The asphalt shall be delivered to the project in insulated pressure distributor vehicles. Tanks for distributors shall have a minimum capacity of 7500 L (2,000 gallons) and be equipped with removable manhole covers, a minimum 50 mm (2 inch) overflow pipe, and suitable strainers at the outlets to the pumps. A metal bar approximately 3 by 13 mm ( $1/8$  by  $1/2$  inch) calibrated to accurately indicate the contents of the tank in 40 L (10-gallon) increments, shall be provided.

Distributors shall be equipped with heating systems consisting of torch-generating type burners and heat flues having sufficient radiation to insure the rapid circulation of hot gases from the burners. Pressure tanks for the burners shall be equipped with pressure gauges and shall be of such capacity to insure efficient operation of the heating system. Heating devices shall be capable of maintaining a uniform temperature of the asphalt of not less than  $175^\circ\text{C}$  ( $350^\circ\text{F}$ ) during the period of pumping. In no case shall the temperature of the asphalt be raised to more than  $5^\circ\text{C}$  ( $10^\circ\text{F}$ ) below the actual flash point.

A thermometer with a 150 to 230°C (300 to 450°F) range shall be so mounted in the tank as to accurately indicate the temperature of the asphalt. Tanks shall be so equipped and operated that the asphalt will be circulated or agitated throughout the entire process.

The distributor truck shall be equipped with a pump of the rotary positive pressure type, capable of pumping asphalt at a pressure between 140 kPa and 410 kPa (20 and 60 psi) through two full circulating delivery lines at the same time, so arranged that either line can be used separately. A pressure gage shall be provided to show pressure at which asphalt is being applied. A bypass regulator shall be provided and the pump shall be reversible. The minimum inside diameter of the return lines and connections shall be 38 mm (1-1/2 inches). All lines and nozzles shall be furnished by the Contractor unless otherwise specified.

The distributor truck shall be equipped with a water tank having a minimum capacity of 380 L (100 gallons) and a pump with hose and nozzle capable of spraying water on the working area at a pressure of 140 kPa (20 psi).

**203-4.5 Measurement and Payment.** For all volumetric quantities to be paid at Contract Unit Price, the unit of measure shall be the liter (U.S. gallon) at a temperature of 15°C (60°F).

In converting weight to volume, computations shall be based on the following for grades 10-25:

Liters per Tonne = 976 (Gallons per ton = 234)

Grams per Liter = 1026 (Pounds per gallon = 8.56)

### 203-5 EMULSION-AGGREGATE SLURRY.

**203-5.1 General.** Emulsion-aggregate slurry shall be a stable mixture of emulsified asphalt, mineral aggregate, water, and when specified, accelerator or retardant and is herein referred to as slurry. Mixing and spreading of slurry shall be as described in 302-4.

**203-5.2 Materials.** The ingredients of the slurry shall conform to the following:

- 1) Emulsified asphalt shall be of a slow-set or quick-set type. The slow-set type shall conform to the requirements of SS-1h or CSS-1h of 203-1.3, Test Reports and Certification, and 203-3.2, Testing Requirements. The quick-set type shall be cationic unless otherwise specified and shall conform to the requirements of CQS-1h of 203-1.3, Test Reports and Certification, and to the following specifications when tested according to appropriate ASTM Methods:

**TABLE 203-5.2 (A) – QUICK SET EMULSION<sup>1</sup>**

Tests	ASTM Test Method	Requirements	
		Min.	Max.
Furol Viscosity at 25°C (77°F), sec.	D 244	15	100
Residue from distillation, % by weight	D 244	60 Min.	
Sieve Test (% retained on 850 µm [No. 20])	D 244	0.10 Max.	
Particle Charge Test (Cationic)	D 244	Positive	
Particle Charge Test (Anionic)	D 244	Negative	
Storage Stability; 1-Day Settlement	D 244	1% Max.	
<b>Residue</b>			
Penetration 0.1 mm	D 5	45	80
Solubility in TCE, %	D 2042	97.5 Min.	
Ductility, 25°C (77°F), mm	D 113	400 Min.	

1. Table does not apply to latex or polymer modified emulsion.

- 2) The additives for quick- and slow-setting emulsion and the asphalt modifier shall be a type approved by the Engineer. The amount of additive and asphalt modifier to be included in the

quickset slurry shall be that amount necessary to ensure that the applied slurry can support vehicular traffic within 60 minutes after the last application.

- 3) Water shall be potable and compatible with the other ingredients of the slurry.
- 4) The Contractor shall provide an aggregate stockpile 24 hours prior to starting the work.
- 5) Aggregate shall be rock dust or other mineral aggregates approved by the Engineer and shall conform to the requirements of Section 200. The aggregate without any additive shall conform to the following requirements:

**TABLE 203-5.2 (B)**

Tests	ASTM Test Method	Requirements
Percentage Wear 500 Revolutions <sup>1</sup>	C 131	40% Maximum
Sand Equivalent	D 2419	55% Minimum
Soundness (5 Cycles) <sup>1</sup>	C 88	15% Maximum

1. ASTM C 131 to be run on plus four graded material before final crushing.

**203-5.3 Composition and Grading.** The grading of the combined aggregate and the percentage of emulsified asphalt shall conform to the requirements indicated in Table 203-5.3 (A).

**TABLE 203-5.3 (A)**

Requirements	Type I	Type II
	% of Combined Aggregate Passing Sieves	% of Combined Aggregate Passing Sieves
9.5 mm (3/8 in)	100	100
4.74 mm (No. 4)	100	90 - 100
2.36 mm (No. 8)	90 - 100	65 - 90
1.18 mm (No. 16)	65 - 90	45 - 70
600 µm (No. 30)	40 - 60	30 - 50
300 µm (No. 50)	25 - 42	18 - 36
150 µm (No. 100)	15 - 30	10 - 24
75 µm (No. 200)	10 - 20	5 - 15
Emulsified Asphalt % of Dry Aggregate Weight (Must meet Residual Asphalt requirement)	17 - 20	14 - 18
Residual Asphalt % of Dry Aggregate Weight	10 min.	7.5 min.

**203-5.4 Mix Design.** The Contractor, at its expense, shall submit for Engineer approval laboratory reports of mix designs performed in accordance with ASTM D 3910 procedures, utilizing the specific materials to be used. ASTM D 3910 procedures shall be modified to include the retained 4.75 mm (No. 4) aggregate if present in the mix design. The Engineer will approve the mix proportions that are best suited for use on the project, based upon the emulsion content and water needed to produce a slurry with a maximum loss of 540 grams per square meter (50 grams per square foot) by the modified Wet Track Abrasion Test. For mix designs containing more than 4% aggregate retained on the 4.75 mm (No. 4) sieve, the maximum loss will be 650 grams per square meter (60 grams per square foot).

The Contractor, at its expense, shall calibrate each slurry mixer to be used in the work according to the approved slurry mix design. The Contractor shall allow 2 days prior to the start of work for calibration and testing at a location to be approved by the Engineer. The Engineer will obtain field samples at the time of calibration for

Extraction Test (ASTM D 2172, California Test 382), Consistency Test, and Wet Track Abrasion Test (Modified ASTM D 3910). When in the judgment of the Engineer, the field samples meet the requirements stipulated in these specifications, the Engineer will notify the Contractor to start the work.

### **203-6 ASPHALT CONCRETE.**

**203-6.1 General.** Asphalt concrete shall be the product of mixing mineral aggregate and a maximum of 15% reclaimed asphalt pavement (RAP) with paving asphalt conforming to 203-1 at a central mixing plant. RAP shall conform to 203-7.2.2, except the viscosity of paving asphalt recovered from the RAP in accordance with ASTM D 1856 (Absorption Recovery Method) will not be required. The content of the paving asphalt recovered from the RAP, if required in the Special Provisions, shall be determined in conformance with California Test 382.

Asphalt concrete will be designated by class and grade (i.e., "C2-AR-4000") and shall conform to the requirements in this section. Asphalt concrete containing up to 15% RAP shall be identified by adding the suffix RAP to the class and grade (i.e., "C2-AR4000-RAP").

### **203-6.2 Mix Designs**

The Contractor shall submit for approval an asphalt mix design for each class and grade of asphalt concrete required to construct the Work. The asphalt concrete mix design method shall be Hveem with the optimum asphalt content determined by California Test 367. The selected aggregate gradation shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but to be uniformly graded from coarse to fine when tested in accordance with ASTM C136 and C117 or California Test 202. The target S-value at the "Optimum Binder Content" for the mix design shall be at least two points above the minimum listed in Table 203-6.4.3(A).

The submittal shall identify the gradation, optimum binder content, void content, RAP percentage and stability values. The mix design shall meet the requirements of Table 203-6.4.3(A) for the class specified on the plans or in the Special Provisions. These values are to be used for design only.

When the mix design is more than 30 days old, it shall be supplemented with a mix certificate that states that the combined gradation is +/- 3% from the referenced mix design based on a 30 day moving average or a minimum of the 10 most current results. The mix design shall be redone whenever the combined grading as defined above does not meet the previously submitted mix design by +/- 3 percentage points on any screen even though it may be within the target values. If the source of any aggregate is changed, grade of binder is changed, or the mix design is over two years old a new mix design shall be submitted to the Engineer for approval. In addition to furnishing all the parameters required to prepare a mix design, plant identification, mix number, the source and individual grading of each material used to make the mix design, (this includes the percentage and individual gradation of both manufactured and natural sands), and the source and grade of binder shall also be submitted. Batch type plants shall obtain their samples from the bins and drum type plants shall obtain their individual samples from under the feeders.

The Contractor shall receive approval of all required asphalt mix designs for the Work before production of any asphalt concrete.

### **203-6.3 Materials.**

**203-6.3.1 Asphalt.** The asphalt binder to be mixed with the aggregate shall be paving asphalt or liquid asphalt conforming to 203-1 or 203-2 and the grade shall be specified by the Agency or its representative.

**203-6.3.2 Aggregate.** Coarse aggregate shall be crushed rock conforming to 200-1.2.

Fine aggregate for asphalt concrete shall be sand, rock dust, mineral filler, or a blend of these materials. Sand shall conform to the requirements of 200-1.5.2. Rock dust shall conform to the requirements of 200-1.2.

If the fine aggregate for asphalt concrete is deficient in material passing the 75  $\mu\text{m}$  (No. 200) sieve, mineral filler conforming to requirements of 203-6.3.3 shall be added to meet the combined grading.

If the combined aggregate grading conforms to the grading of its designated class in 203-6.4.2, the individual grading required by 200-1.2 may be waived. Percentages for the combined gradings, within the specified limits, shall be of such uniformity that the material passing the indicated sieves during any day's run will not exceed the maximum variation as specified in 203-6.4.2.

**203-6.3.3 Mineral Filler.** Mineral filler shall consist of portland cement or mechanically reduced rock. Mechanically reduced rock shall conform to the grading in Table 203-6.3.3 (A) when tested in accordance with ASTM D 422:

**TABLE 203-6.3.3 (A)**

Particle Size	Percentage
Passing 75 $\mu\text{m}$ (No. 200) Sieve	75 - 100
Finer than 0.05 mm	65 - 100
Finer than 0.02 mm	35 - 65
Finer than 0.01 mm	26 - 35
Finer than 0.005 mm	10 - 22

#### **203-6.4 Asphalt Concrete Mixtures.**

**203-6.4.1 General.** Acceptance of plant produced mixtures will be based upon gradation, binder content, and minimum stability values per Table 203-6.4.3 (A). Air Void Values are not to be used as acceptance criteria. The asphalt concrete shall be sampled in conformance with the requirements of California Test 125. The S-value test results shall conform to the moving average provisions of 400-1.1.3, except that no individual test result shall be found acceptable if it is more than 3 points below the minimum S-value listed in Table 203-6.4.3(A). The S-value result shall be the average of 3 tests from one sample representing 1000 tons or a single day's paving, whichever is less. If the range of stabilities for the 3 tests is more than 10, then the sample shall be discarded and a new sample shall be obtained and retested.

**203-6.4.2 Combined Aggregates.** Combined aggregates, after all processing except the adding of asphalt and mineral filler, shall have a minimum sand equivalent of 50 when tested by California Test 217.

When there is a difference in specific gravity (bulk saturated surface dry per ASTM C 127 and 128) of 0.2 or more between that portion retained and that portion passing a 4.75 mm (No. 4) sieve, the grading shall be modified as provided by California Test 105.

**203-6.4.3 Composition and Grading.** The grading of the combined aggregates and the percentage of asphalt binder shall conform to the requirements indicated in the following tabulations in which the percentages shown are based on the weight of dry aggregate only (Outside):

TABLE 203-6.4.3 (A)

Sieve Size	Percentage Passing Sieves							
	A	B	C1	C2	D1	D2	E	F
	Dense Coarse	Dense Medium Coarse	Open Medium	Dense Medium	Open Fine	Dense Fine	Extra Fine	Channel Liner
37.5 mm (1-1/2 in)	100							
25 mm (1 in)	90-100	100						
19.0 mm (3/4 in)	78-90	87-100	100	100				
12.5 mm (1/2 in)	64-78	70-87	90-100	95-100	100	100		
9.5 mm (3/8 in)	54-68	55-76	72-88	72-88	90-100	95-100	100	100
4.75 mm (No. 4)	34-48	35-52	40-54	46-60	40-54	58-72	65-85	95-100
2.36 mm (No. 8)	25-35	22-40	18-34	28-42	20-32	34-48	45-65	70-84
600 µm (No. 30)	12-22	8-24	8-20	15-27	6-18	18-32	22-38	36-50
300 µm (No. 50)	8-16	5-18	4-14	10-20	2-12	13-23	16-28	23-35
75 µm (No. 200)	3-6	0-7	1-6	2-7	0-5	2-9	6-12	6-12
Asphalt Binder %	4.5-5.5	4.5-5.8	4.6-6.0	4.6-6.0	4.8-6.5	4.8-6.5	5.8-7.8	8.0-10.0
Hveem Stability								
"S" Value (min.)	35	35	33	33	30	30		
Air Voids*	4%	4%	4%	4%	4%	4%		

\* Per CTM 367

The Hveem stability ("S") value shall be per California Tests 304 and 366.

When highly absorptive aggregate with a K factor greater than 1.7 per California Test 303 is used, the maximum percentage for asphalt binder may be increased up to 2.0 percentage points over the values shown in the table. Percentages for the combined gradings, within the specified limits shall be of such uniformity that material passing the indicated sieves during any day's run will not exceed the following maximum variations:

- 4.75 mm (No. 4) Sieve - 6 percentage points
- 600 µm (No. 30) Sieve - 5 percentage points
- 75 µm (No. 200) Sieve - 3 percentage points

The gradations in the above tabulations represent the limits which shall determine the suitability of aggregate for use from the sources of supply.

### 203-6.5 Aggregate Storing, Drying, and Screening.

**203-6.5.1 General.** The sand, rock dust, and various sizes of aggregates shall be stored separately at the plant. They shall be evenly fed to the dryer to ensure a uniform flow of properly combined aggregates. In placing materials in storage or in moving them from storage to feeder, no method shall be used which may cause segregation, degradation, or intermingling of different size aggregates. Materials not meeting the gradation requirements shall be discarded or reprocessed to comply with requirements of 203-6.3.2.

**203-6.5.2 Batch Plant Method.** The aggregates shall be dried and heated for a sufficient time in the dryer so that the moisture content will not be greater than 1 percent.

The dryer shall be provided with an approved heat indicating device in order that the temperature of the aggregate leaving the dryer may be determined. The heat indicating device shall be independently mounted from other plant components, accurate to the nearest 5°C (10°F), and shall be installed in such a manner that fluctuation of 5°C (10°F) in the aggregate temperature will be indicated within 1 minute.

After drying, the aggregates shall be evenly fed to the screens in such quantities as to maintain, in separate bins, a uniform grading of materials and proper balance in the amount of material. The operation of the screens shall be so controlled as to secure a thorough separation of aggregate sizes.

TABLE 203-6.5.2 (A)

Size of Openings	Bin No.
<b>4-Bin Plants</b>	
100% passing 37.5 mm (1-1/2 in) sieve	4
100% passing 16.0 mm (5/8 in) sieve	3
100% passing 9.5 mm (3/8 in) sieve	2
100% passing 4.75 mm (No. 4) sieve	1
<b>5-Bin Plants</b>	
100% passing 37.5 mm (1-1/2 in) sieve	5
100% passing 22.4 mm (7/8 in) sieve	4
100% passing 16.0 mm (5/8 in) sieve	3
100% passing 9.5 mm (3/8 in) sieve	2
100% passing 4.75 mm (No. 4) sieve	1

Screens having clear square openings shall be used to separate and classify materials for the hot storage bins. The aggregate passing these screens shall be separately stored in individual bins until proportioned into the mixer as described in 203-6.6.

The No.1 bin shall not contain more than 10 percent of material retained on the 2.36 mm (No. 8) sieve. The remaining bins shall not contain more than 10 percent of material which will pass through the following sizes:

TABLE 203-6.5.2 (B)

Bin. No.	Sieve Size
2	2.36 mm (No. 8)
3	4.75 mm (No. 4)
4	9.5 mm (3/8 in)
5	9.5 mm (3/8 in)

Each bin shall be provided with an opening to prevent overflow into adjacent bins. All overflow material shall be discarded or returned to the appropriate storage area. All material fed to the No. 4 bin shall pass through the screen over that bin and the oversize rock shall be discarded or returned to the appropriate storage area.

If at any time there is a substantial change made in the cold feed to accommodate the demands of a different type of mixture, the hot storage bins shall be emptied and recharged with the correct materials. Discharged material may be returned to a storage area that contains aggregates of the approximate grading of the discharged material.

**203-6.5.3 Drier-drum Method.** When a drier-drum is used, aggregate shall be fed directly to the mixer at a uniform rate.

At the time of spreading, mixtures produced in the drier-drum shall not contain more than 1 percent moisture. Moisture content will be determined by California Test 310, 311, or 370.

A device shall be provided which indicates the temperature of the mixed material leaving the drum. The device shall be accurate to 5°C (10°F) and shall be installed in such a manner that a temperature change of 5°C (10°F) in the mixed material will be shown within 1 minute. The temperature indicator shall be located and maintained at the location where the proportioning operations are controlled.

### 203-6.6 Proportioning.

**203-6.6.1 Batch Plant Method.** All materials shall be proportioned by weight. Volumetric proportioning will not be permitted. The zero tolerance for aggregate scales, asphalt binder scales, and, when used, mineral filler scales shall be 0.5 percent based on the total batch weight of the aggregate.

The indicated weight of material drawn from storage for any material shall not vary from the preselected setting by more than the following percentages based on the total batch weight of the aggregate:

Aggregate	1.0 percent
Mineral Filler	0.5 percent
Asphalt Binder	0.1 percent

Automatic proportioning devices shall be operated so that all weight increments required for a batch are preset on the controls at the same time. The discharge from the several bins shall be interlocked so that only one bin can discharge onto a given scale at a time and that no new batch may be started until all weigh hoppers are empty, the scales are at zero and the discharge gate is closed. The interlock shall prevent the weigh box from discharging until the required quantity of each bin and the other weighing devices have been properly filled and weighed. The proportioning controls shall be equipped with means for inspection of the interlock tolerance settings. Instructions for determining these settings shall be posted at the control panel for the Engineer's use.

When bag house fines or mineral filler is used, it shall be proportioned by weight by a method that uniformly feeds the materials within 10 percent of the required amount.

**203-6.6.2 Drier-drum method.** Asphalt binder shall be measured through a meter calibrated and certified for accuracy by one of the agencies designated in 4-1.7. The asphalt meter shall automatically compensate for changes in asphalt temperature. The system shall be capable of varying the rate of delivery of binder proportionate with the delivery of aggregate. During any day's run, the temperature of the binder shall not vary more than 30°C (50°F). The meter and lines shall be heated and insulated. The storage tank for the binder shall be equipped with a device for automatic plant cutoff when the level of binder in the tank is lowered sufficiently to expose the pump suction line.

When bag house fines or mineral filler is used, it shall be proportioned by weight or volume by a method that uniformly feeds the material within 10 percent of the required amount and shall discharge the material directly into the mixer in proximity to where the binder is added.

The feeders for each material in the mixture and for combined aggregates shall be equipped with devices by which the rate of feed can be determined while the plant is in full operation.

The combined aggregate shall be weighed on a belt scale. The belt scale shall be of such accuracy that, when the plant is operating between 30 and 100 percent of belt capacity, the average difference between indicated weight of the material delivered and actual weight will not exceed 1 percent of the actual rate for three 3-minute runs. For any of the three individual 3-minute runs, the indicated weight of the material delivered shall not vary from the actual weight delivered by more than 2 percent of the actual weight. The actual weight of material delivered shall be determined by a vehicle platform scale.

The belt scale for the combined aggregate, other proportioning devices, and the binder proportioning meter shall be interlocked so that the rates of feed of the aggregates and binder will be adjusted automatically to maintain the binder ratio of dry aggregate designated by the Engineer. The plant shall not be operated unless this automatic system is operating and in good working condition.

Binder meters and aggregate belt scales used for metering the aggregates and binder into the mixer shall be equipped with rate of flow indicators to show the rates of delivery of asphalt and aggregates and resettable totalizers, so that the actual weight of binder and aggregate introduced can be determined. Rate of flow indicators and totalizer for like materials shall be accurate to within 1 percent when compared directly. The asphalt totalizer shall not register when the asphalt metering system is not delivering material to the mixer. The bin containing the fine aggregate, and bag house fines and mineral filler, if used, shall be equipped with a vibrating unit or other equipment which will prevent any hang-up of material while the plant is operating. Before the quantity of material in any one bin reaches strike-off capacity of the feed gate, a device shall automatically close down the plant.

The Contractor shall determine the moisture content of the aggregate at least once during each 2 hours of production and shall adjust the moistures control equipment accordingly.

An aggregate sampling device which will provide a 25 to 40 kg (60-to-80-pound) sample of the combined aggregate while the plant is in full operation shall be provided in advance of the point where the aggregate enters the drier-drum mixer.

When bag house fines or mineral filler is used, a safe and suitable sampling device shall be installed in each feed line or surge tank preceding the proportioning device.

### **203-6.7 Mixing.**

**203-6.7.1 General.** All aggregates, asphalt binder, and RAP, where applicable, shall be mixed in a batch or drier drum plant. The temperature of the completed mixtures, using paving asphalt, at the point of discharge from the plant shall not exceed 163°C (325°F) nor be less than 135°C (275°F). The temperature of the mixture at the Work site shall be as specified in 302-5.5.

Uniformity of distribution of binder will be determined by an extraction test made in accordance with any of the following test methods or other published test methods approved by the Engineer:

- ASTM D 2172
- California Test Method 382
- ASTM D 4125
- California Test Method 362

The binder ratio, kilograms of binder per 100 kilograms of dry aggregate (pounds of binder per 100 pounds of dry aggregate), shall not vary by more than 5 percent above or 10 percent below the amount designated by the Engineer. This requirement shall apply to samples taken from a single batch at any location or operation designated by the Engineer.

**203-6.7.2 Batch Plant Method.** The mixer shall be of the twin-shaft pug mill type and operated at the speed recommended by the manufacturer. It shall be equipped with paddles of sufficient size and number to deliver a uniform mixture. Should the paddles or other parts of the pug mill become worn to such extent as to adversely affect quality of mixing or allow leakage from the discharge gate, they shall be promptly replaced.

The weight of material that may be mixed per batch shall not exceed the manufacturer's rated capacity of the mixer, nor exceed that which will permit complete mixing of all the materials. Dead areas in the mixer shall be corrected either by a reduction in the volume of materials or by other adjustments.

The entire batch shall be continuously mixed until all the materials are thoroughly blended. The batch mixing time shall begin on the charging stroke of the weigh hopper dump mechanism and shall end when discharge from the mixer has started. The mixer shall be equipped with a time lock mechanism which locks the mixer discharge gate for the mixing period and actuates an indicator light by the charging stroke of the weigh hopper charging mechanism. The indicator light shall be so located as to be visible from the operator's platform and from the Engineer's field laboratory.

The minimum mixing time shall be 35 seconds, of which 5 seconds shall be drop time for the aggregate and asphalt into the mixer. If drop time exceeds 5 seconds, the additional time will be added to the 35 seconds. If the Engineer determines that the mixture is not thoroughly blended, the mixing time shall be increased.

The mixer, weigh hopper, and sampling platforms shall be of ample size to provide safe and convenient access to the mixer and other equipment. Weighbox housings shall be provided with gates of ample size to permit ready sampling of the discharge of aggregates from each of the plant bins.

**203-6.7.3 Drier-drum Method.** Mixing shall continue for a sufficient time and at a sufficiently high temperature, that, at discharge from the mixer, the sizes of aggregates are uniformly distributed through the completed mixture and all particles are thoroughly and uniformly coated with binder.

The mixed material shall be discharged from the drum into the silo. The Contractor shall provide a means of diverting flow of material away from the silo, when starting and stopping the plant production, to prevent incomplete mixed portions of the mixture from entering the silo. The burner used for heating the aggregate shall achieve complete combustion of the fuel.

**203-6.8 Asphalt Concrete Storage.** Asphalt concrete shall be stored in insulated silos with heated discharge cones, unless the silo is being used for storage purposes. The storage silo shall be equipped to prevent segregation of the completed mixture as it is discharged into the silo. Asphalt concrete with hardened lumps in the mixture shall not be used.

**203-6.9 Miscellaneous Requirements.** Paving asphalt shall be added to the aggregate at a temperature conforming to the range of temperatures found in 203-1.4.

Liquid asphalt shall be added to the aggregate at a temperature conforming to the range of temperatures provided in 203-2. The temperatures of the aggregates at the time of adding the asphalt binder shall not be in excess of maximum applicable pug mill mixing temperature provided for in 203-2.3. The temperature of the aggregates may be designated by the Engineer.

A temperature-indicating device reading to 260°C (500°F) and accurate to 5°C (10°F) shall be fixed in the binder feed line or storage tank. An indicator shall be located and maintained where the proportioning operations are controlled. The discharge end of the binder circulating pipe shall extend to within 0.3 m (1 foot) of the bottom of the storage tank.

The Contractor shall provide a suitable sampling outlet in the binder feed lines connecting the plant storage tanks to the binder weighing system or spray bar. The sampling valve shall consist of a 13 mm or 19 mm (1/2 inch or 3/4 inch) valve constructed in such a manner that a 1 liter (1-quart) sample may be withdrawn slowly at any time during plant operations, and shall be placed in a nonhazardous location. A drainage receptacle shall be provided for flushing the valve prior to sampling. Four liters (one gallon) shall be drawn from the sampler prior to taking the sample.

The beds of trucks used to haul asphalt concrete may be coated with an EPA and Agency approved bond breaker before loading. Amounts of bond breaker that form visible pools in the truck bed shall be removed prior to loading asphalt concrete. Beds of trucks hauling curb mixes may be sprinkled with mineral filler.

The temperature of asphalt concrete discharged into hauling vehicles shall not vary more than 10°C (20°F) for successive loads. When hauling time from mixing plant to jobsite exceeds 2 hours, or when atmospheric temperature is below 10°C (50°F), or when rain is falling along the haul route, asphalt concrete shall be completely covered with tarpaulins, which are fully secured, during transport. Asphalt concrete shall be delivered to the site of the Work, without segregation of the ingredients and within the temperature range specified in 302-5.5.

When dissimilar surface course mix characteristics are the result of multiple plant delivery, the Engineer may require delivery from only one plant for any one day's production.

### **203-7 RECYCLED ASPHALT CONCRETE-HOT MIXED.**

**203-7.1 General.** Recycled Asphalt Concrete (RAC) shall be the product of mixing reclaimed asphalt pavement, new aggregates and asphalt and/or recycling agent.

RAC will be designated by Class and Grade, i.e., C2-AR-4000-RAC, and shall conform to requirements in this subsection. The end product shall meet both the gradation and asphalt grade specified.

#### **203-7.2 Materials.**

**203-7.2.1 Aggregate.** New aggregate shall conform to 203-6.3.2.

**203-7.2.2 Reclaimed Asphalt Pavement.** Reclaimed Asphalt Pavement (RAP) is pavement containing asphalt and aggregates which has been processed to 37.5 mm (1-1/2 inches) maximum size and is free of detrimental quantities of deleterious materials. The stored RAP shall be uniform in appearance and well graded from fine to coarse.

The RAC supplier shall perform sand-equivalent tests of the unextracted RAP, and tests of RAP asphalt content, RAP asphalt viscosity and gradation of RAP aggregates of solvent extracted samples of RAP taken from stockpiles. Solvent extractions shall be performed in accordance with ASTM D 2172 or California Test 362 and the RAP asphalt shall be recovered in accordance with ASTM D 1856 (Abson Recovery Method). The minimum sand equivalent value of the unextracted RAP shall be 80, when determined in accordance with California Test 217.

The supplier shall maintain current records of the test results at the plant and make them available to the Engineer for its information and use in the approval of RAC mixes. The reports shall be made available prior to use of any RAC in the project.

**203-7.2.3 RAC Bituminous Materials.** RAC bituminous materials shall conform to the following:

- 1) New asphalt shall be paving asphalt conforming to 203-1.
- 2) RAP asphalt shall be defined as the bituminous material present in RAP. The quantity of RAP asphalt shall be determined by solvent extraction of RAP. The quality of RAP asphalt shall be determined by tests performed on the asphaltic residues obtained from the Abson Recovery Method.
- 3) New binder shall be defined as the combined new asphalt and/or recycling agent added to RAP and new aggregates to create RAC.
- 4) RAC binder shall be defined as the total bituminous material present in RAC; consisting of the blend of RAP asphalt, new asphalt and/or recycling agent. The quality of the RAC binder shall be determined by tests performed on the asphaltic residues obtained from the Abson Recovery Method.

The test results of the RAC binder shall meet the RTFO residue requirements in 203-1.2 for the AR grade specified, except the Percent of Original Penetration is not required.

**203-7.2.4 Mineral Filler.** Shall meet requirements of 203-6.3.3.

**203-7.2.5 Recycling Agent.** Recycling Agent (RA) shall comply with Table 203-7.2.5 (A):

**TABLE 203-7.2.5 (A)<sup>1</sup>**

TEST	ASTM Test Methods	RA 5		RA 25		RA 75		RA 250		RA 500	
		Min.	Max.								
Kinematic Viscosity at 60°C (140°F) (cSt) mm <sup>2</sup> /s	D 2170 or D 2171	200	800	1000	4000	5000	10000	15000	35000	40000	60000
Flash Point, COC, COC °C (°F), Min.	D 92 D 2007	205 (400)	25	215 (425)	25	230 (450)	25	230 (450)	25	230 (450)	25
Saturated Wt. %, Max. Residue from RTFO Oven Test at 163°C (325°F)	D 2872 -	3		3		3		3		3	
Viscosity Ratio <sup>2</sup> Max. RTFO Oven Weight Change, ±, %	D 2872 D 70 or D 1298	4	Report	3	Report	2	Report	2	Report	2	Report
Specific Gravity											

1. The acceptance of any recycling agent is subject to its ability to develop a RAC binder which will comply with the asphalt grade specified.

2. Viscosity Ratio =  $\frac{\text{RTFO Viscosity at 60°C, mm}^2/\text{s (140°F, cSt)}}{\text{Original Viscosity at 60°C, mm}^2/\text{s (140°F, cSt)}}$

### 203-7.3 Recycled Asphalt Concrete mixtures.

**203-7.3.1 Combined RAC Aggregates.** Combined aggregate and RAP, after all processing except the adding of new binder and mineral filler, shall have an unextracted minimum sand equivalent of 50 when tested by California Test 217.

When there is a difference in specific gravity (bulk saturated, surface dry per ASTM C 127 and D 128) of 0.2 or more between that portion retained and that portion passing a 4.75 mm (No. 4) sieve, the grading shall be modified as provided by California Test 105.

**203-7.3.2 Composition and Grading.** The combined grading and RAC binder content shall conform to the following table. All percentages are based on weight of dry aggregate only (Outside):

**TABLE 203-7.3.2 (A)**

CLASS	Percentage Passing Sieves										
	A-RAC		B-RAC		C1-RAC		C2-RAC		D2-RAC		
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
37.5 mm (1-1/2 in)	100										
25.0 mm (1 in)	90	100	100	-	-	-	-	-	-	-	-
19.0 mm (3/4 in)	78	90	87	100	100	-	100	-	-	-	-
12.5 mm (1/2 in)	64	78	70	87	90	100	95	100	100	-	-
9.5 mm (3/8 in)	54	68	55	76	72	88	72	88	95	100	
4.75 mm (No. 4)	34	48	35	52	40	54	46	60	58	72	
2.36 mm (No. 8)	25	35	22	40	18	34	28	42	34	48	
600 µm (No. 30)	12	25	8	24	8	20	15	27	18	32	
300 µm (No. 50)	8	16	5	18	4	14	10	20	13	23	
75 µm (No. 200)	3	6	0	7	1	6	2	7	2	9	
RAC binder %	4.5	5.7	4.5	6.5	4.6	6.6	4.6	6.6	4.8	7.2	

When the amount of RAP is 15 percent or less of the total mix, the supplier shall maintain a job mix formula at the plant. The formula shall be based on current test data and approved by the Engineer.

When the amount of RAP to be added is over 15 percent of the total mix, a job mix formula and supporting test data shall be submitted to the Engineer for approval at least 8 working days prior to use. The supporting test data for RAC shall include the result for stability, swell, and moisture vapor susceptibility. These tests are in addition to the tests for the RAP stockpile specified in 203-7.2.2.

TABLE 203-7.3.2 (B)

Test	California Test	Requirements
Stabilometer Value	366	35 Min.
Moisture Vapor Susceptibility (Stabilometer Value)	307	25 Min.
Swell, mm (in.)	305	0.76 (0.030) Max.

Percentages for the combined gradings, within the specific limits, shall be of such uniformity that the material passing the indicated sieves during any day's run will not exceed the following maximum variations:

- 4.75 mm (No. 4) sieve - 6 percentage points
- 600  $\mu$ m (No. 30) sieve - 5 percentage points
- 75  $\mu$ m (No. 200) sieve - 3 percentage points

#### 203-7.4 Aggregate Storing, Drying and Screening.

**203-7.4.1 General.** New aggregate consisting of sand, rock dust, and various sizes of aggregates shall be stored separately at the plant and evenly fed to the dryer to insure a uniform flow of properly combined aggregates. In placing materials in storage or in moving them from storage to the feeder, no method shall be used which causes segregation, degradation, or the intermingling of different size aggregates. Materials not meeting the gradation requirements shall be discarded or reprocessed to comply with 203-6.3.2.

**203-7.4.2 RAC Batch Plant Method.** A conventional batch plant shall be modified to introduce the RAP at locations other than the dryer by:

- 1) Providing a separate RAP storage facility, with direct access to the weigh hopper; or
- 2) Providing for RAP introduction to the hot aggregate elevator; or
- 3) Other method approved by the Engineer.

New aggregate shall be dried and heated for a sufficient time in the dryer so that the moisture content of the aggregate will not be greater than 1 percent.

The dryer shall be provided with an approved temperature indicating device to determine the temperature of the aggregate leaving the dryer. The device shall be mounted independent of the plant components, be accurate to the nearest 5°C (10°F), and shall be installed in such a manner that a temperature change of 5°C (10°F) in the aggregate will be indicated within 1 minute. The temperature indicator shall be located and maintained where the proportioning operations are controlled.

After drying, the aggregate shall be evenly fed to the screens in such quantities as to maintain, in separate bins, a uniform grading of the materials and a proper balance in the amount of material. The operation of the screens shall be controlled so as to secure a thorough separation of the aggregate sizes.

Screens having clear square openings shall be used to separate and classify materials for the hot storage bins. The aggregate passing these screens shall be separately stored in bins until proportioned into the mixer as described in 203-7.5.

TABLE 203-7.4.2 (A)

Bin No.	Maximum Aggregate Size in Bin
	<b>4-Bin Plants</b>
4	100% passing 37.5 mm (1-1/2 in) sieve
3	100% passing 16.0 mm (5/8 in) sieve
2	100% passing 9.5 mm (3/8 in) sieve
1	100% passing 4.75 mm (No. 4) sieve
	<b>5-Bin Plants</b>
5	100% passing 37.5 mm (1-1/2 in) sieve
4	100% passing 22.4 mm (7/8 in) sieve
3	100% passing 16.0 mm (5/8 in) sieve
2	100% passing 9.5 mm (3/8 in) sieve
1	100% passing 4.75 mm (No. 4) sieve

The No. 1 bin shall contain not more than 10 percent of material retained on the 2.36 mm (No. 8) sieve. The remaining bins shall contain not more than 10 percent of material which will pass through the following sieve sizes:

TABLE 203-7.4.2 (B)

Bin. No.	Sieve Size
2	2.36 mm (No. 8)
3	4.75 mm (No. 4)
4	9.5 mm (3/8 in)
5	9.5 mm (3/8 in)

Each bin shall be provided with an opening to prevent overflow into adjacent bins.

All overflow material shall be discarded or returned to the appropriate storage areas. All material fed to the No. 4 bin shall pass through the screen over that bin and the oversize rock shall be discarded or returned to appropriate storage area.

If at any time there is a substantial change made in the cold feed to accommodate the demands of a different type of mixture, the hot storage bins shall be emptied and recharged with the correct materials. Discharged material may be returned to a storage area that contains aggregates of the approximate grading of the discharged material, except when the hot storage bins contain RAP. Discharged material containing RAP shall be returned to a separate stockpile.

**203-7.4.3 RAC Drier-drum Method.** When producing RAC, new aggregate shall be fed directly to the mixer at a uniform rate. The RAP shall be introduced into the drier-drum and combined with the hot, new aggregate in such a manner that the RAC is protected from direct contact with the burner flame by means approved by the Engineer. The new binder shall be introduced into the drum after the RAP and the new aggregate have been combined.

A device shall be provided which indicates the temperature of the mixed material leaving the drum. The device shall be accurate to 5°C (10°F) and shall be installed in such a manner that a temperature change of 5°C (10°F) in the mixed material will be shown within 1 minute. The temperature indicator shall be located and maintained where the proportioning operations are controlled.

The burner used for heating the aggregate shall achieve complete combustion of the fuel. The temperature indicator shall be located and maintained where the proportioning operations are controlled.

### 203-7.5 RAC Proportioning.

**203-7.5.1 RAC Batch Plant Method.** When introducing the RAP into the hot aggregate elevator the conveyors shall be equipped with belt scales with rate-of-flow indicators to show the rates of delivery of each of these ingredients. The belt scales shall be interlocked to maintain the proper proportion of RAP to new aggregate.

When introducing RAP from a separate storage facility, it shall be fed directly into the weigh hopper.

All materials shall be proportioned by weight. Volumetric proportioning will not be permitted. The zero tolerance for aggregate scales, asphalt binder scales, and, when used, mineral filler scales shall be 0.5 percent based on the total batch weight of the aggregate.

The indicated weight of material drawn from storage for any material shall not vary from the preselected setting by more than the following percentages based on the total batch weight of the aggregate:

Aggregate	1.0 percent
Mineral Filler	0.5 percent
Asphalt Binder	0.1 percent

Automatic proportioning devices shall be operated so that all weight increments required for a batch are preset on the controls at the same time. The discharge from the several bins shall be interlocked so that only one bin can discharge onto a given scale at a time and that no new batch may be started until all weigh hoppers are empty, the scales are at zero, and the discharge gate is closed. The interlock shall prevent the weigh box from discharging until the required quantity of each bin and the other weighing devices have been properly filled and weighed. The proportioning controls shall be equipped with means for inspection of the interlock tolerance settings. Instructions for determining these settings shall be posted at the control panel for the Engineer's use.

**203-7.5.2 RAC Drier-drum Method.** When producing RAC, the separate conveyor supplying the RAP to the dryer shall be equipped with a belt scale with rate of flow indicator. This belt scale shall be interlocked to maintain proper proportions of RAP to new aggregate.

New asphalt and RA shall be measured through separate meters calibrated and certified for accuracy by one of the agencies designated in 4-1.7. The asphalt meter shall automatically compensate for changes in asphalt temperature. The system shall be capable of varying the rate of delivery of binder proportionate with the delivery of aggregate. The meter and lines shall be heated and insulated. The storage tanks for new asphalt and RA shall be equipped with a device for automatic plant cutoff when the fluid level in the tank is lowered sufficiently to expose the pump suction line.

The system shall be capable of varying the rates of delivery of binder. During any day's run, the temperature of the binder shall not vary more than 30°C (50°F).

When bag house fines or mineral filler is used, it shall be proportioned by weight or volume by a method that uniformly feeds the material within 10 percent of the required amount. The material shall be discharged directly into the mixer where the binder is added.

The feeders for each material in the RAC shall be equipped with devices by which the rates of feed can be determined while the plant is in full operation.

The RAP and the combined new aggregate shall be weighed on separate belt scales. They shall be of such accuracy that, when the plant is operating between 30 and 100 percent of belt capacity, the average difference between the indicated weight of the material delivered and the actual weight delivered will not exceed 1 percent of the actual weight for three 3-minute runs. For any of the individual runs the

indicated weight shall not vary from the actual weight by more than 2 percent. The actual weight of material delivered shall be determined by a vehicle platform scale.

The individual belt scales, for the RAP and the combined new aggregate, the proportioning meters for the new asphalt and RA, and the other proportioning devices, shall be interlocked so that the rates of feed of the RAP, new aggregate, new asphalt, and RA will be adjusted automatically to maintain the proper proportions. The plant shall not be operated unless this automatic system is operating and in good working condition.

Belt scales and proportioning meters shall be equipped with rate of flow indicators to show the rates of delivery of asphalt, RA, RAP, and aggregates and a resettable totalizer for determining the actual weight of asphalt, RA, RAP, and combined aggregates. Rate of flow indicators and totalizer for like materials shall be accurate within 1 percent when compared directly. The asphalt totalizer shall not register when the asphalt metering system is not delivering material to the mixer, and shall not be reset without approval of the Engineer. The bins containing the fine aggregate and mineral filler if used shall be equipped with a vibrating unit or other equipment which will prevent any hang-up of material while the plant is operating. Before the quantity of material in any one bin reaches the strike-off capacity of feed gate, a device shall automatically close down the plant.

The supplier shall determine the moisture contents of the RAP and aggregates at least once during each 2 hours of production and shall adjust the moisture control equipment accordingly.

A sampling device which will provide 25 to 40 kg (60-to-80 pound) samples of the RAP and the combined aggregate, while the plant is in full operation, shall be provided in advance of the point where these materials enter the drier-drum mixer.

When bag house fines or mineral filler is used, a safe and suitable sampling device shall be installed in each feed line or surge tank preceding the proportioning device.

### **203-7.6 RAC Mixing.**

**203-7.6.1 General.** All aggregates, RAP, recycling agent, and asphalt binder shall be mixed in a batch or drier drum plant. The temperature of the completed mixtures, using paving asphalt, at the point of discharge from the plant shall not exceed 163°C (325°F). The temperature of the mixture at the Work site shall be as specified in 302-5.5.

**203-7.6.2 RAC Batch Plant Method.** The mixer shall be of the twin-shaft pug mill type and shall be operated at the speed recommended by the manufacturer. It shall be equipped with sufficient paddles to deliver a uniform mixture. Should the paddles or other parts of the pug mill become worn to such an extent as to adversely affect the quality of mix or allow leakage from the discharge gate, they shall be promptly replaced.

The weight of material that may be mixed per batch shall not exceed the manufacturer's rated capacity of the mixer, nor exceed that which will permit complete mixing of all materials. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected either by a reduction in the volume of materials or by other adjustments.

The entire batch shall be continuously mixed until all the materials are thoroughly blended. The batch mixing time shall begin on the charging stroke of the weigh hopper dump mechanism and shall end when discharge from the mixer has started. The mixer shall be equipped with a time lock mechanism which locks the mixer discharge gate for the mixing period and actuates an indicator light by the charging stroke of the weigh hopper charging mechanism. The light shall be so located as to be visible from the operator's platform and from the Engineer's field laboratory.

If the plant has been modified to provide separate storage for the RAP, the RAP and the new aggregates shall be weighed together in the weigh hopper prior to introduction into the pug mill. These two materials shall be dry mixed for 10 seconds, or longer if necessary, to effect the heat transfer.

The minimum wet mixing time shall be 35 seconds, of which 5 seconds will be drop time for the RAP, new aggregate and new binder to enter the mixer. If the drop time exceeds 5 seconds, additional time shall be added to the 35 seconds. If the Engineer determines that the mixture is not thoroughly blended and the aggregate not fully coated, the mixing time shall be increased.

The mixer, weigh hopper and sampling platforms shall be of ample size to provide safe access to the mixer and other equipment. Weighbox housings shall be provided with gates of ample size to permit ready sampling of the discharge of aggregates from each of the plant bins.

**203-7.6.3 RAC Drier-drum Method.** RAC mixing shall continue for a sufficient time and at a sufficiently high temperature, that at discharge from the mixer, the sizes of aggregates are uniformly distributed through the completed mixture and all particles are thoroughly and uniformly coated.

The RAC shall be discharged from the drum into a storage silo. The supplier shall provide a means of diverting the flow of material away from the silo, when starting and stopping plant production, to prevent incompletely mixed materials from entering the storage silo.

**203-7.7 RAC Storage.** When RAC is stored, it shall be stored only in insulated silos with heated discharge cones, unless the silo is being used for surge purpose. The storage silo shall be equipped to prevent segregation of the completed mixture as it is discharged into the silo. RAC with hardened lumps in the mixture shall not be used.

**203-7.8 RAC Miscellaneous Requirements.** New binder shall be added to the aggregate and RAP at a temperature conforming to the range of temperatures prescribed in 203-1.4, with a minimum of 95°C (200°F) for RA.

A temperature indicating device reading to 260°C (500°F), accurate to 5°C (10°F), shall be fixed in the new asphalt and RA feed lines or storage tanks at suitable locations. The temperature indicator shall be located and maintained where the proportioning operations are controlled.

The discharge end of the new asphalt and RA circulating pipe shall extend to within 0.3 m (1 foot) of the bottom of the storage tank.

The supplier shall provide sampling outlets in the new asphalt and RA feed lines connecting the plant storage tanks to the weighing system or spray bar. When new asphalt and RA are blended in a single line, a sampling outlet shall be provided. It shall be a 13 mm or 19 mm (1/2 inch or 3/4 inch) valve constructed so that a 1 liter (1-quart) sample may be withdrawn slowly at any time during plant operation. The sampling outlet shall be placed in an accessible, nonhazardous location. A container shall be provided for flushing the valve prior to sampling. Four liters (one gallon) shall be drawn from the valve prior to taking the sample.

The beds of trucks used to haul RAC may be coated with an EPA and Agency approved bond breaker before loading. Amounts of bond breaker that form visible pools in the truck beds shall be removed prior to loading RAC. Beds of trucks hauling curb mixes may be sprinkled with mineral filler.

The temperature of the RAC discharged into the hauling vehicles shall not vary more than 10°C (20°F) for successive loads. When the hauling time from the mixing plant to the jobsite exceeds two hours, or when atmospheric temperature is below 10°C (50°F), or when rain is falling along the haul route, RAC shall be covered with tarpaulins during transport. The tarpaulins shall completely cover the load and be firmly secured. RAC shall be delivered to the Work site without segregation of the ingredients and within the temperature range specified in 302-5.5.

At the time of spreading, RAC mixtures shall not contain more than 1 percent moisture. Moisture content will be determined by California Test 310, 311, or 370. RAC mixes shall be the product from one plant or source unless otherwise permitted by the Engineer.

**203-8 ASPHALT PAINT.** Shall conform to ASTM D 41 or D 43 and be furnished and applied to concrete surfaces as required and shown on the Plans.

**203-9 SEALCOAT - ASPHALT BASED.**

**203-9.1 General.** This specification applies to sealcoat intended to be used for sealing miscellaneous areas such as asphalt parking lots, playgrounds, and similar areas. Sealcoat material shall be a plant blended product composed of mineral aggregates uniformly distributed in a petroleum-based asphalt emulsion. The asphalt emulsion shall conform to 203-3. The sealcoat material shall contain non-asbestos fibers.

**203-9.2 Testing Requirements.** Sealcoat materials, undiluted except as noted, shall conform to the following requirements:

**TABLE 203-9.2 (A)**

Test	Specifications
Weight grams per liter (lbs. per gallon)	1139 (9.5) Min.
Nonvolatile component (%) <sup>1</sup>	60% Min. by weight
Mineral aggregate component	850 $\mu$ m (No. 20) sieve – 100% passing
Working viscosity, diluted 4 parts product to 1 part water – ASTM D 562	75 KREBS Min.
Dried film color	Black
Asphalt content	25% - 35% of nonvolatiles by weight

1. Weigh 10 grams of homogeneous product into a previously tarred, small ointment can lid. Place in a constant temperature oven at 163°C (325°F) for 1-1/2 hours. Cool, reweigh, and calculate nonvolatile components.

**203-10 LATEX MODIFIED ASPHALT CONCRETE.**

**203-10.1 General.** Latex modified asphalt concrete shall be the product of mixing latex, asphalt cement, and aggregate. Latex modified asphalt shall conform to 203-6 and the following requirements.

**203-10.2 Materials.**

**203-10.2.1 Asphalt.** Asphalt binder to be mixed with the latex and aggregate shall be paving asphalt, Viscosity Grade AR-4000 conforming to 203-1, unless otherwise directed by the Engineer.

**203-10.2.2 Latex.** Latex shall be a water-based emulsified suspension of styrene butadiene rubber (SBR) in liquid form. The ratio of styrene butadiene shall be 70 to 30. The rubber solids shall be 70  $\pm$  5 percent of the emulsified material unless otherwise directed by the Engineer.

At the time of delivery of each shipment of latex emulsion, the vendor supplying the material shall deliver to the purchaser a certification document which includes, but is not limited to, the following information:

- Actual percent of rubber solids
- Ratio of styrene to butadiene
- Temperature range or limits for product use
- Unit weight of the emulsion
- Recommended storage conditions

**203-10.2.3 Aggregates.** Aggregates shall conform to 203-6.3.2.

**203-10.2.4 Composition and Grading.** The mix class shall be C2 unless otherwise directed by the Engineer. Where Alternate Rock Products-Type S, Section 400, are specified, the class shall be Type III-C3-AR4000 unless otherwise directed by the Engineer.

The amount of latex to be added shall provide 2 percent dry rubber solids, unless otherwise directed by the Engineer. The percentage of dry rubber solids shall be based on the weight of asphalt cement.

The exact proportions of aggregate and the amount asphalt binder for the mixture shall be determined by Contractor so as to incorporate the specified amount of latex.

If the mix design and/or its individual components have no previous record of use by the Agency, the Contractor shall submit a mix design with supporting test data at least 10 working days prior to initial use.

**203-10.3 Proportioning.** Latex may be added to the mixture by any method approved by the Engineer that will assure uniform distribution and accurate measurement of quantity of latex introduced. The latex shall be introduced to the mix at the same time as the introduction of asphalt.

The latex emulsion temperature at the time it is introduced to the mixture shall be as recommended by the manufacturer.

**203-10.4 Mixing.** The wet-mixing cycle for batch plant production shall be 50 seconds minimum.

Production rates of continuous mix plants shall be carefully regulated by the Contractor to ensure complete and uniform mixing.

**203-10.5 Storage.** Latex emulsion shall be stored in a closed bottom-draw vessel and agitated as recommended by the manufacturer's certificate of compliance.

A latex sampling outlet shall be provided in conformance to the requirements of 203-6.9.

**203-10.6 Placement.** Latex modified asphalt concrete placement shall conform to the requirements of 302-5 with the exception that pneumatic-tired rollers shall not be used.

### 203-11 ASPHALT RUBBER HOT MIX (ARHM) WET PROCESS.

**203-11.1 General.** Asphalt Rubber Hot Mix shall consist of a mixture of paving asphalt, asphalt modifier, crumb rubber modifier (CRM), and aggregate mixed in a central mixing plant, all conforming to these specifications.

**203-11.2 Materials.** The Contractor shall submit test reports and Certificates of Compliance for the paving asphalt, asphalt modifier, and CRM to be used. In addition, when requested by the Engineer, the Contractor shall submit samples of the tested material along with the Certificate of Compliance.

**203-11.2.1 Paving Asphalt.** The asphalt used for asphalt-rubber shall be AR 4000 conforming to 203-1 and shall be modified with an asphalt modifier.

**203-11.2.2 Asphalt Modifier.** The asphalt modifier will be a resinous, high flash point, aromatic hydrocarbon compound and shall conform to the requirements in Table 203-11.2.2(A).

**TABLE 203-11.2.2 (A)**  
**REQUIREMENTS FOR ASPHALT MODIFIER**

Property	ASTM Test Method	Value
Flash Point, C.L.O.C., °C (°F)	D 92	207 (405) min
Viscosity, cSt @ 100°C (212°F)	D 445	X ± 3*
Molecular Analysis		
Asphaltenes, percent by mass	D 2007	0.1 max
Aromatics, percent by mass	D 2007	55 min

\* The symbol "X" is the viscosity of the asphalt modifier the Contractor proposes to furnish. The value "X" which the Contractor proposes shall be between the limits of 19 and 36 and shall be submitted in writing to the Engineer. Any proposed change requested by the Contractor in the value "X" shall require a new asphalt-rubber binder design.

**203-11.2.3 Crumb Rubber Modifier (CRM).** The material shall consist of a combination of scrap tire CRM and high natural CRM meeting the requirements of this subsection. Scrap tire CRM shall consist of ground or granulated rubber derived from any combination of automobile tires, truck tires or tire buffings. The high natural CRM shall consist of ground or granulated rubber derived from materials that utilize high natural rubber sources. Whole scrap tire CRM shall be derived from whole scrap tires generated within the State boundaries of the user agencies. The Certificate of Compliance required in 203-11.2 shall contain a statement confirming conformance with this requirement. The high natural CRM may consist of blended CRM.

CRM shall be ground or granulated at ambient temperature. Cryogenically produced CRM particles which can pass through the grinder or granulator without being ground or granulated shall not be used. Cryogenic separation, if utilized, shall be performed separately from and prior to grinding or granulating. Steel and fiber separation may employ any method

CRM shall not contain more than 0.01 percent of wire by weight and shall be free of all other contaminants, except fabric. Fabric shall not exceed 0.05 percent by weight of CRM. A Certificate of Compliance certifying these percentages shall be furnished to the Engineer.

CRM shall be dry and free-flowing and not produce foaming when combined with the blended paving asphalt and asphalt modifier mixture. Calcium carbonate or talc may be added up to a maximum of 3 percent by weight of CRM to prevent CRM particles from sticking together. The CRM shall have a specific gravity range from 1.1 minimum to 1.2 maximum as determined by ASTM D 297. Scrap tire CRM and high natural CRM shall be delivered to the production site in separate bags and shall be sampled and tested separately. Scrap tire CRM material shall conform to the following chemical analysis in Table 203-11.2.3(A).

**TABLE 203-11.2.3 (A)**  
**CHEMICAL REQUIREMENTS FOR SCRAP TIRE CRM**

Test	ASTM Test Method	Minimum	Maximum
Acetone Extract	D 297	6.0%	16.0%
Ash Content	D 297	—	8.0%
Carbon Black Content	D 297	28.0%	38.0%
Rubber Hydrocarbon	D 297	42.0%	65.0%
Natural Rubber Content	D 297	22.0%	39.0%

The scrap tire CRM described above shall be mixed at the job site with high natural CRM so that  $75\% \pm 2\%$  of the product used is derived from scrap tires and  $25\% \pm 2\%$  from materials that utilize high natural rubber sources. The high natural rubber CRM may consist of blended CRM which, after blending, conforms to the following chemical analysis in Table 203-11.2.3(B).

**TABLE 203-11.2.3 (B)**  
**CHEMICAL REQUIREMENTS FOR HIGH NATURAL CRM**

Test	ASTM Test Method	Minimum	Maximum
Acetone Extract	D 297	4.0%	16.0%
Rubber Hydrocarbons	D 297	50.0%	—
Natural Rubber Content	D 297	40.0%	48.0%

With the approval of the Engineer, the High Natural Rubber per 203-11.2.3 and the Asphalt Modifier per 203-11.2.2 may be eliminated. If High Natural Rubber is not used, then the full amount of required CRM shall be Scrap Tire CRM per Table 203-11.2.3(A). Asphalt Rubber binder without natural rubber shall be designated as Type I and ARHM manufactured with Type I binder shall be designated as ARHM-I.

**203-11.2.3.1 CRM Gradations.** CRM gradations shall conform to the requirements of Table 203-11.2.4 (A) when tested in accordance with the requirements of ASTM C136, amended as follows:

Split or quarter 100 grams  $\pm$  5 grams from the representative CRM sample and dry to a constant weight at a temperature of not less than 57°C (135°F) nor more than 63°C (145°F) and record the dry sample weight. Place the CRM sample and 5.0 grams of talc (or calcium carbonate) in a 1 pint jar. Seal the jar and shake it by hand for a minimum of one minute to mix the CRM and the talc (or calcium carbonate). Continue shaking or open the jar and stir until particle agglomerates and clumps are broken and the talc (or calcium carbonate) is uniformly mixed.

A Rotap (or equivalent) test shaker shall be used for the sieve analysis. Place one rubber ball on each sieve. Each ball shall have a weight of  $8.5 \pm 0.5$  grams, have a diameter of  $24.5 \pm 0.5$  mm, and shall have a Shore Durometer "A" hardness of  $50 \pm 5$  in accordance with the requirements in ASTM D 2240. After sieving the combined material for 10 minutes  $\pm$  1 minute, disassemble the sieves. Any material adhering to the bottom of a sieve shall be brushed into the next finer sieve. Weigh and record the weight of the material retained on the 2.36 mm (No 8) sieve and leave this material (do not discard) on the scale or balance. Any observed fabric balls shall remain on the scale or balance and shall be placed together on the side of the scale or balance to prevent the fabric balls from being covered or disturbed when placing the material from finer sieves onto the scale or balance. The material retained on the next finer sieve (2.00 mm (No 10) sieve) shall be added to the scale or balance. Weigh and record that weight as the accumulative weight retained on that sieve (2.00 mm (No. 10) sieve). Continue weighing and recording the accumulated weight retained on the remaining sieves until the accumulated weight retained in the pan has been determined. Prior to discarding the CRM sample, separately weigh and record the total weight of fabric balls in the sample.

Determine the weight of material passing the 75  $\mu$ m (No. 200) sieve (or weight retained in the pan) by subtracting the accumulated weight retained on the 75  $\mu$ m (No. 200) sieve from the accumulated weight retained in the pan. If the material passing the 75  $\mu$ m (No. 200) sieve (or weight retained in the pan) has a weight of 5 grams or less, cross out the recorded number for the accumulated weight retained in the pan and copy the number recorded for the accumulated weight retained on the 75  $\mu$ m (No. 200) sieve and record that number (next to the crossed out number) as the accumulated weight retained in the pan. If the material passing the 75  $\mu$ m (No. 200) sieve (or weight retained in the pan) has a weight greater than 5 grams, cross out the recorded number for the accumulated weight retained in the pan, subtract 5 grams from that number and record the difference next to the crossed out number. The adjustment to the accumulated weight retained in the pan is made to account for the 5 grams of talc (or calcium carbonate) added to the sample. For calculation purposes, the adjusted total sample weight is the same as the adjusted accumulated weight retained in the pan. Determine the percent passing based on the adjusted total sample weight and record to the nearest 0.1 percent.

**TABLE 203-11.2.3.1 (A)**  
**GRADING REQUIREMENTS FOR CRM**

Sieve Size	Scrap Tire CRM percent passing	High Natural CRM percent passing
2.36 mm (No. 8)	100	100
2.00 mm (No. 10)	98 - 100	100
1.18 mm (No. 16)	45 - 75	95 - 100
600 $\mu$ m (No. 30)	2 - 20	35 - 85
300 $\mu$ m (No. 50)	0 - 6	10 - 30
150 $\mu$ m (No. 100)	0 - 2	0 - 4
75 $\mu$ m (No. 200)	-	0 - 1

\* CRM from more than one source may be used provided the combined CRM gradation meets the specified limits. No particles shall exceed a length of 5 mm (3/16 inch) as measured on any axis.

**203-11.2.4 Aggregate.** The aggregate for ARHM shall meet the quality requirements specified in 200-1 for asphalt concrete.

**203-11.3 Composition and Grading.** Asphalt-rubber hot-mix gap-graded (ARHM-GG) will be designated by type and class, i.e., ARHM-GG-C, and shall conform to the requirements of this section and Table 203-11.3 (A).

**TABLE 203-11.3 (A)**  
**REQUIREMENTS FOR ARHM-GG**

SIEVE SIZE	CLASS		
	GG-B Min.- Max.	GG-C Min.- Max.	GG-D Min.- Max.
25 mm (1 in)	100	-	-
19.0 mm (3/4 in)	90-100	100	-
12.5 mm (1/2 in)	-	90-100	-
9.5 mm (3/8 in)	60-75	78-92	100
4.5 mm (No. 4)	28-42	28-42	28-42
2.36 mm (No. 8)	15-25	15-25	15-25
600 $\mu$ m (No. 30)	5-15	5-15	5-15
75 $\mu$ m (No. 200)	0-5	2-7	2-7
% Asphalt Rubber Binder by Weight of Dry Aggregate <sup>1</sup>	7.5-8.4	7.5-8.7	7.5-8.7
Air Voids % California Test 367	3-6	3-6	3-6
Stabilometer Value Min. California Test 304 and 306	25	23	23
Voids in Mineral Agg. Percent Min. <sup>2</sup>	18	18	18

1. Once the percent asphalt rubber binder is determined by the mix design, the production tolerance shall be  $\pm 0.5\%$  as determined by California Test Method 362, 379, or 382.
2. Percent voids in the mineral aggregate (VMA) is to be determined during the mix design process only and is to be calculated on the basis of ASTM bulk specific gravity as described in the Asphalt Institute MS-2 manual.

**203-11.4 Mixing.** Mixing of the asphalt and CRM shall be accomplished as specified herein.

The paving asphalt and asphalt modifier shall be combined into a blended mixture that is chemically compatible with the crumb rubber modifier to be used. The blended mixture is considered to be chemically compatible when it meets the requirements for asphalt rubber binder (after reacting) found in Table 203-11.4(A).

The asphalt modifier shall be proportionately added to the paving asphalt at the production site where the asphalt rubber binder is blended and reacted. Asphalt modifier shall be added at an amount of 2.5% to 6.0% by weight of the paving asphalt based on the recommendation of the asphalt rubber binder supplier. The paving asphalt shall be at a temperature of not less than 190°C (375°F) nor more than

226°C (440°F) when the asphalt modifier is added. If the asphalt modifier is combined with the paving asphalt before being blended with the CRM, the combined paving asphalt and asphalt modifier shall be mixed by circulation for a period of not less than 20 minutes. This premixing of asphalt modifier and the paving asphalt will not be required when all ingredients of the asphalt rubber binder are proportioned and mixed simultaneously. Asphalt modifier and paving asphalt shall be measured for proportioning with meters conforming to the requirements of asphalt plant proportioning in 203-6-6.

The proportions of the materials, by total weight of asphalt-rubber binder, shall be 80% ± 2% combined paving asphalt and asphalt modifier, and 20 % ± 2% CRM. However, the minimum amount of CRM shall not be less than 18 %. The temperature of the blended asphalt and modifier shall be between 190°C (375°F) minimum and 226°C (440°F) maximum when the CRM is added. The temperature shall not exceed 6°C (10°F) below the actual flash point of the mixture. The CRM shall be combined and mixed together in an asphalt-rubber mechanical blender meeting the requirements of 203-11.5. The combined asphalt and CRM shall be pumped into a storage/reaction tank or distributor truck meeting the requirements of 203-11.5. The required mixing/reaction time shall be 45 minutes minimum. The temperature of the asphalt-rubber mixture shall be between 190°C (375°F) minimum to 218°C (425°F) maximum during the reaction period. After reacting, the asphalt rubber binder shall conform to the requirements in Table 203-11.4(A)

**TABLE 203-11.4 (A)**  
**REQUIREMENTS FOR ASPHALT RUBBER BINDER**

Test Parameter	Test Method	Specification Limit	
		Minimum	Maximum
Haake Field Viscosity @ 191°C (375°F), (Centipoise)	See 203-11.4.1	1500	4000
Cone Penetration @ 25°C (77°F), mm	ASTM D 217	25	70
Resilient @ 25°C (77°F), % Rebound	ASTM D 3407	18	—
Field Softening Point, °C (°F)	ASTM D 36	52 (125)	74 (165)

The reacted asphalt rubber binder shall be maintained at a temperature of not less than 190°C (375°F) nor more than 218°C (425°F). If any of the material in a batch of asphalt rubber binder is not used within 4 hours after the 45-minute reaction period, heating of the material shall be discontinued. Any time the asphalt rubber binder cools below 190°C (375°F), and is then reheated, shall be considered a reheat cycle. The total number of reheat cycles shall not exceed 2. The material shall be uniformly reheated to a temperature of not less than 190°C (375°F) nor more than 218°C (425°F) prior to use. Additional scrap tire CRM meeting the requirements of 203-11.2.3 may be added to the reheated binder and reacted for a minimum of 45 minutes. The cumulative amount of additional scrap tire CRM shall not exceed 10 percent of the total binder weight. Reheated asphalt rubber binder shall conform to the requirements in Table 203-11.4(A)

When permitted by the Engineer, asphalt-rubber binder produced on another agency's project and defined here as "hold over material", may be used on the project if the initial agency certifies the following:

1. The total tons and type of material being held over.
2. The amount of CRM contained within the holdover load on a percentage basis.
3. The grade of paving asphalt and asphalt modifier used and its source.
4. Date of original mixing.
5. Number of reheat cycles.

In no case, will more than 20 tons of holdover material be allowed to be transferred from one project to another. In all cases, the holdover material when blended with new asphalt-rubber binder, shall conform to the requirements in Table 203-11.4(A).

**203-11.4.1 Hand Held Viscometer Test.** The Hand Held Viscometer Test shall be conducted as follows:

#### **Precautions**

This test method may involve hazardous materials, operations and equipment. This test method does not purport to address all the safety issues associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### **Apparatus**

- 1) Viscometer: Haake Model VT - 02 rotational viscometer or equivalent
- 2) Spindle: Rotor No.1, diameter 24 mm  $\pm$  0.1 mm, height 53 mm  $\pm$  0.1 mm or equivalent
- 3) Thermometer: digital with metal-jacketed probe, 1°C (1°F) precision
- 4) Sample Container: 1 gallon metal can with wire bale
- 5) Standard Fluids: per fluid manufacturer recommendations calibrate viscometer in absolute viscosity (centipoise).

#### **Calibration**

The viscometer shall be calibrated per manufacturer recommendations. The accuracy of the viscometer shall be verified by comparing the viscosity results obtained with the hand held viscometer to 3 separate calibration fluids of known viscosity ranging from 1000 to 5000 centipoise. The viscometer will be considered accurate if the values obtained are within 300 centipoise of the known viscosity. The known viscosity value shall be based on the fluid manufacturer standard test temperature or the test temperature versus viscosity correlation table provided by the fluid manufacturer. The viscometer calibration may be performed at an offsite laboratory and Certificate of Compliance verifying the calibration shall be provided to the Engineer.

#### **Test Procedure**

1. Obtain a representative sample of asphalt rubber binder from an appropriate sample valve during production. Prior to sampling, run a one-gallon sample of binder through the sampling valve and discard the sample. Place a clean one-gallon sample can under the sampling valve and fill the container to approximately 85% full.
2. Transport the sample immediately to the testing location. The testing location should be reasonably close to the sampling location to avoid undue temperature loss. The temperature of the binder prior to sampling should be a minimum of 190°C (375°F). The sample container shall then be placed on a smooth, level support for testing.
3. The binder shall be continuously stirred using an appropriate metal stirring rod. Use of the temperature probe is permitted. Insert the temperature probe into the binder and check the temperature. Stirring shall continue until the binder reaches a temperature of 190°C  $\pm$  3°C (375°F  $\pm$  5°F).
4. The viscometer spindle shall be cleaned in a suitable solvent and free of any binder material prior to test. While holding the viscometer over the sample container insert the spindle of the viscometer into the sample container near the side of the container and turn the viscometer on. While the spindle is rotating, move the spindle in and out of the binder three times to bring the spindle up the temperature of the binder. Continue stirring the binder.

5. Determine the viscosity of the binder at  $190^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $375^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) as follows. In one continuous operation, remove the spindle from the binder (after heating), discontinue stirring the binder and immediately insert the spindle back into the center of the binder sample. While holding the viscometer level watch the needle on the viscometer dial and record the maximum value obtained on the dial. Record the test temperature and the maximum viscosity. Subtract 100 centipoise from the maximum value recorded and report this as the viscosity of the asphalt rubber binder. (The viscometer shall be maintained and operated in accordance with the instructions from the manufacturer. However, this test method shall apply if there are any differences in the instructions for determination of the viscosity.)
6. Report the following information for the viscosity test; technician performing viscometer test, date and location of plant, asphalt rubber binder supplier, binder test temperature and viscosity, spindle size and rotating speed in revolutions per minute, viscometer model and serial number.

**203-11.5 Equipment for production of Asphalt-Rubber.** The Contractor shall utilize the following equipment for production of asphalt-rubber binder:

1. **Asphalt Heating Tank.** An asphalt heating tank equipped to heat and maintain the blended paving asphalt and asphalt modifier mixture at the necessary temperature before blending with the CRM. This unit shall be equipped with a thermostatic heat control device and a temperature reading device and shall be accurate to within  $\pm 3^{\circ}\text{C}$  ( $\pm 5^{\circ}\text{F}$ ) and shall be of the recording type.
2. **Blender Equipment.** A mechanical mixer for the complete, homogeneous blending of paving asphalt, asphalt modifier, and CRM. Paving asphalt and asphalt modifier shall be introduced into the mixer through meters. The blending system shall be capable of varying the rate of delivery of paving asphalt and asphalt modifier proportionate with the delivery of CRM. During the proportioning and blending of the liquid ingredients, the temperature of paving asphalt and the asphalt modifier shall not vary more than  $\pm 14^{\circ}\text{C}$  ( $\pm 25^{\circ}\text{F}$ ). The paving asphalt feed, the asphalt modifier feed and CRM feed, shall be equipped with devices by which the rate of feed can be determined during the proportioning operation. Meters used for proportioning individual ingredients shall be equipped with rate-of-flow indicators to show the rates of delivery and resettable totalizers so that the total amounts of liquid ingredients introduced into the mixture can be determined. The liquid and dry ingredients shall be fed directly into the mixer at a uniform and controlled rate. The rate of feed to the mixer shall not exceed that which will permit complete mixing of the materials. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected by a reduction in the volume of material or by other adjustments. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly blended asphalt-rubber binder of unchanging appearance and consistency is produced. The Contractor shall provide a safe sampling device capable of delivering a representative sample of the completed asphalt-rubber binder of sufficient size to permit the required tests.
3. **Storage/Reaction Tank.** An asphalt-rubber binder storage/reaction tank equipped with a heating system that is equipped with a temperature reading device to maintain the proper temperature of the asphalt-rubber binder and an internal mixing unit capable of maintaining a homogeneous mixture of paving asphalt, asphalt modifier and CRM.
4. **Viscometers.** The Contractor shall supply a Haake Viscometer per 203-11.4.1 (or equivalent) for use by the Engineer to verify the viscosity of the asphalt-rubber on all projects where a field laboratory is used. All asphalt concrete plants are required to have a field laboratory for use by the Engineer per 8-3.

The equipment shall be approved by the Engineer prior to use.

**203-11.6 Mix Designs and Certifications.** The optimum binder content for ARHM-GG mixes shall be determined by California Test Method 367 except that Step 2 regarding surface flushing shall not be used. Optimum binder content shall be determined by using a void content between 3 percent minimum to 6 percent maximum as approved by the Engineer. Compaction shall be in accordance with California Test Method 304 except for the following:

Mixing Temperatures:

Asphalt-rubber = 163°C to 182°C (325°F to 360°F)

Aggregate = 143°C to 163°C (290°F to 325°F)

Compaction Temperature = 143°C to 149°C (290°F to 300°F)

In addition to the formulations and certifications required in 203-11.3 and 203-11.4 for asphalt-rubber, the Contractor shall furnish to the Engineer a mix design and samples of all materials to be used at least 10 working days before construction is scheduled to begin. The mix design and certifications shall include, but are not limited to, the following:

- 1) Combined aggregate gradation.
- 2) Individual bin gradations (hot for batch, cold for drum plant).
- 3) Percentage of each bin.
- 4) Asphalt rubber binder content.
- 5) Density.
- 6) Air Voids.
- 7) Voids in Mineral Aggregates (VMA).
- 8) Stability.
- 9) Aggregate source
- 10) Asphalt binder source

**203-11.7 Miscellaneous Requirements.** Miscellaneous requirements shall conform to 203-6.9 except that the temperature of the asphalt-rubber binder shall be 191°C (375°F) minimum to 218°C (425°F) maximum for asphalt-rubber when added to the aggregate. The temperature of the aggregate at the time of adding the asphalt-rubber binder shall be 149°C (300°F) minimum to 166°C (330°F) maximum.

**203-12 Asphalt Rubber and Aggregate Membrane (ARAM) Surfacing or Interlayer.**

**203-12.1 General.** ARAM surfacing or interlayer shall involve cleaning and preparing the existing surface, spreading asphalt rubber and cover aggregate, rolling, and sweeping.

The construction sequence of an ARAM shall be as follows:

- 1) The surface shall be cleaned.
- 2) Asphalt-rubber shall be applied.
- 3) Screenings shall be placed, rolled, and loose material removed. Only then will the ARAM surface be opened to traffic. A minimum of 48 hours shall elapse after placement of the screenings before a slurry seal conforming to 302-4 may be applied, unless otherwise directed by the Engineer.

Certified volume or weight slips shall be delivered to the Engineer for all materials supplied.

**203-12.2 Materials.** Materials used in the construction of ARAM shall be asphalt rubber and screenings as specified below.

**203-12.2.1 Asphalt Rubber.** Asphalt Rubber shall conform to 203-11

**203-12.2.2 Screenings.** Screenings, when used as a cover aggregate for ARAM shall be crushed rock conforming to the following gradations in Table 203-12.2.2 (A):

**TABLE 203-12.2.2 (A)  
SCREENINGS**

Sieve Size	Percentage Passing Sieve		
	Coarse 12.5 mm (1/2 in)	Medium 9.5 mm (3/8 in)	Fine 9.5 mm (3/8 in)
19.0 mm (3/4 in)	100	100	—
12.5 mm (1/2 in)	90 – 100	95 – 100	100
9.5 mm (3/8 in)	50 – 80	70 – 85	85 – 100
4.75 mm (No. 4)	0 – 15 <sup>1</sup>	0 – 15 <sup>1</sup>	5 – 20 <sup>1</sup>
2.36 mm (No. 8)	0 – 5	0 – 5	0 – 5
1.18 mm (No. 16)	—	—	—
75 µm (No. 200)	0 – 1	0 – 1	0 – 1

1. Lower percentages are desirable.

Screenings shall be medium 9.5 mm (3/8 inch) unless otherwise specified. Screenings shall be preheated between 127°C (260°F) to 163°C (325°F) and adequately coated with 0.70 percent to 1 percent Paving Grade AR 4000 asphalt at a central mixing plant to prevent free dust. The exact amount of asphalt shall be recommended by the Contractor and approved by the Engineer. Screenings shall conform to the requirements of Table 200-1.2 (B).

## SECTION 204 - LUMBER AND TREATMENT WITH PRESERVATIVES

### 204-1 LUMBER AND PLYWOOD.

#### 204-1.1 Kinds.

**204-1.1.1 General.** Structural lumber shall be of the kinds and grades indicated on the Plans or in the Specifications. Proper allowance for shrinkage in the lumber shall be made by the Contractor where it is necessary to meet definite dimensions shown on the drawings. All sizes refer to nominal sizes. Rough and dressed sizes shall conform to the sizes set forth in the American Lumber Standards.

**204-1.1.2 Douglas Fir.** Unless otherwise specified, all lumber shall be Douglas fir and shall be selected as to grade and shall conform in all particulars to the Standard Grading Rules for Western Lumber, published by the Western Wood Products Association and approved by the American Lumber Standards Committee.

**204-1.1.3 Redwood.** Redwood lumber shall conform in all particulars to the Standard Specifications for Grades of California Redwood of the Redwood Inspection Service.

**204-1.1.4 Plywood.** Plywood shall be manufactured and graded in accordance with the rules of the American Plywood Association and the latest Product Standard for Softwood Plywood, Construction and Industrial, of the National Bureau of Standards.

**204-1.2 Lumber Uses and Grades.** Unless otherwise specified, lumber quality for the uses listed shall not be less than the grades in Table 204-1.2 (A).

TABLE 204-1.2 (A)

USES	GRADES
Major permanent construction, such as bridges.	"Select Structural" for main structural members. "No. 1" for beams, stringers, joists, and planks. "Select Structural" when redwood is specified.
Minor permanent construction, such as bulkheads, retaining structures, headers for bituminous pavement, wooden warning rails, posts for metal beam guard rails.	"No.1" for posts, joists and planks. "Construction" for boards.
Wooden warning rail posts, guide posts, sign posts.	"Select Structural" redwood. (No. 1 grade Douglas fir optional for wooden warning rail posts.)
Studs, headers, and wales for formwork. Form sheathing for non-showing surfaces of concrete.	"Standard", "No. 4 Common", or "No. 3"; any exterior-type grade of plywood optional for form sheathing.
All exposed surfaces of bridges, viaducts, over-crossing; soffits and sides of beams and girders; slabs between beams and girders; headwalls and endwalls of culverts or covering conduits; form sheathing for showing surfaces of retaining walls, channel walls, etc.	"Exterior B-B" (concrete form) grade of plywood.

### 204-1.3 Grade Marking.

**204-1.3.1 Lumber.** All lumber shall be grade marked by a lumber grading agency certified by the American Lumber Standards Committee.

**204-1.3.2 Plywood.** Each sheet of plywood shall bear the official stamp of a quality control agency stating the grade of the sheet.

### 204-2 TREATMENT WITH PRESERVATIVES.

**204-2.1 General.** All timber products to be treated shall conform to the requirements of the various sections of these specifications.

All preservatives shall comply with the applicable standards contained in the AWPAs Book of Standards.

All cutting such as adzing, boring, chamfering, framing, graining, surfacing, trimming, etc., shall be done prior to treatment.

Wood shall be conditioned, seasoned, prepared, and treated by the pressure process in accordance with the applicable standards in the AWPAs Book of Standards.

With the exception of southern yellow pine and ponderosa pine, all lumber and timber with a nominal thickness of 50 mm (2 inches) and over shall be incised on all sides to ensure penetration in accordance with AWPAs Standards. Lumber edge-worked to pattern (such as T&G) other than S4S need not be incised on the edges.

**204-2.2 Wood Preservatives.** The preservative used shall be one of the following:

- 1) Creosote or creosote solutions;
- 2) Oil-borne preservatives;
- 3) Water-borne preservatives;
- 4) Fire-retardant treatment (either exterior or interior type).

All preservatives and the selection of preservatives shall meet the requirements as listed in the AWWPA Book of Standards. The retention and penetration for each preservative shall be equal to, or greater than, the minimums listed in the AWWPA Standard.

Fire-retardant treated wood is lumber or plywood impregnated with chemicals. When tested in accordance with ASTM E 84 for a period of 30 minutes, it shall have a flame spread of not over 25 and show no evidence of significant progressive combustion. Materials which may be exposed to weather shall maintain this fire-retardant classification when tested in accordance with the rain and weathering tests of ASTM E 108. The materials shall bear identification showing the fire performance rating thereof and shall be further identified to indicate suitability for exposure to the weather. Such identification shall be issued by an approved agency having a series for inspection of materials at the factory.

Preservatives used for wood in contact with ground or fresh water shall be limited to:

- 1) Creosote or creosote solutions
- 2) Pentachlorophenol
- 3) Ammoniacal Copper Arsenate
- 4) Chromated Copper Arsenate

Preservatives used for wood subjected to marine (salt water) exposure shall be limited to:

- 1) Ammoniacal Copper Arsenate
- 2) Chromated Copper Arsenate

**204-2.3 Field Treatment of Cut Surfaces.** When cutting or drilling becomes necessary after plant treatment, the cut or drilled surfaces shall be given protection by field treatment in accordance with provisions of AWWPA Standard M4.

**204-2.4 Quality Control - Inspection.** All materials treated shall be subject to inspection. The inspection and marking shall be in accordance with AWWPA Standard M2.

Inspection shall be performed by any of the following:

- 1) The Engineer;
- 2) An American Wood Preservative License Bureau Inspection organization.

**204-2.5 Handling and Protection of Treated Materials.** Care shall be exercised to not damage the edges or abrade the surfaces to the extent of reducing the depth of treated wood or exposing any wood not penetrated. Cant hooks, peavies, sharp-pointed tools, and the use of metal slings without protective guards shall not be permitted for the handling of treated lumber. Treated piling may be handled with pointed tools, provided that side surfaces are not penetrated over 13 mm (1/2 inch). The use of handling tools and loading devices will not be permitted in the groundline area of poles. Care shall be taken to assure that all damage such as abrasions, nail and spike holes, are thoroughly saturated with the field treating solution in accordance with AWWPA Standard M 4.

Material that is stored at the Work site prior to its use shall be stacked neatly on skids to raise it from the ground, and shall be protected from the sun and weather.

## SECTION 205 - PILES

### 205-1 Timber Piles.

**205-1.1 General.** Timber piles shall be Douglas fir, unless otherwise indicated by the Plans or Specifications.

**205-1.2 Quality.** Piles shall conform to ASTM D 25 for Class B piles and the requirements contained herein. Piles shall be cut from sound, live, close-grained trees and shall be free from large, loose, or unsound knots, scars, decay, holes, insect damage, barnacles, limnoria, or other forms of sea life, and other defects or imperfections that would materially impair their strength or durability.

All piles shall be machine-peeled and all inner skin shall be removed. All branch stubs and partially overgrown knots shall be neatly trimmed flush with the surface, and the butts and tips shall be sawed square with the longitudinal axis of the pile.

No cracks will be permitted in any pile. Splits, shakes, and checks will be permitted only to the extent provided herein. A crack is defined as a break across the grain of the wood extending from surface to surface through the pile; a shake is defined as a separation of the wood along the annual rings; and a check is defined as a lengthwise separation of the wood across the rings of annual growth. A through check or compound check is defined as a check extending from surface to surface, either through the pith center or shunted around by a shake.

Splits in piles shall not be longer than the butt diameter. The length of any shake or combination of shakes in the outer half of the radius of the butt of the pile, when measured along the curve of the annual ring, shall not exceed one-third of the circumference of the butt of the pile.

Any check that would impair the strength of the pile will be cause for rejection, but in no case will any check exceeding 19 mm (3/4 inch) in width be allowed. Any compound or through check, regardless of length, will be cause for rejection.

Spiral grain shall not exceed one-half of a complete twist in any 6 m (20 feet) of length.

Sound knots in piles 15 m (50 feet) or less in length, and in three-quarters of the length from the butt of piles longer than 15 m (50 feet), shall be no longer than 100 mm (4 inches) or one-third of the diameter of the pile at the point where they occur, whichever is smaller. Sound knots in the remaining one-quarter of the length of piles longer than 15 m (50 feet) shall be no larger than 125 mm (5 inches) or one-half of the diameter of the pile at the point where they occur, whichever is the smaller. The size of a knot shall be its diameter measured at right angles to the length of the pile.

Unsound knots or knot clusters will not be permitted. A knot cluster is two or more knots grouped together, the fibers of the wood being deflected around the entire unit. A group of single knots, with fibers deflected around each knot separately, is not a cluster, even though the knots may be in close proximity. The sum of sizes of all knots in any foot of length of the pile shall not exceed twice the size of the largest single knot permitted.

Holes less than 13 mm (1/2 inch) in average diameter will be permitted in piles, provided the sum of the average diameters of all holes in any 0.1 m<sup>2</sup> (1 ft<sup>2</sup>) of pile surface does not exceed 38 mm (1-1/2 inches).

The presence of invisible internal checks, and shattering or water-burses, shall be determined by sounding with a suitable hammer, and a resultant hollow or shattered sound will be sufficient cause for rejecting the pile.

The requirements prescribed herein relative to cracks, splits, shakes, and checks shall apply equally to treated and untreated piles, and any such defects that develop or occur as a result of any treating operation may be cause for rejection.

No nails, spikes, or other metal shall be present in any timber pile unless specifically authorized by the Engineer.

**205-1.3 Dimensional Requirements.** The diameter of a pile at any section shall be considered as the average diameter at such section measured at right angles to the longitudinal axis of the pile; but in determining an average diameter, no single diameter that is more than 10 percent greater than the least diameter at the same section shall be used. The butt and tip diameters shall be such as to conform with the requirements indicated in the following tabulation and the diameter 1 m (3 feet) from the butt shall not be smaller than 25 mm (1 inch) less than that at the butt.

**TABLE 205-1.3 (A)**

Length Meters (Feet)	1 m (3 Ft) From Butt				All Tip Minimum	
	Minimum		Maximum		Circum- ference mm (in)	Approx. Dia. mm (in)
	Circum- ference mm (in)	Approx. Dia. mm (in)	Circum- ference mm (in)	Approx. Dia. mm (in)		
Under 12 (40)	965 (38)	305 (12)	1600 (63)	510 (20)	635 (25)	203 (8)
12-16 (40-54)	965 (38)	305 (12)	1600 (63)	510 (20)	559 (22)	178 (7)
17-22 (55-74)	1040 (41)	330 (13)	1600 (63)	510 (20)	559 (22)	178 (7)
23-27 (75-90)	1040 (41)	330 (13)	1600 (63)	510 (20)	483 (19)	152 (6)
Over 27 (90)	1040 (41)	330 (13)	1600 (63)	510 (20)	406 (16)	127 (5)

The average diameter of the heartwood at the butt of Douglas fir piles that are to be treated shall be not less than 70 percent, and of those that are to be used untreated not less than 75 percent, of the average outside butt diameter of the pile.

A straight line from the center of the butt to the center of the tip pile shall lie entirely within the body of the pile.

Piles shall be free from short crooks in which the deviation from straightness in any 1.5 m (5 feet) of length anywhere exceeds 64 mm (2-1/2 inches). Short crooks shall also comply with the requirements for straightness.

The individual lengths in which timber piles are to be furnished shall be as stipulated by the Plans, Specifications, requisition, or purchase order issued in connection therewith. Unless otherwise prescribed, as many as 30 percent of the number furnished on any single order or in any single lot may run as much as 0.6 m (2 feet) longer than the specified lengths.

## **205-2 STEEL PILES.**

**205-2.1 General.** Steel piles furnished under this specification shall consist of structural steel shapes that fulfill the requirements prescribed for such material in ASTM A 36 and shall conform to the details and dimensions indicated by the Plans and Specifications relating directly thereto.

Splices in steel piles shall be made by a full penetration butt weld of the entire cross section. Care shall be taken to properly align adjacent sections so that the axis of the pile will be straight. The number of splices in the length of the pile shall be limited to two. Splices in the top 3 m (10 feet) of the piles will not be permitted. The locations of pile lugs, when used, shall be subject to the approval of the Engineer. All weldings shall be performed by qualified welding operators in accordance with 304-1.9.

**205-2.2 Manufacturing Requirements.** Material for steel piles shall not be made by the acid Bessemer process.

Steel sheet piling shall consist of standard interlocking sheet pile sections having positive interlocks in both longitudinal and transverse directions which are continuous throughout the entire length of the piece.

### **205-3 CONCRETE PILES.**

**205-3.1 General.** The types of concrete piles covered by these specifications are precast, cast-in-place, and prestressed piles. The type to be used or furnished shall be as indicated on the Plans or in the Specifications. Steel and concrete shall be placed in accordance with 303-1. Portland cement concrete and reinforcing steel shall conform to the provisions of 201-1 and 201-2.

Compressive strength tests for precast and prestressed piles shall be performed in accordance with ASTM C 31.

**205-3.2 Precast Piles.** Precast concrete piles shall be of such quality that the finished piles can be handled and driven to required bearing without cracking or other damage which would impair their strength or durability. Concrete shall have a minimum strength of 27.6 MPa (4,000 psi) at 28 days.

Concrete for precast concrete piles shall be cast in smooth, mortar-tight forms so supported as to prevent deformation or settlement during concrete placement or curing. The piles after being cast shall be cured by water, steam, curing compound, or other such methods of curing as may be approved by the Engineer. Curing shall be continued until specimens of the concrete from which the piles were cast attain a compressive strength of at least 27.6 MPa (4,000 psi). Piles shall not be driven until completion of the specified curing.

The piles shall present true, smooth, even surfaces, free from honeycombs or voids and shall be sufficiently straight that a line stretched from butt tip along any face will not deviate nor be deflected for more than 25 mm (1 inch) in 15 m (50 feet) at any point. Defects in any pile may be accepted if repaired to the satisfaction of the Engineer.

Concrete piles may be cast the full length of the reinforcing bars provided that, after the piles have been driven, the concrete is removed to expose the steel as shown on the Plans.

### **205-3.3 Cast-in-Place Concrete Piles.**

**205-3.3.1 Metal-Cased Cast-in-Place Concrete Piles.** Piles shall be cast in steel shells that have been previously driven to the penetration or bearing value required by the Engineer.

The shell shall be cylindrical and may be fluted, step-tapered, or uniformly tapered from butt to tip.

Shells that are driven without a mandrel shall be equipped with steel driving tips and shall be constructed of material conforming to the requirements prescribed in ASTM A 252, Grade 2. They shall be of sufficient thickness (3.8 mm (9 gage) minimum), strength, and rigidity to withstand distortion from driving, soil pressure, or the driving of adjacent piles. Continuous welds shall be used at all shell splices to develop the full strength of the section.

After being driven, but prior to placing of the reinforcing steel and concrete, the shells shall be examined for collapse or reduced diameter. The Contractor shall have available at all times a suitable light for the inspection of the shell throughout the entire length. Shells that are improperly driven, broken, or show partial collapse shall be replaced by and at the expense of the Contractor. Partial collapse of shells shall be interpreted to mean any collapse which reduces any diameter to less than 80 percent at any point. The replacement of the shell shall be made by withdrawing the entire shell and driving another in its place. Driving one shell within a shell is not permitted. If the withdrawal of the defective shell is impossible or impractical, as determined by the Engineer, the Contractor shall fill the

defective shell with concrete and shall replace the defective pile with another pile driven alongside. Any enlargement of the footing required to accommodate such piling shall be at Contractor's expense.

Driven shells shall be clean and free of water before reinforcing steel and concrete are placed therein. Concrete shall be vibrated to within 1.5 m (5 feet) of the tip of the shell.

**205-3.3.2 Piles Cast in Drilled Holes.** All holes for concrete piles cast in drilled holes shall be drilled dry to the tip elevations and diameter shown on the Plans or to the elevation determined by the Engineer. Any hole which shows less than one-half the diameter of the hole at the bottom shall be rejected. Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is placed therein.

All loose material and water, existing at the bottom of the hole after drilling operations have been completed, shall be removed before placing concrete in the hole.

If the casing is to be removed, it shall be removed from the hole as concrete is placed therein. The bottom of the casing shall be maintained not more than 1.5 m (5 feet) nor less than 0.3 m (1 foot) below the top of the concrete during withdrawal and placing operations, unless otherwise permitted by the Engineer. Damage to the concrete during withdrawal and placing operations shall be avoided by hammering or vibrating the casing.

The Contractor shall ensure that the concrete in the hole is dense and homogeneous. Vibration of the concrete during placing will not be permitted. However, rodding may be required. After the hole has been filled with concrete, the concrete in the top 3 m (10 feet) of the hole or for the length of the reinforcing, whichever is the greater, shall be vibrated.

#### **205-3.4 Prestressed Concrete Piles.**

**205-3.4.1 General.** The manufacture of prestressed piles shall be performed in accordance with 303-3. Concrete shall have a minimum strength at 28 days of 34.5 MPa (5,000 psi). Piles shall be of such quality that the finished piles can be handled and driven to required bearing without cracking or other damage which would impair their strength or durability. Piles shall present true, smooth, even surfaces free from honeycombs or voids and shall be sufficiently straight that a line stretched from butt to tip along any face will not deviate more than 25 mm (1 inch) in 15 m (50 feet) at any point. Piles showing defects in the upper 3 m (10 feet) which reduce the cover over the steel to less than required, will be rejected. Defects in the remainder of the pile may be accepted if repaired in a manner satisfactory to the Engineer.

Prestressed forces shall not be transferred to the piles until the concrete has attained a strength of 24.1 MPa (3,500 psi).

**205-3.4.2 Handling and Driving.** Prestressed concrete piles shall be lifted or supported only at the points shown on the approved shop drawings. Piles shall not be driven until they have attained a minimum compressive strength of 34.5 MPa (5,000 psi) as determined by tests on concrete cylinders cast and cured under the same conditions as the piles.

## SECTION 206 MISCELLANEOUS METAL ITEMS

### 206-1 STRUCTURAL STEEL, RIVETS, BOLTS, PINS, AND ANCHOR BOLTS.

#### 206-1.1 Requirements.

**206-1.1.1 General.** All steel, the class of which is not definitely designated herein, in the Specifications, or on the Plans, shall be structural steel and shall conform to the requirements of ASTM A 36. Steel manufactured by the acid Bessemer process shall not be used.

**206-1.1.2 Certification.** The Contractor shall furnish to the Engineer, before fabrication, a mill certified report (in duplicate) of the tests for each heat of steel or iron from which the material is to be fabricated. The certification shall contain the results of chemical and physical tests required by ASTM specifications for materials.

**206-1.1.3 Additional Tests.** The Agency reserves the right to require or make additional mill and laboratory tests. The number of such additional tests will be limited as follows, except that in case of failure of the material to comply with the ASTM requirements, more tests may be made or the material rejected:

- 1) Structural steel - One complete test for each heat number or each 9 tonnes (10 tons) of identifiable stock
- 2) Rivets - One complete test for each size
- 3) Bolts - One complete test for each lot

“Identifiable stock” is material for which authentic records of the chemical and physical properties are available.

Test specimens shall be furnished cut and machined in accordance with the ASTM specifications for the material to be tested, as referred to herein.

**206-1.1.4 Stock Material.** When the Contractor proposes to use material already in stock, it shall notify the Engineer of such intention at least 10 days in advance of beginning fabrication.

**206-1.1.5 Mill Tolerance.** Rolling and cutting tolerances, permissible variations in weight and dimensions, defects, and imperfections shall not exceed the limits contained in ASTM A 6.

#### 206-1.2 Structural Steel.

**206-1.2.1 Stock Materials.** The Contractor shall select the material intended for use from stock and place it in location apart from other stock material and accessible for inspection and sampling. It shall also select the material from as few heat numbers as possible and shall furnish certified mill test reports for each of the heat numbers. Two samples shall be taken by the Engineer from each heat number; one for the tension test and one for the cold-bend test. If the heat numbers cannot be identified, the Engineer may select random test specimens from the unidentifiable heats.

**206-1.2.2 High-Strength Low-Alloy Structural Steel.** The material shall conform to the requirements of ASTM A 242, A 440, A 441, A 606, A 607, or A 446 (Grades C, D, or E) as specified.

**206-1.2.3 Copper Bearing Structural Steel.** Copper bearing structural steel shall conform to requirements of ASTM A 36, A 440, A 446, A 570 or A 611 as specified.

#### 206-1.3 Rivets.

**206-1.3.1 Stock Material.** Rivets taken from identifiable stock may be accepted by the Engineer based on certified mill test reports.

Rivets from unidentifiable stock shall not be used except where shown on shop drawings.

**206-1.3.2 High-Strength Structural Steel Rivets.** The material shall conform to the requirements of ASTM A 502.

**206-1.3.3 Structural Steel Rivets.** The material shall conform to the requirements of ASTM A 502, except that the test specimen shall be bent upon itself when performing the bend test.

**206-1.4 Bolts.**

**206-1.4.1 Unfinished Bolts.** The bolts shall have square heads and square nuts unless otherwise specified. The bolts shall be long enough to extend entirely through the nut but not more than 6 mm (1/4 inch) beyond. Washers shall not be furnished unless specified. Bolts shall be of steel conforming to the requirements of ASTM A 307.

**206-1.4.2 High-Strength Bolts.** Shall conform to ASTM A 325.

**206-1.4.3 Anchor Bolts.** Shall be manufactured from steel conforming to ASTM A 36 or A 307.

**206-1.5 Mild Steel Forgings for Structural Purposes.**

Steel forgings shall conform to the requirements of ASTM A 325. They shall be Class C forgings with a maximum carbon content of 0.35 percent and shall be given a thorough annealing. The metal shall have a minimum Brinell hardness of 130 and a maximum of 190, when tested in accordance with ASTM E 10.

**206-2 STEEL CASTINGS.**

**206-2.1 General.** Steel castings shall be true to pattern in form and dimension and free from defects that would affect the service value of the casting. Minor defects which do not impair the strength of the casting may be repaired with the approval of the Engineer. Castings which have been repaired without the permission of the Engineer may be rejected. Chemical analysis shall be performed in accordance with ASTM E 30.

**206-2.2 Test Specimens.** When required by the Agency, test coupons shall be poured monolithically with the castings. If, in the opinion of the manufacturer, the design of the casting is such that test coupons should not be attached thereto, the test coupons shall be cast attached to separate blocks. Two coupons shall be cast to represent each lot. A lot shall be considered as all castings from a melt which constitutes a part of a charge. Coupons shall remain attached until properly identified by the Engineer. Where test coupons are cast separately from the castings, the Engineer shall be notified of the time of pouring so as to permit him to identify both coupons and castings. Coupons cast separately from the castings shall not be detached from the block to which they are fastened until identified by the Engineer.

Test specimens shall be furnished and machined in accordance with ASTM A 370 at the Contractor's expense.

If the results of the tests for any lot do not conform, the entire lot will be rejected.

**206-2.3 High-Strength Steel Castings for Structural Purposes.** Castings shall conform to ASTM A 148, Grade 80-50, except that the steel shall contain not less than 0.60 percent of manganese and not less than 0.20 percent of silicon.

**206-2.4 Mild-to-Medium Carbon-Steel Castings for General Application.** Castings shall conform to ASTM A 27, Grade 65-35. The metal shall have a minimum Brinell hardness number of 130 when tested in accordance with ASTM E 10.

**206-3 GRAY IRON CASTINGS.**

**206-3.1 General.** Gray iron castings shall be true to pattern in form and dimension and free from defects that would affect the service value of the casting. Minor defects may be repaired with Engineer

approval. Castings which have been repaired without the permission of the Engineer may be rejected. Castings that show injurious defects revealed by X-ray or machining operations will be rejected.

The casting shall be filleted boldly at angles, and the arrises shall be sharp and true.

Before the castings are removed from the foundry, they shall be thoroughly cleaned and the parting lines, grates, and risers ground flush.

All castings not specifically classified shall conform to ASTM A 48, Class 30B. Gratings (inlet, manhole, trench, and tree) and manhole frames and covers shall conform to ASTM A 48, Class 35B.

**206-3.2 Testing Requirements.** Testing shall be performed in accordance with Method A or Method B.

Method A shall consist of testing tensile specimens in accordance with ASTM A 48. The Engineer shall be notified so that he may be present at the time of the melt to permit identification of both coupons and castings. The test specimens shall be provided and machined by the manufacturer to the dimensions specified for Specimen B of ASTM A 48 and Agency requirements. The specimens shall be tested at the location designated by the Agency. Machining and testing of specimens shall be at the Contractor's expense.

Method B shall consist of a proof-load test. The Engineer shall be notified and may be present during the proof-load test. Frames and covers and gratings selected by the Engineer shall be loaded to the proof-load specified on the Standard Plan. The loads shall be concentrated on a 230 mm by 230 mm by 25 mm (9 inch by 9 inch by 1 inch) minimum-thickness steel plate placed on a 6 mm (1/4 inch) rubber pad centered on the assembled cover or grate. The specified load shall be applied by a calibrated testing machine and held for a period of 1 minute. Upon removal of the load, the test specimens shall be examined for cracks and permanent deformation, either of which are cause for rejection. The testing of the specimens shall be at the Contractor's expense.

Test specimens shall be selected as follows:

- 1) Two assembled test specimens shall be proof-load tested for each lot. A lot shall be defined as consisting of no more than 25 complete units from the same foundry facility.
- 2) If the tested specimens of a designated lot pass the test, all of the units of that lot shall be considered as complying with the load requirements.
- 3) If either of the tested specimens of a designated lot fails to pass the test, then five additional specimens from the same lot shall be selected for testing.
- 4) If the five additional specimens pass, the total number of that lot will be considered as complying with the requirements, except previously failed specimens.
- 5) If any of the five additional specimens fails to meet the load tests requirements, the entire lot shall be rejected, except those specimens that passed.

**206-3.3 Manhole Frame and Cover Sets.** The bearing surface of the frames and covers shall be machined and the cover shall seat firmly into the frame without rocking. The frames and covers shall be coated as specified in 206-3.6.

**206-3.4 Railings, Railing Posts, and Wheel Guards.** Castings shall conform to ASTM A 48, Class 40.

**206-3.5 Rockers, Rocker Plate Bearings, and Bearing Plates for Bridges.** Castings shall conform to ASTM A 48, Class 50. Castings shall be machined and finished as required by the Engineer.

**206-3.6 Asphalt Coatings.** Unless otherwise specified, exposed surfaces with the castings assembled and disassembled shall be painted with a commercial quality asphalt paint after testing and inspection.

## 206-4 BRONZE CASTINGS.

**206-4.1 General.** Bronze castings shall be true to pattern in form and dimension and free from defects that would affect the service value of the casting. Minor defects may be repaired with Engineer approval. Castings which have been repaired without Engineer approval may be rejected. Castings that show injurious defects revealed by machining operations or by X-ray will be rejected.

**206-4.2 Testing Requirements.** Chemical analysis shall be made in accordance with ASTM E 54.

When required by the Agency, test coupons shall be provided as specified in 206-2.2 except specimens shall be prepared in accordance with ASTM B 208.

**206-4.3 Expansion and Bearing Plates.** Expansion and bearing plates shall conform to the requirements of ASTM B 22, Alloy C. The sliding contact faces shall be machined smooth to true planes. If practical, one plate shall be machined at right angles to other plates in the set.

### 206-4.4 Ornamental Tablets and Miscellaneous Castings.

**206-4.4.1 General.** Ornamental tablets, railings, miscellaneous ornaments, and fixtures shall conform to the chemical requirements of ASTM B 584 Copper Alloy UNS No. C90300.

**206-4.4.2 Bearing Plates** The letters shall be heavily raised and spaced carefully to secure a uniform and balanced effect over the entire area of the panel. The background of the letter panel shall have a finely pebbled surface. The model of the tablet shall be submitted to the Engineer for approval.

Castings shall be boldly filleted at angles, and the arrises shall be sharp and true.

The faces and edges of all lettering and ornaments shall be tooled sharp and clean. Beveled edges shall be tooled smooth and true. Outside borders shall be straight and true and thoroughly polished. Filling and other tool marks shall be removed.

Ornaments, lettering, and the beveled edges shall be given a fine satin, hand finish. Lettering, bevels, and rosettes shall be highlighted; leaves and scrolls slightly highlighted, but well-polished. The pebble background shall be finished in dark statuary bronze and polished.

## 206-5 METAL RAILINGS.

**206-5.1 Metal Hand Railings Materials.** The fabrication of metal hand railings shall be in accordance with 304-2.

Steel railing material shall be welded or seamless steel pipe conforming to ASTM A 53, structural steel conforming to ASTM A 36, or tubular sections of hot rolled-mild steel, conforming to ASTM A 501.

The base metal for aluminum railing shall be ASA alloy designation 6063-T6. Pipe and tubing shall be extruded conforming to requirements of ASTM B 429, plates and sheets shall be rolled conforming to ASTM B 209, and rods, bars, or shapes shall be extruded conforming to ASTM B 221.

**206-5.2 Flexible Metal Guardrail Materials.** Unless otherwise provided on the Plans or in the Specifications, materials and construction for the railings shall conform to the following requirements:

The rail elements, terminal sections, bolts, nuts, and other fittings shall conform to the specifications of AASHTO M 180, except as modified in this subsection. The edges and center of the rail element shall contact each post or block. Rail element joints shall be lapped not less than 315 mm (12-1/2 inches) and bolted. The rail metal shall be open hearth, oxygen furnace, or electric furnace steel and, in addition to conforming to the requirements of AASHTO M 180, shall withstand without cracking, a cold bend of 180 degrees around a mandrel of a diameter equal to two and one-half times the thickness of the plate.

Two certified copies of mill tests reports of each heat, from which the rail element is formed, shall be furnished to the Engineer.

The ends of each length of railing shall be fitted with terminal sections.

Workmanship shall be equivalent to commercial practice and all edges, bolt holes, and surfaces shall be free of torn metal, burrs, sharp edges, and protrusions.

Bolts shall have shoulders of such shape that will prevent them from turning.

Rail elements shall be fabricated for splicing at wood posts at intervals not to exceed 4 m (12.5 feet).

The rail element shall have full bearing at joints. When the radius of curvature is 50 m (150 feet) or less, the rail element shall be shaped in the shop.

Railing parts furnished under these specifications shall be interchangeable with similar parts regardless of source.

Unless otherwise specified, the rail elements, terminal sections, bolts, nuts, and other fittings shall be galvanized in accordance with 210-3.

Posts, including blocks, shall be "Construction" grade, Douglas fir, free of heart center.

The posts and blocks shall be pressure treated after fabrication with creosote, creosote-coal tar solution, creosote-petroleum solution (50-50), pentachlorophenol (oil borne), or copper-naphthenate (oil borne) as provided in 204-2.

#### **206-6 CHAIN LINK FENCE.**

**206-6.1 General.** All materials and fittings shall be new and all ferrous materials shall be coated in accordance with 210-3. Class 1A steel pipe shall additionally be coated in accordance with 210-4. When specified, Class 1 or Class 1A materials shall additionally be clad coated with PVC in accordance with 210-5. The base material for the manufacture of steel pipe used for posts, braces, top rails, and gate frames shall conform to the requirements of ASTM F 1083, Schedule 40, for Class 1 or ASTM A 569 for Class 1A. Class 1A steel shall have a minimum yield strength of 345 MPa (50,000 psi). All unit weights shall be subject to the standard mill tolerance of plus or minus 5 percent.

Posts shall be fitted with caps designed to fit securely over the posts and carry a top rail where specified. Posts shall have a total length of not less than the depth of the concrete footing, as specified herein, plus the length required above ground. Where no top rail is required, pipe posts shall be fitted with suitable caps. Caps will not be required for "C" or "H" section posts.

Top rails shall be furnished in random lengths of approximately 6 m (20 feet) where required.

Barbed wire shall be installed on the fence only when specifically required by the Plans or Specifications. When required, it shall be installed on extension arms of a type specified under 206-6.6.

**206-6.2 Materials for Posts, Rails and Braces.** Materials for posts, rails, and braces shall conform to Table 206-6.2 (A).

TABLE 206-6.2 (A)

Use	Nominal <sup>1</sup> Type And Size	Actual O.D. mm (Inches)	Weight kg/m (lbs/feet)	
			Class 1	Class 1A
End, corner, slope, and gate posts for single gates 1.8 m (6 feet) or less in width and double gates 3.6 m (12 feet) or less in width for fences less than 1.8 m (72 inches) in height.	2 NPS	60.3 (2.375)	5.43 (3.65)	4.64 (3.12)
End, corner, slope, and gate posts for single gates 1.8 m (6 feet) or less in width and double gates 3.6 m (12 feet) or less in width for fences 1.8 m (72 inches) or higher.	2-1/2 NPS	73.0 (2.875)	8.62 (5.79)	6.91 (4.64)
Gate posts for single swing gates over 4m (13 ft) but not over 5.5 m (18 ft) in width and double swing gates over 8 m (26 ft) but not over 11 m (36 ft) in width.	3-1/2 NPS	101.6 (4.0)	13.56 (9.11)	—
	3 NPS	88.9 (3.5)	—	8.50 (5.71)
Gate posts for single swing gates over 4 m (13 feet) but not over 5.5 m (18 feet) in width and double swing gates over 8 m (26 feet) but not over 11m (36 feet) in width.	6 NPS	168.3 (6.625)	28.23 (18.97)	—
Gate posts for single swing gates over 5.5 m (18 feet) in width and double swing gates over 11 m (36 feet) in width.	8 NPS	219.1 (8.625)	36.76 (24.70)	—
Line posts for fences 1.8 m (72 inches) higher.	2 NPS	60.3 (2.375)	5.43 (3.65)	4.64 (3.12)
	48 x 41 mm (1-7/8 in x 1-5/8 in)C	—	3.20 (2.15)	—
	57 x 48 mm (2-1/4 in x 1-7/8 in)H	—	6.10 (4.10)	—
Line posts for fences less than 1.8 m (72 inches) in height.	1-1/2 NPS	48.3 (1.90)	4.05 (2.72)	3.39 (2.28)
	48 x 41 mm (1-7/8 in x 1-5/8 in)C	—	2.75 (1.85)	—
	48 x 41 mm (17/8 in x 1-5/8 in)H	—	4.17 (2.80)	—
	—	—	—	—
Top rails and braces.	1 1/4 NPS	42.2 (1.660)	3.39 (2.27)	2.72 (1.83)
	41 x 32 mm (1-5/8 in x 1-1/4 in)C	—	2.01 (1.35)	—
	38 x 32 mm (1-1/2 in x 1-1/4 in)H	—	3.27 (2.20)	—
Frames for gates.	1-1/2 NPS	48.3 (1.900)	4.05 (2.72)	3.39 (2.28)
Stiffeners for gates.	1-1/4 NPS	42.2 (1.660)	3.39 (2.27)	2.72 (1.83)

1. Nominal Pipe Size (NPS), a non-dimensional unit as defined in ASTM F 1083.

**206-6.3 Chain Link Fabric.** Unless otherwise specified, shall conform to 206-3.1 or 206-6.3.2.

**206-6.3.1 Galvanized Fabric.** Chain link fabric shall conform to the requirements of ASTM A 392. The fabric shall be 3.1 mm (11-gage) for all fence 1500 mm (60 inches) or less in height and shall be 3.8 mm (9-gage) for all fence over 1500 mm (60 inches) in height, unless otherwise specified.

All chain link fabric shall be woven into approximately 50 mm (2 inch) mesh and galvanized either prior to or after fabrication, unless otherwise specified by the Contract Documents. Fabric 1500 mm (60 inches) or less in width shall have knuckled finish on the top and bottom edges. Fabric greater than 1500 mm (60 inches) in width shall have knuckled finish on the top edges and twisted and barbed finish on the bottom edge. Barbing shall be done by cutting the wire on the bias.

**206-6.3.2 Polyvinyl Chloride (PVC) Coated Fabric.** This specification covers PVC coated chain link fabric coated before weaving. PVC coated fabric shall conform to ASTM F 668. Fabric may be produced in two classes of wire defined as follows: Class 1 shall consist of PVC extruded or extruded and adhered to zinc-coated steel wire. Class 2 shall consist of PVC fusion-bonded to zinc-coated steel wire. PVC coating thickness shall be a minimum 380  $\mu\text{m}$  (15 mils) for Class 1 and 180  $\mu\text{m}$  (7 mils) for Class 2. The core wire for the fabric shall be 3.0 mm (0.120 inches) for all fence 1500 mm (60 inches) or less in height and shall be 3.76 mm (0.148 inches) for all fence over 1500 mm (60 inches) in height unless otherwise specified. The specified diameter is the metallic core wire diameter and the PVC coating shall not be considered when determining the diameter.

All chain link fabric shall be woven into approximately 50 mm (2 inch) mesh. All fabric widths shall have knuckled finish on the top and bottom edges. At the time of fabrication, cut ends shall be covered with acrylic enamel. Acrylic enamel shall be a PVC resin in solution, consisting of high-level pigments, ultraviolet absorbers and solvent blends applied by brush or dabbing applicator.

**206-6.4 Tension Wires and Fabric Ties.** Tension wires shall be at least 4.5 mm (7-gage) galvanized coil spring steel wire.

Ties used to fasten the fabric to posts, rails, and gate frames shall be not smaller than 3.1 mm (11-gage) galvanized steel, 4.9 mm (6-gage) aluminum wire, or approved noncorrosive metal bands.

Tension bars used in fastening fabric to end and corner posts and gate frames shall be galvanized high carbon steel bars not smaller than 9.5 mm (3/16 in) by 19 mm (3/4 in).

**206-6.5 Truss or Tension Rods.** Truss or tension rods used in trussing gate frames and line posts adjacent to end, corner, slope or gate posts shall be adjustable 9.5 mm (3/8 inch) diameter galvanized steel rod. When used in trussing line posts, adjustment shall be provided by means of galvanized turnbuckles or other suitable tightening devices.

**206-6.6 Fittings.** All required fittings and hardware shall be galvanized.

Couplings to connect the individual lengths of top rail shall be of the outside sleeve type and at least 175 mm (7 inches) long. The bore of the sleeves shall be sufficiently true to maintain adjacent lengths of rail in alignment.

Extension arms for barbed wire shall be of a type that can be attached to the tops of the posts and carry three wires at approximately 140 mm (5-1/2 inch) centers in a plane approximately 45 degrees from the vertical, inclined as shown on the Plans or as directed by the Engineer.

**206-6.7 Barbed Wire.** Barbed wire shall be four-point pattern, composed of two strands of 2.5 mm (12-1/2-gage) galvanized steel wire with barbs spaced 125 mm (5 inches) apart and shall conform to ASTM A 121.

**206-6.8 Repair of Damaged Coatings.** All welds made after galvanizing shall be ground smooth and wire brushed to remove loose or burned zinc coating, after which the cleaned areas shall be prepared and neatly coated with 50-50 solder or as prescribed in 210-3.5. Repairs to abraded or otherwise damaged zinc coating shall be made in a similar manner.

## SECTION 207 - PIPE

### 207-1 NONREINFORCED CONCRETE PIPE.

**207-1.1 General.** The nonreinforced concrete pipe to be furnished shall be as shown on the Plans, or as specified under the item of work for the project.

Concrete pipe shall be extra-strength unless otherwise specified, shall be manufactured from portland cement concrete, and shall be so constructed that it will conform to the requirements described herein.

**207-1.2 Materials.** Materials used in manufacturing the pipe shall be as specified in ASTM C 14M (ASTM C 14), with the following exceptions:

- 1) The portland cement shall be as specified in 201-1.2.1.
- 2) At least 28 percent of the aggregate by weight shall be larger than 25 mm (9/10 inch) for pipes 300 mm (12 inches) and larger in diameter.
- 3) All aggregates shall conform to 201-1.2.2.

**207-1.3 General Requirements.** The plane of the ends of the pipe, except for special shapes, shall be perpendicular to the longitudinal axis of the pipe. The interior surface shall be smooth and well-finished. Joints shall either be of the socket and spigot type or the tongue and groove type, as approved by the Engineer, and so constructed that, when laid, the pipe will form a continuous conduit with a smooth and uniform interior surface.

When shown on the Plans, the pipe shall have a gasketed joint. The gasket shall be seated in an accurately shaped groove on the spigot end of the pipe section and the gasket shall be of suitable cross section and size. Alternate joint details may be used with Engineer approval. The gasket shall be considered as the principal element in making the joint watertight. The gasket shall be manufactured from a synthetic rubber of neoprene base and shall conform to the requirements of 208-1.2 and 208-2.2.

The completed pipe shall be free from fractures, large or deep cracks, laminations, and surface roughness. Specimens which, when placed in a vertical position, do not give a metallic ring when struck with a hammer, or which exhibit any of the following defects, will be subject to rejection:

- 1) Indications of honeycomb or open texture or of imperfect mixing or molding.
- 2) Fractures or cracks passing through the wall or socket, except a single end crack less than 75 mm (3 inches) measured transversely or 50 mm (2 inches) measured longitudinally will not be deemed cause for rejection unless such defects appear in more than 5 percent of the number of sections inspected; in which event, the defective sections will be rejected.
- 3) Cracks sufficient to impair the strength, durability or serviceability of the pipe; a single crack in the body of the pipe, extending through one-half of the thickness of the wall and over 75 mm (3 inches) in length; or two or more such cracks regardless of length.
- 4) Variations in dimensions in excess of those permissible, as set forth in the following tables.
- 5) Failure to meet the test requirements set forth herein.

- 6) In pipe designed to be straight, deviations greater than 10 mm per linear meter (3/8 inch per linear foot). The deviation shall be measured from a straight-edge on the concave side of the pipe.

**207-1.4 Dimensions.** Each straight pipe of all sizes and classes shall be not less than 0.9 m (3 feet) in length unless otherwise specified for special purposes. The minimum length of 150 mm (6 inch) Y's and T's shall be 450 mm (18 inches) and 600 mm (24 inches) for 200 mm (8 inch) and larger Y's and T's. Other dimensions of pipe shall conform to the following tables:

**TABLE 207-1.4 (A)**  
**STANDARD STRENGTH CONCRETE PIPE**

1 Nominal Size mm (Inches)	2 Thickness of Wall mm (Inches)	3 Depth of Socket mm (Inches)	4 Minimum Annular Space <sup>1</sup> mm (Inches)
150 (6)	19(3/4)	57(2-1/4)	16(5/8)
200 (8)	22(7/8)	64(2-1/2)	16(5/8)
250 (10)	25(1)	64(2-1/2)	16(5/8)
300 (12)	29(1-1/8)	70(2-3/4)	16(5/8)
375 (15)	35(1-3/8)	70(2-3/4)	16(5/8)
450 (18)	38(1-1/2)	76(3)	16(5/8)
525 (21)	44(1-3/4)	89(3-1/2)	19(3/4)

1. Applies to socket ends only.

**TABLE 207-1.4 (B)**  
**EXTRA-STRENGTH CONCRETE PIPE**

1 Nominal Size mm (Inches)	2 Thickness of Wall mm (Inches)	3 Depth of Socket mm (Inches)	4 Minimum Annular Space <sup>1</sup> mm (Inches)
150 (6)	19(3/4)	57(2-1/4)	16(5/8)
200 (8)	22(7/8)	64(2-1/2)	16(5/8)
250 (10)	25(1)	64(2-1/2)	16(5/8)
300 (12)	38(1-1/2)	70(2-3/4)	16(5/8)
375 (15)	48(1-7/8)	70(2-3/4)	16(5/8)
450 (18)	60(2-3/8)	76(3)	16(5/8)
525 (21)	70(2-3/4)	89(3-1/2)	19(3/4)

The annular space is the space between the inside of the socket and the outside of the spigot of the pipe as placed in the socket. The minimum annular space, as shown in column 4, is measured at the outer end of the socket. The space at the bottom of the socket, known as the caulking space, shall be not less than 6 mm (1/4 in).

1. Applies to socket ends only.

**TABLE 207-1.4 (C)**  
**LIMITS OF PERMISSIBLE VARIATION IN STANDARD**  
**STRENGTH AND EXTRA-STRENGTH CONCRETE PIPE**

Nominal Size		Variation from Indicated Length ( $\pm$ )		Depth of Socket (-)		Thickness of Wall (-)		Inside Diameter of Bore				Length of Two Opposite Sides	
								Minimum		Maximum			
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
150	6	13	1/2	6	1/4	2	1/16	150	5-13/16	160	6-3/16	10	3/8
200	8	13	1/2	6	1/4	2	1/16	200	7-13/16	210	8-1/4	10	3/8
250	10	13	1/2	6	1/4	2	1/16	250	9-13/16	260	10-1/4	10	3/8
300	12	13	1/2	6	1/4	2	1/16	300	11-13/16	312	12-5/16	10	3/8
375	15	13	1/2	6	1/4	3	1/8	375	14-3/4	390	15-5/16	10	3/8
450	18	13	1/2	6	1/4	3	1/8	450	17-3/4	465	18-3/8	10	3/8
525	21	13	1/2	6	1/4	3	1/8	525	20-11/16	545	21-7/16	10	3/8

**Note:** This minus (-) alone indicates the plus variation is not limited; the plus and minus sign ( $\pm$ ) indicates variations in both excess and deficiency.

**207-1.5 Marking.** Each pipe shall be marked clearly and legibly to show the class of pipe, date of manufacture, and the name or trademark of the manufacturer.

#### **207-1.6 Test Requirements.**

**207-1.6.1 General.** Before pipe is delivered to the Work site for use in any work, test pipe shall meet the requirements of the hydrostatic pressure test and the loading test described herein. Tests shall be made at the point of manufacture and shall be made under the supervision of the Engineer.

All testing equipment shall be calibrated by an agency approved by the Engineer at intervals not to exceed 6 months.

**207-1.6.2 Selection of Test Pipes.** Each lot of non-reinforced concrete pipe is defined as not more than 450 sections of pipe of one size and class. All the pipe shall be manufactured from the same mix of concrete, have the same cure, and be from 1 day's manufacture.

The Engineer will select at random and have tested one pipe for each 50 pipes or fraction thereof in each lot. The minimum number of pipes tested for any lot shall be five. The pipes selected for test shall be sound and have dimensions consistent with these specifications.

The Contractor shall furnish the test pipes without charge and shall provide adequate equipment and facilities for conducting tests. Unless otherwise specified, the Contractor shall bear all costs.

**207-1.6.3 Hydrostatic Pressure Test.** The hydrostatic pressure test shall precede the loading test by not more than 3 hours.

When the pipe is subjected to an internal hydrostatic pressure of 70 kPa (10 psi) for the time shown in the following table, the accumulated moisture on the exterior surface shall not run down the sides in such quantity that will exceed 10 mL (0.34 fluid ounce). Each 6500 mm<sup>2</sup> (10 square inches) of moisture appearing on the exterior surface shall be considered to be 1 mL (0.03 fluid ounce) of runoff.

TABLE 207-1.6.3 (A)

Thickness of Wall mm (Inches)	Testing Time (Minutes)
Up to and including 25 mm (1 inch)	7
Over 25 mm (1 inch) and including 38 mm (1-1/2 in)	9
Over 38 mm (1-1/2 inches) and including 50 mm (2 in)	12
Over 50 mm (2 inches) and including 60 mm (2-1/2 in)	15
Over 63 mm (2-1/2 inches) and including 75 mm (3 in)	18
Over 75 mm (3 inches)	21

**207-1.6.4 Loading test.** The loading test shall be the three-edge bearing conforming to ASTM C 14.

TABLE 207-1.6.4 (A)  
kN per linear meter (pounds per linear foot)

Size mm (Inches)	Standard Strength	Extra Strength
150(6)	16.1(1100)	29.2(2000)
200(8)	19.0(1300)	29.2(2000)
250(10)	20.4(1400)	29.2(2000)
300(12)	21.9(1500)	32.8(2250)
375(15)	25.5(1750)	40.1(2750)
450(18)	29.2(2000)	48.2(3300)
525(21)	32.1(2200)	56.2(3850)

The net inside length of pipe from the bottom of the socket to the spigot end of the pipe shall be used as the divisor to calculate the load per linear foot.

**207-1.6.5 Acceptance or Rejection of Pipe.** When all the pipe tested passes the required tests, the entire lot of pipe will be acceptable. When two test pipes fail, the entire lot will be rejected.

When only one test pipe of the first group selected fails, five additional pipes shall be tested. If none of the additional pipes fail, the entire lot will be acceptable. If one fails, the entire lot will be rejected.

**207-1.7 Perforated Pipe.** Perforated pipe shall conform to the requirements of this section except the hydrostatic pressure test will not be required, and the strength requirements shall be reduced 10 percent from the values given in 207-1.6.4.

The pipe shall be shop perforated with perforations symmetrically located within a maximum arc of 160 degrees. Perforations shall have a total open area of at least 630 mm<sup>2</sup> per linear meter (0.3 square inches per linear foot) of pipe, with a minimum of 3 perforations per linear meter (one perforation per linear foot); except for joint areas. Perforations shall be either holes or slots. Diameter of the holes may vary from 6 mm (1/4 inch) minimum to 10 mm (3/8 inch) maximum; the width of the slots may vary from 5 mm (3/16 inch) minimum to 8 mm (5/16 inch) maximum; the length of the slot shall not exceed 100 mm (4 inches).

#### 207-1.8 Curing.

**207-1.8.1 General.** The manufacturer shall provide adequate steam plant, enclosures, piping, and other facilities for curing the pipe. The enclosures shall be such that the humidity shall be maintained so as to keep the pipe surfaces moist at all times. The temperature shall be maintained continuously between 50°C and 65°C (120°F and 150°F).

**207-1.8.2 Curing Requirements.** The pipe shall be cured under either of the following methods:

- 1) After the pipe has been manufactured, it shall be placed in enclosures and saturated steam applied for at least 6 hours, starting not sooner than 1 hour nor more than 10 hours, after completion of manufacture. Starting not later than 1 working day after completion of the steam curing, the pipe shall be kept constantly and thoroughly wet for at least 7 days. When an approved temperature-time recorder is used, 1 hour of steam may be substituted for each 4 hours of the required water cure.
- 2) Starting not later than 24 hours after the pipe has been manufactured, it shall be kept constantly and thoroughly wet for at least 14 days.

**207-1.9 Inspection.** Sections of pipe to be inspected shall be so situated at the manufacturer's plant as to provide the Engineer with free accessibility for inspection and marking. In no case shall the pipe be stacked for inspection to a height that would require the Engineer to climb or use a ladder.

At the place of manufacture, the Engineer will indicate acceptance of the pipe for delivery to the job by marking the pipe with the Agency's stamp. Such acceptance, however, shall be considered a tentative acceptance. Final acceptance will be made only when the project has been completed.

If pipe is rejected subsequent to its manufacture, the mark placed thereon by the Engineer shall be defaced.

## **207-2 REINFORCED CONCRETE PIPE (RCP).**

**207-2.1 General.** These specifications apply to reinforced concrete pipe intended to be used for the construction of storm drains, sewers, and related structures.

The size, type, and D-load of the concrete pipe to be furnished shall be as shown on the Plans or in the Specifications.

Prior to the manufacture of the RCP, three sets of prints of the pipeline layout diagrams shall be furnished to the Engineer per 2-5.3, except transparencies will not be required. Catch basin connector pipes need not be included in the layout; but, in lieu thereof, a list of catch basin connector pipes shall accompany the layout. The connector pipe list shall include size and D-load of pipe, station at which pipe joins mainline, number of sections of pipe, length of sections, and type of sections (straight, horizontal bevel, vertical bevel, etc.). The diagrams and lists submitted will be used by the Agency for reference only, and their use shall in no way relieve the Contractor of its responsibility for correctness. The Engineer may waive the pipeline layout and connector pipe list requirement.

Unless otherwise specified, RCP shall be either wet-cast, spun, or machine-made.

Plants and processes not previously qualified by the Agency may require initial qualification by the Agency using any or all of the following tests described in ASTM C 497M (ASTM C 497) and as listed below. Upon qualification, no additional tests will be required unless changes have been made in the equipment and procedures, or an increase in the largest aggregate size is made from the previous approved mix designs. The manufacturer shall provide qualifying data upon request by the Engineer:

- 1) **Three-Edge Bearing Test.** Two tests minimum on each of three different pipe sizes per 207-2.9.2.
- 2) **Core Strength Test.**
  - a) Minimum allowable adjusted compressive strength: 27.6 MPa (4,000 psi).
  - b) Number of tests: two each from three different pipes.
  - c) Unit weight to be used as a baseline for future reference.

- 3) **Absorption Test per ASTM C 497M (ASTM C 497), Section 7, Method A.**
- a) Obtain two core samples (one each from the middle area of two pipes for each mix design).
  - b) Maximum allowable absorption value: 9 percent.
- 4) **Hydrostatic Test.** One test sample selected by the Engineer shall meet the following criteria:
- a) 24-hour presoak (manufacturer's option).
  - b) Hydrostatic pressure of 90 kPa (13 psi) minimum shall be maintained for 20 minutes.
  - c) End bulkheads or internal plugs may be used at the manufacturer's option. Leakage at the bulkhead of plugs is allowed if leakage does not interfere with the test.
  - d) Allowable leakage: none. Moisture appearing on the exterior surface of the pipe in the form of beads adhering to the surface will not be considered leakage. The tests may be repeated after the 24-hour presoak at the manufacturer's option to determine if test pipe stops leaking. Pipe which stops leakage after the presoak will be considered to have passed.
- 5) **Visual Inspection.** Pipe inspection shall include the following:
- a) 207-2.5 (Joints).
  - b) Interior surface finish and textures.
  - c) Reinforcing steel placement and twist, per 207-2.4.2 and 207-2.4.3. Concrete from a portion of one piece of green pipe shall be stripped or raked to determine cage twist, location, clearance, and voids. Voids around reinforcing steel cage caused by cage twist will not be acceptable. Cage twist resulting from pipe production in excess of 6 mm (1/4 inch) in 2.4 m (8 feet) will not be acceptable.
  - d) Longitudinally cut pipe. One pipe shall be longitudinally sawcut in half using equipment which will not damage the concrete or reinforcing steel. The exposed surface shall be inspected for voids adjacent to the circumferential steel. Voids shall be considered continuous if a 1.5 mm (1/16 inch) diameter pin can be inserted 6 mm (1/4 inch) deep.

This test will be acceptable if no more than 10 percent of the circumferential bars exposed have continuous voids.

Plant inspection shall include cage manufacturing, curing process, batching equipment and process, aggregate and cement storage, concrete mix designs, and product handling.

The interior surface of the pipe shall be smooth and well-finished. Joints shall be of such type and design and so constructed as to be adequate for the purpose intended so that, when laid, the pipe will form a continuous conduit with a smooth and uniform interior surface.

Sockets and spigots shall be free from any deleterious substance or condition which might prevent a satisfactory mortar bond at the joints.

If the Engineer determines that the forms, end rings, or form gaskets used in the manufacture of the pipe are inadequate, the Contractor shall replace or repair said equipment to the satisfaction of the Engineer.

Pipe of greater strength than that specified or cover greater than required in 207-2.4.2 may be furnished at the Contractor's option, and its expense, provided such pipe conforms in all other aspects to the applicable provisions of these specifications.

The Contractor shall furnish, install, and maintain stulls or other devices in the pipe as may be necessary to meet the limitations on cracks specified herein.

**207-2.2 Materials.** Except when otherwise permitted by the Engineer, no materials shall be used in manufacturing the pipe other than water, water reducing admixture, portland cement, mineral aggregates, and steel conforming to ASTM C 76M (ASTM C 76), with the following requirements:

- 1) The portland cement shall be as specified in 201-1.2.1.
- 2) All aggregate shall conform to the reactivity requirements in 201-1.2.2.
- 3) Fly ash shall conform to the quality requirements in 201-1.2.5.

The aggregate shall be so graded, proportioned, and thoroughly mixed in a batch mixer to produce a homogeneous concrete mixture of such quality that pipe will conform to the test and design requirements of these specifications. The proportion of cementitious material (portland cement and fly ash) shall not be less than 330 kg/m<sup>3</sup> (560 pounds per cubic yard) of concrete.

**207-2.3 Dimensions.**

**207-2.3.1 Length.** The nominal length shall be not less than 2.4 m (8 feet) except as otherwise specified or required for bends or special joints.

Variations in laying lengths of two opposite sides of pipe shall not be more than 10 mm per m (1/8 inch per foot) of diameter with a maximum of 16 mm (5/8 inch) in any length of pipe.

**207-2.3.2 Cast Pipe Wall Thickness.** Cast pipe wall thickness shall conform to the following:

**TABLE 207-2.3.2 (A)**

Nominal Internal Diameter Millimeters (Inches)	Minimum Barrel Thickness Millimeters (Inches)
300 (12)	50 (2)
375 (15)	57 (2-1/4)
450 (18)	57 (2-1/4)
525 (21)	57 (2-1/4)
600 (24)	76 (3)
675 (27)	76 (3)
750 (30)	76 (3)
825 (33)	76 (3)

For pipe larger than 825 mm (33 inches) in diameter, the minimum wall thickness permitted will depend upon the strength of the concrete used. If the concrete has a strength of 31.0 MPa (4,500 psi) in 28 days, any wall thickness not less than 1/12 the internal diameter is permitted. If the concrete has a strength less than 31.0 MPa (4,500 psi) but more than 27.6 MPa (4,000 psi) at 28 days, a wall thickness 25 mm (1 inch) greater than 1/12 the internal diameter will be required. The concrete strength shall be determined in accordance with ASTM C 31 and C 39.

**207-2.3.3 Spun Pipe Wall Thickness.** Spun pipe wall thickness shall conform to the following:

**TABLE 207-2.3.3 (A)**

Nominal Diameter Millimeters (Inches)	Minimum Wall Thickness Millimeters (Inches)
300 (12)	50 (2)
375 (15)	50 (2)
450 (18)	50 (2)
525 (21)	50 (2)
600 (24)	63 (2-1/2)
675 (27)	66 (2-5/8)
750 (30)	69 (2-3/4)
825 (33)	73 (2-7/8)
900 (36)	76 (3)
975 (39)	85 (3-1/8)
1050 (42)	95 (3-3/4)
1125 (45)	98 (3-7/8)
1200 (48)	101 (4)

The thickness of the barrel of pipe larger than 1200 mm (48 inches) in diameter shall not be less than 1/12 the internal diameter of the pipe.

**207-2.3.4 Machine-Made Pipe Wall Thickness.** The minimum wall thickness for all pipe sizes shall be as specified in ASTM C 76M (ASTM C 76) Wall B (1/12 the internal diameter plus 25 mm (1 inch)) using 27.6 MPa (4,000 psi) minimum strength concrete.

#### **207-2.4 Reinforcement.**

**207-2.4.1 General.** The reinforcement shall be a cage fabricated of bars or wire. Circumferential reinforcement shall be in the amount and type shown on Plans, or that required to sustain the specified test loads. Longitudinal reinforcement shall be sufficient to make the cage rigid and to support the circumferential reinforcement firmly in place in the forms during placing and consolidation of the concrete.

Pipe which is to be jacked shall have a circular cage reinforcement.

In pipe larger than 2400 mm (96 inch) diameter, the minimum size of circumferential reinforcement for the inside circular cage shall be 11 mm (7/16 inch) diameter.

Fastenings (supports) and/or retractable mechanical devices, approved by the Engineer, shall be used for holding the cage rigidly in place in the form in its elliptical or circular shape. In wet-cast and machine-made pipe these fastenings shall be spaced not closer than 0.6 m (2 feet) center-to-center along the longitudinal reinforcement except for pipe having a nominal length of 1.2 m (4 feet) or less.

All reinforcing steel shall be clean and free from loose rust, scale, paint, grease, form oil, or other foreign matter.

Splices shall be butt-welded or lap-welded a minimum of 6 diameters. Nonwelded splices shall be lapped a minimum of 20 diameters for deformed bars and 40 diameters for plain bars or cold-drawn wire. Nonwelded lapped splices shall be wired tightly. Welds shall develop not less than 75 percent of the minimum specified ultimate strength of the bars or wires being welded.

Elliptical cages may be specifically fabricated or deformed from a circular cage to the required elliptical dimensions.

Cages for machine-made pipe shall be circular.

Upon request, the Contractor shall furnish data to the Engineer indicating lot number, wall thickness, and the size, spacing, and positioning of reinforcement for any pipe manufactured.

**207-2.4.2 Location of Reinforcement.** Measurements of position, except for concrete cover, shall apply to the center of the bar or wire.

For pipe with wall thickness greater than 57 mm (2-1/4 inches), the required minimum cover measured between reinforcement surface and pipe surface, and the permitted cover tolerances are given in the following table:

**TABLE 207-2.4.2 (A)**

Reinforcement	Storm Drain Pipe Nominal Diameter			Sewer Pipe Nominal Diameter	
	900 mm (24 in to 36 in)	975 mm to 2400 mm (39 in to 96 in)	Greater than 2400 mm (96 in)	2400 mm (96 in) or less	Greater than 2400 mm (96 in)
Circumferential mm (in)	19 ± 6 (3/4 ± 1/4)	19 ± 6 (3/4 ± 1/4)	32 ± 6 (1-1/4 ± 1/4)	25 ± 6 (1 ± 1/4)	32 ± 6 (1-1/4 ± 1/4)
Longitudinal mm (in)	10 Min. (3/8 Min.)	13 Min. (1/2 Min.)	13 Min. (1/2 Min.)	25 Min. (1 Min.)	25 Min. (1 Min.)

**Note:** In lined sewer pipe, the tabulated cover shall be increased as necessary to ensure that the distance from any reinforcement to embedded lugs or locking extensions of the liner is at least 6 mm. (1/4 inch).

The required covers shown in the table are minimums. Certain conditions such as high velocities or corrosive environments, may require greater covers as indicated on the Plans or in the Specifications.

The tabulated tolerances shall not apply where the Plans show cover over circumferential steel which differs from the values shown above.

For pipe with a wall thickness of 57 mm (2-1/4 inches) or less, the circumferential reinforcement shall be located at the center of the wall. The cover over longitudinal reinforcement shall be at least 10 mm (3/8 inch).

**207-2.4.3 Placement of Reinforcement.** The location of the minor axis of elliptically reinforced pipe shall be marked so that an imprint will be left in the interior of the concrete.

The circumferential reinforcement shall be placed in the body of pipe in such a manner that the longitudinal reinforcement of the cage will hold the last hoop or coil 19 mm (3/4 inch) minimum from the end plates or rings. Both ends of the circumferential reinforcement shall be finished off with a complete hoop of reinforcement.

For storm drain pipe, the longitudinal reinforcement may extend to the base plate or ring to act as a cage support. For sanitary sewer pipe, the longitudinal reinforcement shall have a minimum cover of 19 mm (3/4 inch) from the end faces of the pipe.

Circumferential reinforcement may be included in the joint projections at the option of manufacturer, and shall be included when required by Plans or Specifications.

Where the wall reinforcement does not extend into the joint projection, the longitudinal distance to the last circumferential reinforcement from the inside shoulder of the bell or shoulder of the spigot shall be a maximum of 44 mm (1-3/4 inches), but not less than 19 mm (3/4 inch) from any face.

**207-2.5 Joints.** Joints shall be designed to be self-centering. Unless otherwise specified, joints in concrete pipe shall be of the tongue-and-groove mortar type of joint.

When pipe joints of the reinforced concrete collar type or of rubber-gasketed type are specified or indicated on the Plans, joint details shall be submitted to the Engineer for approval before commencing pipe manufacture.

Pipe with beveled ends for use around curves, the radii of which are shown on the Plans, shall be provided where necessary. Either one or both ends shall be beveled a maximum of 5 degrees as may be required to provide well-fitting joints.

If required by the Engineer, the pipe shall be "match-marked" to meet specified laying tolerances at the place of manufacture and laying diagrams shall be furnished to the Contractor.

#### **207-2.6 General Manufacturing Requirements.**

**207-2.6.1 Wet-Cast Pipe.** Wet-cast RCP shall be manufactured by placing the concrete into stationary, vertical, cylindrical metal forms. During placing of each batch the concrete shall be vibrated continuously with internal or external mechanical vibrators operating at a minimum rate of 6,500 vibrations per minute.

**207-2.6.2 Spun Pipe.** Spun RCP shall be manufactured by introducing the concrete into a rotating horizontal cylindrical metal form. After the concrete materials have been mixed, they shall be promptly placed in the forms and spun on a horizontal axis. If, for any reason, the work of filling the forms is interrupted long enough for the concrete to take its initial set, any partly-filled form shall be emptied and the concrete rejected. While the concrete is being placed in the forms, they shall be revolved on a horizontal axis at a speed that will ensure uniformity of aggregates. After all the concrete has been placed in the forms, they shall be revolved at proper speed and duration to secure a dense concrete with smooth interior surface. Water and laitance collecting on the surface of the concrete shall be removed, and the interior surface of the pipe shall be troweled and finished to the form of a true cylinder.

**207-2.6.3 Machine-Made Pipe.** Machine-made RCP shall be manufactured by placing the concrete between vertical cylindrical forms or by placing the concrete into a vertical form and the interior surface formed with one or more roller packing heads and a long bottom-trowel rotating in opposite directions. The concrete shall be mixed to a uniform consistency and the reinforcing cage shall be held by fastening (supports) and/or retractable mechanical devices to ensure correct cage position.

Concrete placed between inner and outer forms shall be continuously vibrated throughout the manufacturing cycle and after all concrete has been placed in the forms, axial pressure shall be applied simultaneously with vibration to further densify the concrete, or the concrete shall be placed against the outer jacket and densified by continuous vibration during the manufacturing cycle. On completion of densification, the pipe may be removed immediately from the forms.

#### **207-2.7 Curing.**

**207-2.7.1 Steam Curing Facilities.** The manufacturer shall provide adequate enclosures, steam plant, piping, and other facilities for curing pipe. The enclosures shall be such that the temperature and humidity can be controlled to keep the pipe surfaces moist at all times and temperature maintained continuously between 27°C and 77°C (80°F and 170°F). Bulkhead curing is permissible, but will only be given credit for a maximum of 12 hours of the steam cycle.

### 207-2.7.2 Curing Procedures.

**General.** Wet-cast, machine-made, and spun pipe shall be cured by steam or water, or a combination of both, as described in the following paragraphs:

(a) **Steam Curing.** Steam may be applied as soon as the pipe is enclosed, but not later than 10 hours after completion of concrete placement. The temperature within the enclosure shall not be raised above 38°C (100°F) by the use of steam for the first hour; thereafter the temperature shall not be increased at a rate greater than 22°C (40°F) per hour. The temperature shall be maintained continuously between 27°C and 77°C (80°F and 170°F) for 28 hours.

For wet-cast and spun pipe, 6 hours of steam (at least 5 hours at 27°C (80°F) or higher) is required before forms may be removed. The period necessary to remove the forms may be included in the 28 hours, as long as it does not exceed 4 hours. Any time more than 4 hours shall be added to the total steam cycle. The time lapse during form removal shall not exceed 1 working day.

(b) **Combination Curing.** At any time after 6 hours of the steam cycle, the steam may be stopped and the cure continued using water applied in such a manner that the outside surfaces of the pipe is kept moist. Water may be substituted for steam on a basis of 4 hours of water being equal to 1 hour of steam. The manufacturer shall notify the Engineer prior to using water in lieu of steam.

(c) **Water Curing.** Pipe may be water cured by any method that will keep the outside surface moist for 4 consecutive days. Pipe to be given a total water cure may not be stripped from the forms until 20 hours after concrete placement or until the concrete has reached a compressive strength of 10.3 MPa (1,500 psi), whichever occurs first.

(d) **Alternate Curing Based On Compressive Strength.** Pipe cured by any of the above methods may have the water or steam stopped when the concrete strength reaches 20.7 MPa (3,000 psi). The strength shall be determined in accordance with ASTM C 31 and C 39.

(e) **Alternate Curing Procedures.** The manufacturer may request approval of alternate methods of curing that differ from the procedures specified above. The alternative method shall be specified in writing to the Engineer and fully substantiated by test data.

**207-2.8 Causes for Rejection.** Inspection of pipe as may be deemed necessary by the Agency will be made at the place of manufacture, and unless it can be repaired as provided in 207-3.3, or as approved by the Engineer, pipe may be rejected for any of the following reasons:

- 1) A piece of any size broken out of the pipe.
- 2) Defects that indicate imperfect mixing or molding.
- 3) Any crack extending entirely through the wall of the pipe and having a longitudinal or transverse length greater than the wall thickness of the pipe.
- 4) Any shattering or flaking of concrete at a crack.
- 5) A deficiency greater than 6 mm (1/4 inch) from the specified wall thickness of pipe 750 mm (30 inches) or smaller in diameter, or a deficiency greater than 5 percent (6 percent) from the specified wall thickness of pipe larger than 750 mm (30 inches) in internal diameter, except that the deficiency may be 7 percent (8 percent) adjacent to the longitudinal joint, provided that additional deficiency does not lie closer than 20 percent of the internal diameter to the vertical axis of the pipe and does not extend along the circumference for a distance greater than 20 percent of the internal diameter.

The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasketed joint pipe. Dimensions and tolerances of such contact surfaces shall be submitted for approval.

- 6) Internal diameter of the pipe exceeds the specified metric diameter by 2.6 percent or is less than the specified metric diameter. (For projects specifying units in U.S. Standard measures, a variation from a true circle of the specified diameter by more than 1 percent.)
- 7) The roundness of the pipe varies from a true circle of the actual internal diameter by more than one percent at any location along the barrel.
- 8) Rock pockets and water pockets in any pipe.
- 9) Exposure of any reinforcement arising from misplacement thereof.
- 10) Evidence of cage twist or misplacement of reinforcement.
- 11) Delamination of the concrete.
- 12) Surface defects indicating honeycomb or open-texture.
- 13) Separations or "blisters".
- 14) Slumped or sagged concrete.
- 15) For sewer pipe, any crack showing two visible lines or separation for a continuous length of 0.6 m (2 feet) or more, or an interrupted length of 0.9 m (3 feet) or more anywhere in evidence, both inside and outside, except where such cracks occur during the external loading test specified herein.
- 16) Any continuous crack or concrete separation having a surface width of 0.255 mm (0.010 inch) or more and extending for a length of 300 mm (12 inches) or more, regardless of depth or position in the wall of the pipe.
- 17) The pipe fails the D-load bearing strength test.

The imperfections and variations as causes for rejection in sewer and storm drain pipe, as specified herein, shall apply to pipe for which design details are indicated on the Plans as well as for pipe which is specified by D-load. The procedure of the Engineer for marking the pipe with the Agency's stamp at the place of manufacture shall not be considered a final acceptance of the pipe.

Pipe shall be considered ready for transporting to the project site when it conforms to the specified requirements for curing, testing, and inspection.

#### **207-2.9 Basis for Acceptance.**

**207-2.9.1 General.** The basis for acceptance shall be by one of the following, as designated in the Specifications:

- 1) The D-load bearing strength test, compliance with these specifications, inspection of the pipe manufacture and inspection of the completed pipe.
- 2) The structural design details, materials, tests, inspection of the pipe manufacture and inspection of the completed pipe.
- 3) Acceptance of certification of compliance with these specifications.

**207-2.9.2 D-load Bearing Strength Test.** Pipe to be D-load tested shall be selected at random by the Engineer at the point of manufacture. One pipe will be selected for each lot, or fraction thereof, of the pipe to be furnished for the project.

For the purpose of these specifications, a lot is defined as 122 m (400 feet) but no more than 50 sections of pipe, or fraction thereof, of one size and class manufactured on consecutive working days. If the 122 m (400 feet), but no more than 50 sections, of pipe are not made on consecutive working days, then only those made on consecutive working days shall be considered a lot. If an interruption in manufacturing occurs, the Engineer may permit the pipe made after the interruption to be included in the lot, provided that the interruption lasts less than 7 calendar days. A new lot number will be assigned if any change occurs in size or spacing of reinforcing steel, in the concrete mix, or in the curing method.

The Contractor shall furnish the test pipe without charge and shall provide adequate equipment and facilities for conducting tests and shall bear all expense in connection therewith, all tests being under the supervision of the Engineer. All testing equipment shall be calibrated at intervals not to exceed 6 months, by an agency approved by the Engineer.

Test Pipe shall conform in all other respects to the applicable requirements specified herein. Pipe shall be tested by the 3-edge bearing test as prescribed in ASTM C 497 M (ASTM C 497).

**TABLE 207-2.9.2 (A)**  
**ALLOWABLE CRACK WIDTH**

Pipe Wall Thickness Millimeters (Inches)	Allowable Crack Width in Millimeters (Inches) Pipe Diameters to 2400 mm (96 Inches)					
	Concrete Cover on Transverse Reinforcement in Millimeters (Inches)					
	19 mm (0.75 in)	32 mm (1.25 in)	44 mm (1.75 in)	57 mm (2.25 in)	70 mm (2.75 in)	
63(2.5)	0.255(0.010)	0.380(0.015)				
76(3.0)	0.255(0.010)	0.355(0.014)				
89(3.5)	0.255(0.010)	0.330(0.013)	0.455(0.018)			
101(4.0)	0.255(0.010)	0.330(0.013)	0.430(0.017)			
114(4.5)	0.255(0.010)	0.305(0.012)	0.380(0.015)	0.510(0.020)		
127(5.0)	0.255(0.010)	0.305(0.012)	0.380(0.015)	0.455(0.018)		
140(5.5)	0.255(0.010)	0.305(0.012)	0.355(0.014)	0.430(0.017)	0.535(0.021)	
152(6.0)	0.255(0.010)	0.305(0.012)	0.330(0.013)	0.405(0.016)	0.485(0.019)	
165(6.5)	0.255(0.010)	0.305(0.012)	0.330(0.013)	0.380(0.015)	0.455(0.018)	
178(7.0)	0.255(0.010)	0.280(0.011)	0.330(0.013)	0.380(0.015)	0.430(0.017)	
191(7.5)	0.255(0.010)	0.280(0.011)	0.330(0.013)	0.355(0.014)	0.430(0.017)	
203(8.0)	0.255(0.010)	0.280(0.011)	0.330(0.013)	0.355(0.014)	0.405(0.016)	
216(8.5)	0.255(0.010)	0.280(0.011)	0.330(0.013)	0.355(0.014)	0.380(0.015)	
229(9.0)	0.255(0.010)	0.280(0.011)	0.330(0.013)	0.330(0.013)	0.380(0.015)	
241 to 267 (9.5 to 10.5)	0.255(0.010)	0.280(0.011)	0.330(0.013)	0.330(0.013)	0.355(0.014)	
Pipe Wall Thickness Millimeters (Inches)	Allowable Crack Width in Millimeters (Inches) Pipe Diameters Greater than 2400 mm (96 Inches)					
	Concrete Cover on Transverse Reinforcement in Millimeters (Inches)					
		32 mm (1.25 in)	44 mm (1.75 in)	57 mm (2.25 in)	70 mm (2.75 in)	83 mm (3.25 in)
203 (8.0)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.355(0.014)	0.405(0.016)
216 (8.5)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.355(0.014)	0.380(0.015)
229 (9.0)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.330(0.013)	0.380(0.015)
241 (9.5)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.330(0.013)	0.380(0.015)
254(10.0)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.330(0.013)	0.355(0.014)
267(10.5)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.330(0.013)	0.355(0.014)
279(11.0)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.330(0.013)	0.355(0.014)
292(11.5)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.305(0.012)	0.330(0.013)
305(12.0)		0.255(0.010)	0.280(0.011)	0.305(0.012)	0.305(0.012)	0.330(0.013)
318(12.5)		0.255(0.010)	0.280(0.011)	0.280(0.011)	0.305(0.012)	0.330(0.013)
330(13.0)		0.255(0.010)	0.280(0.011)	0.280(0.011)	0.305(0.012)	0.330(0.013)
343(13.5)		0.255(0.010)	0.280(0.011)	0.280(0.011)	0.305(0.012)	0.330(0.013)

1. Concrete cover is measured between reinforcement surface and concrete surface.
2. The tabulated crack width dimensions are measured in millimeters (inches).
3. Sewer pipe shall have an allowable crack width of 0.25 mm (0.01 in) regardless of concrete cover.

The required strength of the pipe specimens undergoing the bearing test will be designated in terms of D-load. Such designation indicates the actual load in Newtons per meter of length (pounds per linear foot) of pipe, divided by the inside diameter of the pipe in millimeters (feet). The pipe shall withstand the required test load before a crack having a width as indicated in the following table, measured at close intervals, occurs throughout a length of 300 mm (1 foot) or more. The crack shall be considered to be at the indicated width when the point of the measuring gauge will, without forcing, penetrate it 1.5 mm (1/16 inch) at close intervals throughout the specified distance of 300 mm (1 foot).

The load shall be applied at a uniform rate not to exceed 29.2 kN per minute per meter of length (2,000 pounds per minute per foot-length) of pipe for the first 80 percent of the required load and then at a uniform rate not to exceed 7.3 kN per minute per meter of length (500 pounds per minute per foot-length) of pipe for the remainder of the test.

The test specimens shall be surface dry when tested.

The length on which the test load is computed shall be determined by measuring the inside length of the barrel of the pipe from the bottom of the socket to the end of the spigot. The length of a beveled pipe shall be the average length of the inside of the barrel of the pipe, measured from the bottom of the socket to the end of the spigot.

If the tested specimen of a designated lot passes the test, all of the pipe of that lot shall be considered as complying with the requirements.

If the tested specimen of a designated lot fails to pass the test, then five additional specimens from that same lot shall be selected for testing.

If the five additional specimens pass, the total number of that lot to be furnished shall be considered as complying, except the one previous failing specimen.

If any of the five additional specimens fail, the entire lot shall be rejected; or may be downgraded except those specimens which passed the first time.

The Contractor may test specimens of a rejected lot individually to determine whether they may comply with the requirements for acceptance.

**207-2.9.3 Structural Design Basis.** Where structural details of the pipe are shown on the Plans, the manufacture of pipe shall be checked by making the appropriate tests on the concrete placed in the pipe forms, by inspection of the steel reinforcing cages that are to be used in the pipe, and by inspection of the fabrication of the pipe.

Concrete in pipe shall attain a minimum compressive strength of 31.0 MPa (4,500 psi) at 28 days.

**207-2.9.4 Downgrading of Pipe.** For the purpose of these specifications, "downgraded" pipe shall be defined as pipes which are to be used under loads less than that for which they were designed.

Pipes manufactured in accordance with these specifications which have not met their designed test loads may be downgraded by the Engineer and used provided that:

- 1) Enough load tests are made to establish the load under which they may be used. The number of tests to be made shall be as determined by the Engineer and may require the testing of each section.
- 2) They comply with the testing and inspection requirements of these specifications.

Individual specimens of pipe which will require major repair, or which have numerous hairline cracks extending the full length of the section on the inside of the pipe at the minor axis or on the outside of the pipe at the major axis, may be tested for downgrading purposes only at the discretion on the Engineer.

**207-2.9.5 Acceptance of Stockpiled Pipe.** Pipe may be used from stockpiles only when approved in advance by the Engineer, and provided the pipe meets all other requirements for pipe with the exception of inspection of manufacture.

For the purpose of these specifications, "stockpiled" pipe shall be defined as pipe manufactured in quantity which will meet requirements of this section, but was not manufactured for use in specific projects. However, pipe which has been rejected by another agency will not be considered as "stockpiled" pipe, nor will such pipe be accepted.

**207-2.10 Marking.** The date of manufacture, size and D-load, lot number, manufacturer's identification mark, and where elliptical reinforcement is used, a 100 mm (4 inch) high "T" marking the location of the minor axis of the reinforcement shall be legibly painted or stamped on the inside of each pipe. If the Plans or Specifications require a minimum interior clearance for the reinforcing steel, the minimum clearance shall also be painted or stamped on the inside of the pipe.

Sections of pipe to be inspected shall be so situated at the manufacturer's plant as to provide the Engineer with free accessibility for inspection and marking. In no case shall the pipe be stacked to a height that would require the Engineer to climb or use or a ladder to properly inspect the pipe.

At the place of manufacture, the Engineer will indicate acceptance of the pipe for delivery to the Work by marking the pipe with the Agency's stamp. Such acceptance, however, shall be considered a tentative acceptance. Final acceptance will be made only when the project has been completed.

If pipe is rejected subsequent to its manufacture, the mark placed thereon by the Engineer shall be defaced.

**207-2.11 Inspection Platform.** For machine-made pipe, a permanently installed inspection platform shall be provided. The platform shall be located such that the inspector can observe the cage and concrete during placement and manufacturing.

### **207-3 LINED REINFORCED CONCRETE PIPE.**

**207-3.1 General.** These specifications apply to pipe manufactured with a plastic lining. The plastic lining material shall be tested in accordance with 211-2 and conform to 210-2. Pipe not installed within 180 days from the date of pipe manufacture shall have both ends of the pipe covered with an opaque material to prevent ultra-violet degradation of the plastic liner. The Contractor shall not install any lined RCP that is more than 2 years old from the date of manufacture.

Such pipe shall conform to the applicable provisions in 207-2, except that the causes for rejection shall be as listed herein, and repair of pipe will be permitted only within limits set forth in this subsection.

All such pipe shall be manufactured with Type II cement unless otherwise specified in the Special Provisions. All cement shall contain not more than 0.6 percent by weight of alkalis calculated as  $\text{Na}_2\text{O}$  plus  $0.658 \text{ K}_2\text{O}$ .

Chairs or spacers between the reinforcement and forms or base rings shall be stainless steel or a nonferrous material approved by the Engineer. Spacers may only come in contact with the liner plate if they are made of plastic and have a flat base plate of sufficient size to prevent puncture of the liner plate.

**207-3.2 Causes for Rejection.** Lined pipe may be rejected for any of the following reasons:

- 1) Exposure of any wires, positioning spacers, or chairs used to hold the reinforcement cage in position, or steel reinforcement in any surface of the pipe, except for holding rods in end projections.
- 2) Transverse reinforcing steel found to be in excess of 6 mm (1/4 inch) out of specified position after the pipe is molded.
- 3) Any shattering or flaking of concrete at a crack.

- 4) Air bubble voids (bugholes) on the interior and exterior surfaces of the pipe exceeding 6 mm (1/4 inch) in depth unless pointed with mortar or other approved material.
- 5) Unauthorized application of any wash coat of cement or grout.
- 6) A deficiency greater than 6 mm (1/4 inch) from the specified wall thickness of pipe 750 mm (30 inches) or smaller in internal diameter.
- 7) A deficiency greater than 5 percent (6 percent) from the specified wall thickness of pipe larger than 750 mm (30 inches) in internal diameter, except that the deficiency may be 7 percent (8 percent) adjacent to the longitudinal form joint, provided that the additional deficiency does not lie closer than 20 percent of the internal diameter to the vertical axis of the pipe and does not extend along the circumference for a distance greater than 20 percent of the internal diameter of the pipe.

The deficiencies in wall thickness permitted herein do not apply to gasket contact surfaces in gasketed joint pipe. Dimensions and tolerances of such contact surfaces shall be submitted for approval.

- 8) Internal diameter of the pipe exceeds the specified metric diameter by 2.6 percent, or is less than the specified metric diameter, or interior surfaces reworked after placing of the concrete. (For projects specifying units in U.S. Standard measures, a variation from the specified internal diameter in excess of 1 percent, or interior surfaces reworked after placing of the concrete.) The variation in internal diameter permitted herein does not apply to gasket contact surface in gasketed joint pipe. Tolerances at such contact surfaces shall be submitted for approval.
- 9) A water pocket (identified by tapping the internal surface of the pipe) which is greater than 750 mm (30 inches) in length or wider than three times the specified wall thickness. Repair of such defective areas not exceeding these limits shall be made as described in 207-3.3.
- 10) A piece broken from the end projections of the pipe which has circumferential length exceeding 60 degrees of the circle, or extends into the body of the pipe, or extends into the gasket contact surfaces of gasketed joint pipe for a circumferential length in excess of 150 mm (6 inches) measured at the midpoint of the gasket contact surface on the bell end, and at the inner shoulder of the gasket groove at the spigot end). If two or more pieces are broken from an end projection, the total length of such broken pieces on any end shall not exceed 90 degrees of the circle; and there shall be a distance of at least 230 mm (9 inches) of sound concrete between breaks. The total length of broken pieces that extends into the gasket contact surfaces of gasketed joint pipe shall not exceed a circumferential length of 150 mm (6 inches).

If less than 230 mm (9 inches) of sound concrete exists between two individual breaks, the two breaks shall be considered as one continuous break. Repair of such defects not exceeding above limits shall be made by Method III as described in 207-3.3.3. Unsound portions of end projections shall be removed, and if pieces removed do not exceed the above limits, the pipe may be similarly repaired.

- 11) Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open-texture (rock pockets) greater in size than an area equal to a square with a side dimension of two and one-half times the wall thickness or deeper than two times the maximum graded aggregate size; or a local deficiency of cement resulting in loosely bonded concrete, the area of which exceeds in size the limits of area described in 9) and 10) above when the defective concrete is removed. Repair of such defects not exceeding these limits shall be made as provided in 9) and 10) above. Sand rings occurring at the ends of the pipe shall be repaired for the full circumference.

12) Any of the following cracks:

- (a) A crack having a width of 0.255 mm (0.01 inch) or more throughout a continuous length of 300 mm (12 inches) or more.
- (b) Any crack extending through the wall of the pipe and having a length in excess of the wall thickness.
- (c) Any crack showing two visible lines of separation for a continuous length of 0.6 m (2 feet) or more, or an interrupted length of 0.9 m (3 feet) or more anywhere in evidence, both inside and outside, except where such cracks occur during the external loading test specified in 207-2.9.

When required by the Engineer, any crack which is 0.255 (0.01 inch) wide or wider and is not a cause for rejection, shall be filled with neat cement grout composed of cement mixed with water to a fluid consistency.

### **207-3.3 Repair of Imperfections.**

#### **207-3.3.1 Method I - Repair by Hand-Placed Mortar.**

(a) **Preparation of Surfaces to be Repaired.** Unsound or imperfect concrete shall be removed by chipping. Edges where concrete has been chipped out shall be sharp and squared with the surface, leaving no feathered edges. The chipped area shall be washed with water to remove all loose material and concrete dust.

Surfaces within the trimmed areas shall be kept wet for several hours, preferably overnight, before the repair replacement is made. All surfaces in areas to be repaired shall be damp, but not wet, when the material is applied.

(b) **Placement of the Mortar.** The mortar used for the repair shall contain the same proportions of cement and sand as the mix from which the pipe was made.

This mortar shall be pre-shrunk by mixing it to a plastic consistency as far in advance of its use as possible. Trial mixes shall be made and aged to determine the longest period the mortar's use can be delayed while retaining sufficient plasticity to permit good workmanship.

Immediately prior to the application of the mortar, the damp surface of the area to be repaired shall be scrubbed thoroughly with a small quantity of neat cement grout, using a wire brush. Remaining loose sand particles shall be swept away before application of the mortar.

In applying the mortar, it shall be compacted into the space to be filled, care being taken to eliminate air pockets and to secure bond at the edges. The surfaces shall be shaped and finished to correspond with the adjacent surface of the pipe.

(c) **Curing.** The newly repaired surfaces shall be kept damp for 24 hours after the repair is completed. A membrane coating of an approved white-pigmented sealing compound shall then be applied.

#### **207-3.3.2 Method II - Repair by Pneumatically Applied Mortar (PAM).**

(a) **General.** PAM shall not be used when the repair extends to a depth greater than the embedment of the reinforcing steel. Such repairs shall be made with pre-shrunk mortar.

(b) **Preparation of Surface to be Repaired.** Surfaces to which PAM is to be applied shall be prepared in the same manner as described in 207-3.3.1 (a) except that the edges of the area from which unsound or imperfect concrete is removed shall be beveled so as not to entrap rebound.

(c) **Placement of Mortar.** No rebound shall be included in the repair. The pipe shall be turned so that the area being repaired is at the side of the pipe in a near vertical position to permit rebound to fall clear.

The mortar used for the repair shall contain the same properties of cement and sand as the mix from which the pipe was made.

Before repairing grooved concrete spigots, the snap ring shall be replaced and retained in position until the repair has attained sufficient strength to assure no damage to the gasket groove by its removal.

Areas repaired with PAM shall be filled in excess of the dimension required and then carefully trimmed to correspond with adjacent surfaces.

(d) **Curing.** Surfaces to which PAM has been applied shall be cured in the same manner as described in 207-3.3.1 (c).

### **207-3.3.3 Method III - Bonding Mortar Repairs With Epoxy Resin Adhesives.**

Unsound or imperfect concrete shall be removed by chipping. If hand placed mortar is to be used, the edges shall be left sharp and square with the surface. If PAM is to be used, the edges shall be beveled.

The area to be repaired shall be kept dry. Loose material and concrete dust remaining after the chipping operation shall be removed by means of an air jet.

Epoxy resins previously approved for such use by the Engineer shall be used in the manner prescribed by the Engineer. The prepared area shall be primed with the epoxy resin compound, care being taken to ensure intimate contact with the base material. Mortar shall be applied before the epoxy resin compound sets. Mortar shall be applied by either Method I or II as described in 207-3.3.1 and 207-3.3.2.

## **207-4 CONCRETE CYLINDER PIPE.**

**207-4.1 General.** These specifications apply to concrete cylinder pipe intended for use in water supply pipelines and distribution systems that carry water under pressure. Concrete cylinder pipe may be furnished in pipe diameters of 250 mm (10 inches) or larger for operating pressures from 690 kPa (100 psi) to 2,760 kPa (400 psi).

**207-4.2 Design, Manufacture, and Tests.** Concrete cylinder pipe shall be designed, manufactured and tested in accordance with AWWA C303. The average circumferential stress in the steel cylinder and bar or wire reinforcement of the pipe at design pressure shall not exceed 114 MPa (16,500 psi) nor 50 percent of the minimum yield strength of the steel used in the cylinder.

**207-4.3 Fittings.** Fittings for concrete cylinder pipe shall conform to requirements of Federal Specification SS-P-381.

## **207-5 REINFORCED CONCRETE PRESSURE PIPE.**

**207-5.1 General.** These specifications apply to three types of reinforced concrete pressure pipe, two of which are not prestressed (and one prestressed), with internal diameters of 300 mm (12 inches) and larger, to be used in the transmission and distribution systems that carry water under pressure as shown on the Plans.

**207-5.2 Manufacture and Tests.** Reinforced concrete pressure pipe and fittings shall be manufactured and tested to conform to one of the following specifications:

- 1) AWWA C300 for the steel bar reinforcement and cylinder type in pipe diameters 600 mm (24 inches) and larger, for design pressures of 275 kPa to 1,800 kPa (40 to 260 psi), and for external loading conditions as may be designated on the Plans or in the Specifications.
- 2) AWWA C301 for the prestressed steel wire reinforcement and cylinder type, in pipe diameters of 750 mm (30 inches) and larger, for design pressure up to 2,410 kPa (350

psi), and for external loading conditions as may be designated on the Plans or in the Specifications.

- 3) AWWA C302 for the steel reinforcement (without cylinder) type, in pipe diameters 300 mm (12 inches) and larger, for design pressures of not more than 310 kPa (45 psi), and for external loading conditions as may be designated on the Plans or in the Specifications.

## **207-8 VITRIFIED CLAY PIPE.**

**207-8.1 General.** Except as modified in this subsection, vitrified clay pipe and fittings including perforated pipe shall be extra strength or high strength manufactured in accordance with ASTM C 700.

### **207-8.2 Manufacturing Requirements.**

**207-8.2.1 General.** All pipe and fittings shall be clearly marked with the name or trademark of the manufacturer, the location of the plant, and the strength designation. All standard length straight pipe as defined in 207-8.2.2 shall, in addition to the above, be marked with a manufacturer's date code. All fabricated bends and/or bevels shall be manufactured from pipe meeting all requirements of the pipe specifications for the project.

**207-8.2.2 Dimensions and Tolerances.** The pipe diameter shall not vary from a true circle by more than 3 percent of nominal diameter. Except for special purposes, the minimum standard length of straight pipe, exclusive of socket depth, shall be 1000 mm (40 inches). Pipe shall not deviate from straight by more than 5 mm per 1 m of length (1/16 inch per foot).

**207-8.2.3 Imperfections.** Imperfections in pipe and fittings containing blisters, cracks, and chips in excess of the limits herein will be rejected; however, certain cracks and chips meeting the requirements of 207-8.2.4 may be repaired in accordance with 207-8.6.

(a) **Blisters.** For pipe of nominal sizes 75 to 450 mm (3 to 18 inches), blisters shall not exceed 75 mm (3 inches) in any direction, and no blister or pimple shall project more than 3 mm (1/8 inch) above the surface of the pipe.

For pipe of nominal sizes over 450 mm (18 inches), no blister shall exceed in any direction, 170 mm per meter (2 inches per foot) of internal diameter, and no blister or pimple shall project above the surface of the pipe more than 10 mm per meter (1/8 inch per foot) of internal diameter.

Pipe shall have no broken blisters.

(b) **Cracks.** There shall be no cracks passing through the barrel or socket except that a single crack at the spigot end of the pipe not exceeding 75 percent of the depth of the socket, or a single circumferential crack in the socket not exceeding 75 mm (3 inches) in length or a single crack not exceeding 50 mm (2 inches) in the axial direction is permitted.

(c) **Chips.** Chips on the interior surface shall not exceed 25 mm (2 inches) in length, 25 mm (1 inch) in width, and a depth of 1/4 of the barrel thickness, but not to exceed 6 mm (1/4 inch). A single pipe shall contain no more than two such defects.

### **207-8.2.4 Repairable Imperfections.**

(a) **General.** Structurally sound clay pipe larger than 375 mm (15 inch) size, may be repaired as provided in 207-8.6.

Repairs of any type at the spigot or socket, shall be limited to one for each 60 degrees of circumference, and a maximum of four at either end. Repaired pipe shall not be used for fabricated fittings unless the repaired pipe is tested. Molded fittings may be repaired within the scope of the Specifications.

(b) **Cracks.** The following longitudinal cracks parallel to the axis caused by shrinkage or drying and not more than 0.8 mm (1/32 inch) wide may be repaired:

- 1) A crack on the exterior of the spigot that does not penetrate the entire barrel thickness and does not exceed 50 percent of the depth of the socket in length.
- 2) A crack in the socket of the pipe that does not penetrate the entire thickness and does not exceed 75 percent of the depth of the socket in length.
- 3) A crack that penetrates the entire thickness of the socket and does not exceed 50 percent of the depth of the socket in length.
- 4) A crack on the interior of the socket and in the shoulder on the exterior of the socket which does not exceed 75 mm (3 inches) in length and does not penetrate more than 20 percent of the wall thickness.

**(c) Surface Chips.** Surface chips located on the exterior of the spigot, the interior or exterior of the socket, or on the shoulder of the socket may be repaired, provided:

- 1) The length of the circumference of the chip does not exceed twice the barrel thickness.
- 2) The width is not greater than 50 percent of the socket depth measured parallel to the axis.
- 3) The depth is not greater than 25 percent of the wall thickness measured perpendicularly to the axis.

**(d) Full Depth Chips.** Full depth chips located on the socket may be repaired provided the length of the chip does not exceed twice the barrel thickness or the width does not exceed 25 percent of the socket depth.

**207-8.3 Fittings and Stoppers.** Fittings shall be made to such dimensions as will accommodate the joint system specified. Y- and T-branch fittings shall be furnished with spurs securely fastened by the manufacturer to the barrel of the pipe. There shall be no projection on the inner surface of the barrel.

T-branch fittings shall have their axis perpendicular to the longitudinal axis of the pipe. The axis of the spur on Y-branch fittings shall be 45-degrees from the longitudinal axis of the pipe. The barrel of each spur shall be of sufficient length to permit the proper jointing of the connecting pipe.

Stoppers furnished for installation in branch fittings and ends of pipe left unconnected shall be strong enough to sustain all applied construction and in-place loads, including field pressure tests. Stoppers for pipe shall be one of the following: polyethylene (PE), polyurethane, polypropylene, acrylonitrilebutadiene-styrene (ABS), polyvinyl chloride (PVC), ozone-resistant synthetic rubber, clay discs, or other material approved by the Engineer. The Contractor shall retest within 60 days prior to installation any stopper that is more than 180 days old from the date of manufacture to ensure compliance with the requirements of the Specifications. The Contractor shall not install any stopper that is more than 2 years old from the date of manufacture.

**207-8.4 Joints.** Joints for vitrified clay pipe are specified in 208-2. The maximum bevel of the ends of pipe to be laid on a curve is 4 degrees. Plain-end pipe shall not be beveled.

Each joint within vertical and horizontal curves shall be constructed using factory fabricated mitered or beveled pipe or by deflecting joints. In no case shall joints be deflected more than allowed in 306-1.2.3. Shop and layout drawings for mitered or beveled pipe shall be submitted to the Engineer for review and approval.

### **207-8.5 Testing Requirements.**

**207-8.5.1 General.** Before a lot of pipe is acceptable for use, test pipes selected from the lot shall meet the requirements of the hydrostatic pressure and bearing tests described herein. The tests shall be made at the point of manufacture, under the supervision of the Engineer, and at no cost to the Agency. Fittings will be subject to the requirements of the hydrostatic pressure test only.

When less than 50 pipes are to be furnished to any one project, the Engineer may waive the sampling, testing and acceptance requirements of this subsection and accept the manufacturer's written

certification that the pipe meets the quality and strength specified. All pipe will be subject to visual inspection and acceptance by the Engineer after delivery to the Work site.

All testing equipment shall be calibrated by a testing agency acceptable to the Engineer at intervals not to exceed 12 months or following repair of the hydraulic system or modification or relocation of the equipment.

Each lot of vitrified clay pipe is defined as not more than 500 sections of pipe for one size and class. The Engineer shall select for testing the following number of samples:

TABLE 207-8.5.1 (A)

No. of Sections in Lot	No. of Sections for Testing
Less than 41	2
41 - 60	3
61 - 80	4
81 - 250	5
251 - 300	6
301 - 350	7
351 - 400	8
401 - 450	9
451 - 500	10

The pipe selected for testing shall be sound and shall meet the dimensions and tolerances of the specifications.

**207-8.5.2 Hydrostatic Pressure Test.** Shall be carried out in accordance with the applicable requirements of ASTM C 301 and shall precede the bearing test by not more than 3 hours.

**207-8.5.3 Bearing Tests.** Shall be carried out in accordance with the 3-edge bearing method requirements of ASTM C 301. The pipe shall withstand the minimum 3-edge bearing test loads indicated in the following table:

TABLE 207-8.5.3

Nominal Diameter		Extra Strength Pipe		High Strength Pipe	
mm	(Inches)	kN per Meter of Length	(lbs./ft)	kN per Meter of Length	(lbs./ft)
75	3	29.2	2000	32.1	2200
100	4	29.2	2000	32.1	2200
150	6	29.2	2000	32.1	2200
200	8	32.1	2200	35.0	2400
250	10	35.0	2400	37.9	2600
300	12	37.9	2600	42.3	2900
375	15	45.2	3100	49.6	3400
450	18	52.5	3600	58.4	4000
525	21	61.3	4200	67.1	4600
600	24	70.1	4800	77.3	5300
675	27	75.9	5200	83.2	5700
750	30	80.3	5500	89.0	6100
825	33	84.6	5800	93.4	6400
900	36	91.9	6300	100.7	6900
975	39	96.3	6600	106.5	7300
1050	42	102.2	7000	112.4	7700

**207-8.5.4 Acceptance.** When all test pipes meet the hydrostatic pressure and bearing tests, the entire lot of pipe is acceptable. When two test pipes fail, the entire lot will be rejected. When one pipe fails, a second group of two pipes must pass the tests, otherwise the entire lot will be rejected.

### **207-8.6 Clay Pipe Repair.**

#### **207-8.6.1 Repair Methods and Materials.**

(a) **General.** All surfaces to be repaired shall be clean and dry. All unsound material at lumps or blisters shall be ground smooth and flush with adjacent surfaces. Cracks shall be grooved 3 mm to 6 mm (1/8 to 1/4 inch) wide and 3 mm to 6 mm (1/8 to 1/4 inch) deep for the full length of the crack. All unsound material at chips, flakes, pits, and spalls shall be removed and edges shall be 1.5 mm (1/16 inch) minimum below adjacent surfaces. There shall be no feather edges.

Prepared areas shall be cleaned of dust and other loose particles and then filled with repair material compounded to provide properties most desirable for sewerage service. Repair material shall resist bacterial attack and attack by chemicals or combinations of chemicals normally present in domestic and industrial sewage.

Repair material shall be mixed, applied, and cured as recommended by the manufacturer and approved by the Engineer, and shall have a color contrasting with the color of pipe to be repaired. If necessary to produce a contrast in color, carbon black in a small quantity may be added to the repair material. The repair material shall be subject to adhesion and chemical testing as required by the Engineer to determine its suitability for use.

(b) **Adhesion Test.** Vitrified clay bars 25 mm (1 inch) square in cross section and approximately 200 mm (8 inches) in length, compounded of the same materials as the vitrified clay pipe and fired to clay pipe manufacturing temperature shall be used in preparing test specimens. The bars shall have a modulus of rupture of not less than 11.0 MPa (1,600 psi) when tested in flexure with third-point loading.

The bars shall be cut through at the midpoint and then bonded with the repair material. Following a 7-day maximum cure period at ambient room temperature, the bonded bars shall be tested in flexure with third-point loading.

The average modulus of rupture of five test bars bonded with the repair material shall not be less than 11.0 MPa (1,600 psi).

Five additional test bars bonded with the repair material and immersed for 60 days in water at ambient room temperature shall have an average modulus of rupture not less than 10.3 MPa (1,500 psi).

(c) **Chemical Tests.** Each specimen of repair material shall lose not more than 2 percent of its weight after being immersed in the solutions listed in 208-2.3.2 (Note 3 in table) for a period of 30 days and being reconditioned as indicated.

**207-8.6.2 Inspection of Repairs.** All pipe to be repaired shall be inspected by the Engineer after preparation for repair, again after repair has been made. Repairs made without prior inspection will be rejected. The Engineer may require retesting of any repaired pipe to demonstrate its soundness. The Agency shall be reimbursed for all costs incurred for inspection and testing of repaired pipe.

### **207-9 IRON PIPE AND FITTINGS.**

**207-9.1 General.** This subsection specifies ductile iron pipe for water and other liquids, and cast iron soil pipe. Cast iron soil pipe shall not be used for mainline gravity sewers or for any pressure piping used to convey sewage.

## 207-9.2 Ductile Iron Pipe for Water and Other Liquids.

**207-9.2.1 General.** Ductile iron pipe for water and other liquids shall be furnished in the sizes, classes, grades, or nominal thicknesses and joint types shown on the Plans or in the Specifications.

Ductile iron pipe shall comply with AWWA C 151.

**207-9.2.2 Pipe Joints.** Iron pipe joints shall comply with the following requirements for the types shown on the Plans or in the Specifications:

**TABLE 207-9.2.2 (A)**

Type of Joint	Specifications
Rubber Gasket Push-on Joint	AWWA C 111
Mechanical Joint	AWWA C 111
Flanged Joint	AWWA C 110
Flanged Joint (Threaded Flanges)	AWWA C 115

Rubber gasket material shall conform to 208-1.2.

**207-9.2.3 Fittings.** All ductile iron and cast iron rubber gasket, push-on, mechanical, and flanged joint fittings for iron pipe shall be manufactured in accordance with AWWA C 110.

**207-9.2.4 Lining and Coating.** Unless otherwise specified, the internal surfaces of iron pipe and fittings shall be lined with a uniform thickness of cement mortar then sealed with a bituminous coating in accordance with AWWA C 104. The outside surfaces of ductile iron pipe and fittings for general use shall be coated with a bituminous coating 25  $\mu\text{m}$  (1 mil) thick in accordance with AWWA C 151 or AWWA C 110.

**207-9.2.5 Inspection and Certification.** The manufacturer shall furnish a certified statement that the pipe and fittings have been manufactured and tested in accordance with these specifications.

**207-9.2.6 Polyethylene Encasement for External Corrosion Protection.** When loose polyethylene encasement for the protection of iron pipes, cast or ductile iron fittings, valves, and appurtenances is specified in the Plans or in the Specifications, it shall be furnished and installed in accordance with the requirements of AWWA C 105.

**207-9.3 Cast Iron Soil Pipe and Fittings.** Cast iron soil pipe and fittings shall comply with ASTM A 74.

## 207-10 STEEL PIPE.

**207-10.1 General.** These specifications apply to steel pipe for the transmission and distribution of water under pressure. Steel pipe shall be of the size, type, and cylinder wall thickness or pressure class shown on the Plans or in the Specifications.

### 207-10.2 Fabricated Steel Pipe.

**207-10.2.1 General.** Fabricated steel pipe shall consist of butt or offset butt electrically welded straight or spiral-seam steel cylinders, shop fabricated from plates or sheets in accordance with AWWA C 200.

Steel pipe to be cement-mortar lined may also be fabricated to the requirements of Federal Specification SS-P-385 a.

One hundred mm (4 inch) pipe, when required, shall conform to the requirements of AWWA C 200.

Prior to fabrication of pipe, the Contractor shall in accordance with 2-5.3, submit complete shop fabrication drawings of all pipe, pipe specials and joint details. The Contractor shall also submit a schedule of pipe marks accompanied by a plan showing the field location of each mark.

Steel plates or sheets used in the manufacture of fabricated steel pipe shall comply with the physical and chemical requirements of ASTM A 570, Grades 30 or 33, for steel sheets or strip, or to ASTM A 283 Grades C or D, or A 36 for steel plates, or be of other steel of equal quality if approved by the Engineer.

The Contractor shall submit to the Engineer a certified laboratory report stating the type of steel, and the physical and chemical properties for each heat number of the steel used in the fabrication of the pipe.

After fabrication, but prior to the application of the specified lining and coating, straight pipe cylinders of all sizes shall be successfully hydrostatically tested to 75 percent of the specified minimum yield point of the steel sheets or plates used in the manufacture of the pipe in accordance with Section 3.5 of AWWA C 200.

**207-10.2.2 Design Criteria.** The cross-sectional area of steel in the wall of the pipe cylinder shall be computed on the basis of a minimum design safety factor of two of the ratio of yield point stress for that particular type steel used in the fabrication of the pipe, to the maximum design working stress in the pipe cylinder wall.

Steel cylinders shall have a wall thickness of not less than 1.9 mm (14 gage).

**207-10.2.3 Diameter.** Fabricated steel pipe shall have a minimum net inside diameter, after application of the interior protective lining, equal to the nominal diameter of the pipe shown on the Plans or in the Specifications, with a permissible tolerance of minus 6 mm (1/4 inch).

**207-10.2.4 Length.** Unless otherwise specified, fabricated steel pipe shall be manufactured in lengths to fit the pipeline alignment shown on the Plans, subject to a maximum pipe length of 13 m (42 feet). Pipe may be furnished in lengths less than the manufacturer's standard length to facilitate the laying of the pipe on curved alignments.

The Contractor shall fabricate and furnish all necessary short pipe sections required for pipeline closures and the proper location of any special section, fitting or pipeline appurtenance shown on the Plans.

**207-10.2.5 Joints.** Joints for fabricated steel pipe shall be one of the following types as specified on the Plans or in the Specifications and shall comply with the requirements of Section 3.7 of AWWA C 200.

- 1) Bell-and-spigot ends with rubber gaskets.
- 2) Lap joints for field welding.
- 3) Plain ends fitted with butt straps for field welding.
- 4) Ends prepared for mechanical coupled field joints.
- 5) Plain ends fitted with flanges.

Joint tolerances shall be as specified in Section 3.7.9 of AWWA C200.

For pipe less than 675 mm (27 inches) in nominal diameter, butt straps for butt strap joints shall be furnished with a 100 mm (4 inch) diameter hand hole, complete with screwed cap or plug, suitable for use in "pointing" the interior joint lining after field installation of the joint.

All joints, except flanged and mechanical coupling joints, shall be designed for a maximum interior pipe lining gap joint of 13 mm (1/2 inch) after joint assembly, measured from the ends of the lining of the two pipe sections being joined.

The laying of bell-and-spigot, rubber-gasket-joint pipe on curved alignment by means of unsymmetrical closure of spigot into bell will be permitted. The amount of "pull" and the method of achieving the "pull" shall be in accordance with the manufacturer's recommendation, but the deviation from the normal lining gap at the joint shall not exceed a 19 mm (3/4 inch) "pull" on the outside of the curve, and a 6 mm (1/4 inch) "push" on the inside of the curve, with no "push" to be permitted until the full 19 mm (3/4 inch) "pull" has been used.

Where the allowable deflection of the pipe by means of unsymmetrical closure of joints is not sufficient to fit the curved alignment of the pipe, as shown on the Plans, special sections consisting of beveled ends or multiple-piece bends shall be fabricated. In no case shall the pipe bell or spigot composing the joint between sections of pipe be cut or altered in any manner.

**207-10.2.6 Rubber Gaskets.** Rubber gaskets and gasket lubricant shall be furnished with rubber gasket joint pipe in sufficient quantity for the amount of pipe ordered. Rubber gaskets shall be new and made in conformance with section 3.4 of AWWA C 300. Gasket material shall conform to 208-1.2.

**207-10.2.7 Special Sections.** Special sections, including curves, tees, branches, manifolds, outlets, reducers, and enlargers shall be fabricated as shown on the Plans or in the Specifications. Special sections shall be fabricated from sections of previously lined and coated straight pipe, of the kind being furnished under the contract or of specially rolled, lined, and coated pipe for fittings to meet job conditions shown in the Plans or in the Specifications.

Bends shall be required on curves which have a shorter radius than can be accommodated by beveled pipe ends or by pushing and pulling the joint. Bends, tees, crosses, and wyes shall be fabricated and dimensioned in accordance with AWWA C 208.

The courses of special sections shall be joined by butt welding after which the pipe protective lining and coating shall be repaired to a like condition as existed on the previously lined and coated straight pipe section from which the special was fabricated.

Bends, angles, reducers, enlargers, and other special pipe sections made by certified welding operations from previously tested pipe sections need not be subjected to a hydrostatic test. All special pipe sections not fabricated from tested pipe shall be hydrostatically tested after fabrication as specified in 207-10.3.2 for straight pipe. Sections that cannot be tested in a testing machine may be prepared for testing by welding a head on the open ends, or as may otherwise be approved by the Engineer. After testing, the ends shall be reconditioned.

Any welds which have not been subject to a hydrostatic test shall be tested by the air-soap or dye-check method.

**207-10.2.8 Welding.** Welding of fabricated steel pipe shall conform to the requirements of AWWA C 200.

Patching of pipe where test specimens have been taken will not be permitted.

If provided for in the Specifications, the Contractor shall furnish the Engineer with a certified laboratory report stating the results of the welding tests required in this subsection.

### **207-10.3 Mill-type Steel Water Pipe.**

**207-10.3.1 General.** Mill-type steel pipe shall consist of furnace-welded, electrically welded, or seamless pipe produced to meet finished pipe specifications in accordance with AWWA C 200.

Acceptable grades of pipe under this standard shall be:

ASTM A 53 Grades A & B

ASTM A 135 All grades

ASTM A 139 All grades

ASTM A 134 Using only grades of steel shown in 10.2.1

If required in the Specifications, the Contractor shall submit to the Engineer a certified laboratory report stating the type of pipe and the physical and chemical properties for each heat number of the steel used in the manufacture of the pipe.

**207-10.3.2 Dimensions, Weights, and Test Pressure.** The inside and outside diameters, wall thickness, weight, test pressures, and weight and dimension tolerances for mill-type steel pipe shall conform to ANSI B36.10 or AWWA C 200.

**207-10.3.3 Length.** Mill-type steel pipe shall be furnished in single random lengths, double random lengths, or in specified cut lengths.

For specified cut lengths, the actual length of the pipe shall not vary from the specified length by more than 3 mm (1/8 inch).

For special random lengths, the average length shall not be less than 5.3 m (17-1/2 feet) and no piece shall be shorter than 2.7 m (9 feet). Double random lengths shall have an average length of not less than 10.7 m (35 feet) with not more than 10 percent of the lengths shorter than 8.0 m (26-1/4 feet) and no piece shorter than 4.3 m (14 feet).

For specified average lengths in excess of 6.1 m (20 feet), not more than 10 percent of the lengths shall be shorter than 75 percent of the average length specified and no length shall be shorter than 40 percent of the specific average length.

#### **207-10.3.4 Joints.**

(a) **General.** Joints for mill-type steel pipe shall be one of the following types as shown on the Plans or in the Specifications.

(b) **Mechanical Couplings.** Pipe ends for mechanical couplings shall be square cut or beveled with all burrs removed. All outside surfaces of the pipe ends, where the mechanical coupling will be seated, shall be free of all indentations, projections, or roll marks to ensure a watertight joint. Pipe ends for mechanical couplings shall have tolerances within the limits required by the manufacturer of the mechanical coupling specified.

(c) **Field Butt-Welded Joints.** Pipe with a wall thickness 6.0 mm (15/64 inch) or greater, intended for field butt welding, shall have the pipe ends beveled on the outside or inside or both sides, as shown on the Plans or in the Specifications. Bevels shall have an angle of 30 degrees, with a maximum plus tolerance of 5 degrees and no minus tolerance, measured from a line drawn perpendicularly to the axis of the pipe. The width of the root face at the end of the pipe shall be 1.5 mm  $\pm$  0.8 mm (1/16 inch  $\pm$  1/32 inch).

(d) **Flanged Joints.** Welding flanges shall be forged steel conforming to ASTM A 181 and faced and dimensioned in accordance with ANSI B16.5 for the pressure class shown on the Plans or in the Specifications. Class ANSI B12.5 shall be the minimum class flange permitted for water distribution purposes. Threads for screwed flanges and companion pipe ends shall be dimensioned in accordance with ANSI B2.1.

Pipe ends for welding neck flanges shall be beveled.

**207-10.3.5 Special Sections.** These include elbows, returns, tees, reducers, and crosses which shall be manufactured from mill-type steel pipe in accordance with ANSI B16.9.

Special sections manufactured from previously tested pipe need not be tested hydrostatically but any welds not previously hydrostatically tested shall be tested by the air-soap or dye-check method.

**207-10.3.6 Marking of Pipe and Special Sections.** Each length of pipe and each special section shall be legibly marked by paint stenciling, die stamping, or hot-roll marking to show the manufacturer's name or mark, size and weight of the pipe or special section, and the type of steel from which the pipe or special section was made.

**207-10.4 Protective Lining and Coating for Steel Pipe.**

**207-10.4.1 General.** The interior and exterior surfaces of all steel water pipe shall be protected from corrosion by one of the following methods, as shown on the Plans or in the Specifications.

**207-10.4.2 Cement-Mortar Lining and Coating.** Cement mortar lining and coating shall comply with the requirements of AWWA C 205, or shall be fabricated, lined, and coated to the requirements of Federal Specification SS-P-385a.

The interior and exterior surfaces of all pipe to which cement mortar will be applied shall be thoroughly cleaned prior to the application of the cement mortar. Loose scale, rust, and all accumulations of dirt or debris shall be removed. Oil and grease shall be removed by a volatile solvent.

When a curing compound is used to facilitate curing of the cement mortar lining, it shall be applied to the cement mortar within 1 hour after placing the mortar. The curing time of cement-mortar so cured shall be 7 days. Sealing compound used shall be in conformance with Section 2.5 of AWWA C 205.

The results of cleaning, lining, and coating of special sections shall be equivalent to the results of similar work on straight pipe sections and shall conform to the requirements of Sections 4.5 and 5.7 of AWWA C 205.

**207-10.4.3 Cement Mortar Lining and Asphalt Mastic Coatings.** Cement mortar lining shall comply with the requirements of 207-10.4.2.

Materials, manufacture, and application of asphalt protective coatings for pipelines (mastic systems) shall comply with "Asphalt Protective Coating for Pipelines" of the Asphalt Institute, Construction Series No. 96, Specifications M-2.

Mastic systems for pipelines shall consist of an asphalt prime coat followed by a coating of a dense, impervious, essentially voidless mixture of asphalt, mineral aggregate, and mineral filler which may include asbestos fiber. The finished mastic coating shall be painted with a water-resistant whitewash.

A Grade 3 mastic system shall be furnished under these specifications.

Unless otherwise specified, the minimum thickness of the asphalt mastic coating shall be as shown in Table 207-10.4.3 (A).

**TABLE 207-10.4.3 (A)**

Diameter		Coating			
		Thickness <sup>1</sup>		Tolerance	
Millimeters	(Inches)	mm	(in)	mm	(in)
100 thru 200	(4 thru 8)	10	(3/8)	+ 3.2	(+ 1/8)
250 thru 300	(10 thru 12)	11	(7/16)	+ 3.2	(+ 1/8)
Over 300	(over 12)	13	(1/2)	+ 3.2	(+ 1/8)

1. Subject to the provisions of Section 2.8 of the Asphalt Institute "Specifications M-2".

**207-10.4.4 Coal Tar Enamel Lining and Coating.** Coal-tar enamel protective lining and coating shall comply with the requirements of AWWA C 203.

The interior and exterior surfaces of the pipe shall be thoroughly cleaned by grit blasting immediately prior to the application of the coal-tar protective system.

The interior surfaces of the pipe shall first be coated with a coal-tar primer followed by a uniform lining of hot coal-tar enamel. Thickness of the lining shall be 2.4 mm (3/32 inch) with an allowable variation of ± 0.8 mm (1/32 inch).

The exterior surfaces of the pipe shall be protected with one coat of coal-tar primer followed by one or more coats of hot coal-tar enamel. A single layer of 73 kg per 100 m<sup>2</sup> (15 pounds per 100 ft<sup>2</sup>) asbestos coal-tar saturated felt or fibrous glass mat shall be bonded into each coat of hot coal-tar enamel. The coating system shall be finished with a single wrap of heavy paper followed by a coat of water-resistant whitewash.

The thickness of each exterior coal-tar enamel coating shall be 2.4 mm (3/32 inch) with an allowable variation in thickness not to exceed  $\pm 0.8$  mm (1/32 inch) (excluding the wrapping).

The number of exterior hot coal-tar enamel coats and the type of exterior wrapping shall be as shown on the Plans or in the Specifications.

The results of cleaning, lining and coating of special sections shall be equivalent to the results of similar work on straight pipe sections. Methods deviating from the prescribed procedures of AWWA C 203 shall require the approval of the Engineer. If the shape precludes spinning, the lining and exterior coating shall be applied by hand daubers and hand wrapping as specified in Section 3.11 of AWWA C 203.

Whenever possible, all welding operations for straight pipe sections, including the welding of flanges, shall be completed prior to the application of the coal-tar enamel lining and coating.

Coal-tar enamel lining and coating shall be held back from the ends of all joints to be field welded. Field-welded joints on coal-tar enamel lined and coated pipe less than 675 mm (27 inches) in diameter shall have a 100 mm (4 inch) diameter hand hole complete with a screwed cap or plug to permit priming and daubing of the interior pipe joint upon completion of the field welding.

**207-10.4.5 Cement Mortar Lining and Asphalt Coating and Wrapping.** Cement mortar lining shall comply with 207-10.4.2.

The exterior surfaces of the pipe shall be thoroughly cleaned by grit blasting followed immediately by a coat of hot asphalt primer. The pipe shall then be coated with one or more coats of hot asphalt. A single layer of 115 kg per 100 m<sup>2</sup> (23-1/2-pounds per 100 ft<sup>2</sup>) asbestos felt or 195 kg per 100 m<sup>2</sup> (40-pounds per 100 ft<sup>2</sup>) rag felt or fiberglass wrap shall be machine wrapped into each coat of hot asphalt. The coating system shall be finished with a single wrap of heavy paper followed by a coat of water resistant whitewash.

The thickness of each exterior asphalt coating shall be 2.4 mm (3/32 inch) with an allowable variation in thickness not to exceed  $\pm 0.8$  mm (1/32 inch) excluding the wrapping.

The number of exterior hot asphalt coats and the type of exterior wrap shall be as shown on the Plans or in the Specifications.

The results of coating special sections shall be equivalent to the results of similar work on straight pipe sections. If the shape precludes machine application, the coating of specials shall be applied by hand daubing and wrapping.

**207-10.4.6 Preparation of Pipe Ends (Lined and Coated Pipe).** The pipe protective lining and coating shall be held back from the socket and spigot ends respectively, for all socket-and-spigot rubber gasket, welded lap, and driven field joint pipe in accordance with the manufacturers' standard practices. The pipe protective coating shall be held back from the ends of all butt strap, mechanical coupling, and flanged joint pipe for a sufficient distance to permit field assembly of the particular joint.

The protective lining shall terminate at the pipe ends of all pipe except where otherwise specified herein.

All noncoated surfaces shall be cleaned and given a brush coat of a suitable rust preventative material to protect said surfaces from pitting or rusting. The rust preventative material used shall be nontoxic and of such properties that the quality of the field joint or the lining and coating to be applied to the joint will not be adversely affected.

## 207-11 CORRUGATED STEEL PIPE AND PIPE ARCHES.

**207-11.1 General.** Corrugated steel pipe, pipe arches, nestable pipe, slotted pipe, spiral rib pipe, spiral rib pipe arches, and coupling bands shall be manufactured and inspected in conformance with AASHTO M36/ASTM A 760/A760M or AASHTO M245/ASTM A 762/A762M and as specified herein. The size, type, and metal thickness of the pipe to be furnished shall be shown on the Plans or in the Specifications.

Corrugated steel pipe arches and spiral rib pipe arches shall consist of round pipe which has been reformed to multi-centered pipe having an arch shaped top with a slightly curved integral bottom. Nominal diameter shall be the minimum inside dimensions of the round pipe. Pipe arch dimensions shall be in accordance with AASHTO M36/ASTM A 760/A760M or AASHTO M245/ASTM A 762/A762M.

### 207-11.2 Materials.

**207-11.2.1 General.** The material for corrugated steel pipe, pipe arches, spiral rib pipe, and spiral rib pipe arches shall be zinc coated (galvanized) or aluminum coated (AL-T-2) or polymer precoated steel sheet conforming to AASHTO M218/ASTM A 444/A 444M or AASHTO M274/ASTM A 819 or AASHTO M246/ASTM A 742/A 742M. Material Safety Data Sheets (MSDS) are available from the pipe manufacturers.

In accordance with the requirements of Section 4, the manufacturer of corrugated steel pipe, pipe arches, spiral rib pipe, and spiral rib pipe arches shall furnish to the Engineer a certificate of compliance stating that the materials furnished comply in all respects with these specifications. Additional testing, as required by the Engineer, shall be done at the Contractor's expense.

**207-11.2.2 Coupling Bands.** The coupling bands shall be of either one-, two-, or three-piece construction and shall be of the same material as the pipe. The coupling bands for the pipe larger than 1,050 mm (42 inch) shall be of two- or three-piece construction. Coupling bands shall be formed metal not more than three standard culvert sheet thicknesses lighter than that of the pipe to be connected, but shall be not less than 1.32 mm (0.052 inch) or more than 2.77 mm (0.109 inch) thick. The minimum width of the coupling bands for pipe ends other than flanged shall be 265 mm (10-1/2 inches) for annular corrugations and rerolled ends and 300 mm (12 inches) for helical corrugations except for Huggar bands for pipes 1050 mm (42 inches) or less in diameter installed in a buried condition without watertight joints, which may be 100 mm (4 inches). Dimpled coupling bands shall not be used without prior written approval of the Engineer. All coupling band connection hardware shall be galvanized in accordance with 210-3 or electroplated in accordance with ASTM A 164, Type RS, or ASTM B 633, Class Fe/Zn 5. Bolts and nuts for all types of coupling bands shall conform to the requirements of ASTM A 307.

The installed distance between corrugated pipe ends shall be no greater than 38 mm (1-1/2 inches) and the maximum difference in diameter between pipe ends to be joined shall be 13 mm (1/2 inch) for pipe sizes 1200 mm (48 inches) and under and 1 percent of the diameter for larger pipe sizes.

When required by the Plans or the Specifications, watertight joints shall be provided by the use of approved sealant or gasket materials. Gasket material shall conform to 208-1.2. These materials shall be neoprene expanded rubber or sheet rubber gaskets, "O" ring rubber gaskets, butyl rubber base joint sealant, or other approved materials. Sheet rubber gaskets shall be at least 175 mm (7 inches) wide and 9.5 mm (3/8 inch) thick and shall conform to the requirements of ASTM D 1056 with Grades 41 to 43 inclusive, unless otherwise specified. "O" rings shall conform to ASTM C 443 and shall not be used on helical corrugations. Test for watertight joints shall conform to 306-1.4.6.

### 207-11.3 Fabrication.

**207-11.3.1 General.** Unless otherwise specified, corrugated steel pipe, pipe arches, spiral rib pipe and spiral rib pipe arches, shall be furnished with pipe ends cut perpendicularly to the longitudinal axis of the pipe. Pipe ends shall be cut uniformly and shall be fabricated so that the pipe can be effectively joined with coupling bands conforming to 207-11.2.2.

Corrugated steel pipe may be fabricated either by riveting, resistance spot welding or using a helically corrugated steel pipe with a continuous helical lock seam or a continuous helical welded seam paralleling the corrugation.

Spiral rib pipe shall be fabricated with helical ribs projecting outwardly with a continuous lock seam or welded seam paralleling the rib.

**207-11.3.2 Fabrication by Spot Welding.** Pipe fabrication by spot welding shall conform to the requirements of AASHTO M36/ASTM A 760/A 760M. Pipes fabricated by resistance spot welding shall be the full circle type with lap joint construction. The center of each spot weld shall be at least its radius plus 6.5 mm (1/4 inch) from the edge of the steel sheets.

Spot welding shall be performed in such a manner that the exterior surfaces of 90 percent or more of the spot welds on a length of pipe show no evidence of melting or burning of the base metal; and the base metal is not exposed when the area adjacent to the electrode contact surface area is wire brushed. Discoloration of the spot weld surfaces will not be cause for rejection.

### 207-11.3.3 Fabrication by Continuous Helical Seam.

(a) **Helical Corrugations and Pitches.** Helically corrugated steel pipe and spiral rib pipe shall be fabricated using corrugated profiles and continuous helical pitches as shown in Table 207-11.3.3 (A).

TABLE 207-11.3.3 (A)

Diameters Millimeters (Inches)	Nominal Pitch <sup>1</sup> Millimeters (Inches)	Max. Pitch <sup>1</sup> Millimeters (Inches)	Rib Width Millimeters (Inches)	Min. Depth Millimeters (Inches)	Seam Pitch <sup>1</sup> Millimeters (Inches)
150 thru 300 (6 thru 12)	38 (1-1/2)	48 (1-7/8)	—	6.5 (1/4)	305 (12)
300 thru 2400 (12 thru 96)	68 (2-2/3)	73 (2-7/8)	—	13 (1/2)	610 (24)
1050 thru 3000 (42 thru 120)	75 (3)	83 (3-1/4)	—	25 (1)	533 (21)
1050 thru 3000 (42 thru 120)	125 (5)	133 (5-1/4)	—	25 (1)	749 (29-1/2)
450 thru 1800 (18 thru 72)	292 (11-1/2)	298 (11-3/4)	19 (3/4)	25 (1)	— —

1. Pitch shall be measured at right angles to the direction of the corrugation.

For spiral rib pipe and spiral rib pipe arches, the corrugations shall be essentially rectangular ribs projecting outwardly from the pipe wall. The width of the ribs shall be 19 mm (3/4 inch) plus two times the wall thickness  $\pm$  3 mm (1/8 inch). The height of the ribs shall be a minimum of 23 mm (0.90 inch). The radius bend of the metal at the corners of the ribs shall be not less than 2.55 mm (0.10 inch) or greater than 4.30 mm (0.17 inch). All rib measurements will be made outside to outside except for the inside radius bend. The rib spacing shall be 292 mm (11-1/2 inches)  $\pm$  13 mm (1/2 inch) center to center.

(b) **Continuous Lock Seam Pipe.** Pipe shall be fabricated with the lock seam parallel to the corrugation, and may be used for full circle and equivalent pipe-arch sizes. The lock seam shall be formed in the tangent element of the corrugation profile with its center near the neutral axis, and shall meet the following requirements:

- 1) The edges of the sheets within the cross-section of the lock seam shall lap at least 4 mm (5/32 inch) for the pipe 250 mm (10 inches) or less in diameter and at least 8 mm (5/16 inch) for pipe greater than 250 mm (10 inches) in diameter, with an occasional tolerance of minus 10 percent of lap width allowable.
- 2) The lapped surface shall be in tight contact.
- 3) There shall be no excessive angularity on the interior of the 180-degree fold of metal at the lock seam which will cause any visual cracks in the sheet. Roller indentations shall not cause any cracks in the sheet or a loss of metal-to-metal contact within the seam.
- 4) Tensile specimens cut from production pipe normal to and across the lock seam shall develop the strength as tabulated in Table 207-11.3.3 (B).

**TABLE 207-11.3.3 (B)**

Pipe Sheet Thickness mm (Inches)	Gage No. (U.S. Std.)	Minimum Lock Strength kN/m (lb/in) of width
1.63 (0.064)	16	74 (425)
2.01 (0.079)	14	114 (650)
2.77 (0.109)	12	153 (875)
3.51 (0.138)	10	193 (1,100)
4.21 (0.168)	8	263 (1,500)

5) Continuous lock seam pipe shall be sampled and tested in accordance with AASHTO T249.

(c) **Continuous Welded Seam Pipe.** Pipes fabricated with a continuous helical weld seam parallel to the corrugations may be used for full circle and equivalent pipe arch sizes. The welding process shall be so controlled that the combined width of the weld and adjacent spelter coating burned by the welding does not exceed three times the thickness of the metal. If the spelter is burned outside of these limits, the weld and burned spelter shall be treated as specified in 207-11.4. When pipe is fabricated with aluminum coated sheets, the weld seam shall be metalized during the fabrication of the pipe with an aluminum alloy wire to completely cover and protect the damaged coated area. Testing for welded seam quality control shall conform to AASHTO T241. This test may be waived for pipe manufactured with factory reformed ends.

**207-11.4 Repair of Damaged Galvanizing or Aluminizing.** When the metallic coated surface has been burned by gas or arc welding, all surfaces of the welded connections shall be thoroughly cleaned by wire brushing and all traces of the welding flux and loose or cracked zinc or aluminum removed, after which the areas shall be repaired as specified in 210-3.5. In addition, damaged aluminized surfaces shall be given an asphalt mastic coating per 207-11.5.2.

#### **207-11.5 Coatings, Linings, and Pavings.**

**207-11.5.1 General.** When required by the Specifications, corrugated steel pipe, coupling bands, and fittings shall be coated, lined, or paved. Each section of pipe and fittings shall have the nominal metal thickness painted on the inner surface so that the metal thickness can readily be identified. Coupling bands need not be coated on the interior surface.

### 207-11.5.2 Coatings.

(a) **General.** Coatings shall be applied to one or both pipe surfaces to a minimum thickness as specified herein. Any appearance of pinholes, blisters, cracks, excessive whiskering (stalactites), or lack of bond shall be cause for rejection.

(b) **Bituminous Coatings.** Hot-applied bituminous coating shall be applied to both surfaces and shall conform to AASHTO M190, Type A/ASTM A 849, Class B. Minimum coating thickness shall be 1.3 mm (0.050 inch). Where concrete lining or paving is to be placed on aluminum coated steel, that portion of the conduit in contact with the concrete shall be coated with asphalt mastic coating per 207-11.5.2 prior to placement of the concrete. With the approval of the Engineer, the Contractor or manufacturer may add (anti-corrosion) additives to the concrete mix in lieu of asphalt coating.

(c) **Asphalt Mastic Coating.** Cold-applied asphalt mastic coating shall conform to the requirements of AASHTO M243, except that asbestos fiber shall not be used. The asphalt mastic material shall be applied to the surface specified to a minimum thickness of 1.3 mm (0.050 inch).

(d) **Polymeric Coating.** The polymeric coating shall comply with the requirements of ASTM A 849 Class P, and may be plant applied after pipe fabrication. Polymeric coatings shall be applied to the surfaces specified to a minimum thickness of 0.25 mm (0.010 inch).

### 207-11.5.3 Linings.

(a) **General.** Linings shall be applied to the interior of the pipe to produce a smooth surface.

(b) **Bituminous Linings.** Hot-applied bituminous linings shall conform to the requirements of AASHTO M190, Type D/ASTM A 849, Class M. Minimum lining thickness shall be 3.2 mm (1/8 inch) over the tops of the crests of the inside corrugations.

(c) **Concrete Lining.** The concrete lining shall be plant applied to produce a homogeneous, non-segregated, smooth lining with a minimum thickness of 3.2 mm (1/8 inch) over the crest of the inside corrugations, in accordance with ASTM A 849, Class C.

The concrete shall comply with 201-5, except that sand gradation requirements will be waived. Fly ash in accordance with 201-1.2.5 is permitted. The 28-day strength of the concrete shall be a minimum of 34.5 MPa (5,000 psi). Cracks in the lining greater than 1.5 mm (1/16 inch) shall be repaired in accordance with 207-3.3. Interior joints shall be mortared in accordance with 306-1.2.4.

### 207-11.5.4 Pavings.

(a) **General.** Paving material shall cover at least 25 percent of the circumference of round pipe and 40 percent of the circumference of pipe arches and shall be placed symmetrically, left and right of the bottom centerline of the pipe.

(b) **Bituminous Paving.** Hot-applied bituminous paving shall conform to the requirements of AASHTO M190, Type C/ASTM A 849, Class M.

(c) **Concrete Paving.** The concrete paving shall be Class 360-E-23 (600-E-3250). Steel reinforcing, when specified, shall conform to 201-2. The concrete shall be placed to the thickness specified, after the pipe has been backfilled.

**207-11.6 Nestable Pipe.** Nestable pipe shall be fabricated in two separate half-circle sections and the sections shall be firmly joined together, all in accordance with Federal Specification MIL-P-236E. The longitudinal joint of the nestable pipe sections may be either Type I, flanged, or Type II, notched, as specified in MIL-P-236E.

**207-11.7 Slotted Pipe.** The corrugated steel pipe used in the slotted drain shall meet the requirements of AASHTO M36/ASTM A 760/A 760M and shall be galvanized or aluminized coated (AL-T-2) steel. The diameter and gage shall be as shown on the Plans.

The grates shall be manufactured from ASTM A 570/A 570M, Grade 36 steel. The spacers and bearing bars (sides) shall be 4.763 mm (3/16 inch) material  $\pm 0.190$  mm (0.0075 inch).

The spacers shall be on 152 mm (6 inch) centers and welded on both sides to each bearing bar (sides) with four 32 mm (1-1/4 inch) long 5 mm (3/16 inch) fillet welds on each side of the bearing bars.

The Engineer may require tensile strength tests on the grate if the grate is not in compliance with the above. If tensile strength tests are required, minimum results for an in-place spacer pulled perpendicular to the bearing bar shall be:

$$T = 53.4 \text{ kN (12,000 pounds) for 64 mm (2-1/2 inch) grate}$$

$$T = 66.7 \text{ kN (15,000 pounds) for 152 mm (6 inch) grate}$$

The grates shall be trapezoidal with a 44 mm (1-3/4 inch) opening in the top and 30-degree slanted spacers unless shown otherwise on the Plans. If vertical grates are shown on the Plans, the grates shall be vertical (straight sides) with a 44 mm (1-3/4 inch) opening in the top and 30-degree slanted spacers. The grate shall be 64 mm (2-1/2 inches) or 152 mm (6 inches) high as shown on the Plans.

The grate shall be galvanized in accordance with ASTM A 123 except with a 605 g/m<sup>2</sup> (2 oz/ft<sup>2</sup>) galvanized coating.

The grate shall be fillet welded with a minimum 25 mm (1 inch) long weld to the corrugated steel pipe on each side of the grate at every other corrugation.

The corrugated steel pipe shall have a minimum of two re-rolled annular ends. The slotted drain bands shall be a modified Hugger band to secure the pipe and prevent infiltration of the backfill. When the slotted drain is banded together, the adjacent grates shall have a maximum 76 mm (3 in) gap.

**207-11.8 Underdrains.** The pipe for underdrains shall be of the full-circle type and perforations in the pipe may be drilled or punched. The perforations may be located either in the inside crests or in the flat tangent portion of the corrugations, but not in both locations in the same length of pipe.

Steel band couplers shall be as specified in 207-11.2.2. Sleeve type couplings may be substituted for the band couplers. The couplings may be either plastic or galvanized steel, suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets. The couplings shall not distort under normal conditions of use.

**207-11.9 Siphons.** Pipe and couplings shall be watertight and shall conform to 207-11.2.

The pipe for siphons shall be of such lengths that the number of field connections will be held to a minimum. The outside seams of riveted, spot welded or continuous helical lock seam pipe shall be continuously soldered. Rivets and spot welds on circumferential seams shall be spaced at approximately 65 mm (2-1/2 in) centers with maximum of 76 mm (3 in).

Prior to backfilling, the pipe for siphons shall be subject to the hydrostatic test as specified in 306-1.4.6.

**207-11.10 Pipe Downdrains.** Pipe and couplings for downdrains shall be watertight in accordance with 207-11.2. When required by Plans and Specifications, the Engineer may require testing in accordance with 306-1.4.6.

Joints for downdrains shall comply with the following joint property requirements:

**TABLE 207-11.10 (A)**  
**TENSILE STRENGTH (PULL APART STRENGTH)**

0 thru 1050 mm (0 thru 42 inches) pipe diameter	22.3 kN (5,000 lbs.)
1050 thru 2200 mm (42 thru 84 inches) pipe diameter	44.5 kN (10,000 lbs.)

## **207-12 STRUCTURAL STEEL PLATE PIPE AND ARCHES.**

**207-12.1 General.** The sizes, thicknesses, and dimensions of structural steel plate pipe, arches, and pipe arches shall be as designated on the Plans or in the Specifications.

### **207-12.2 Materials.**

**207-12.2.1 General.** Steel sheets, plates, bolts, and nuts shall conform to AASHTO M 167. In accordance with the requirements of Section 4, the fabricator of the structural steel products shall furnish to the Engineer a Certificate of Compliance stating that the materials furnished comply with these requirements. Galvanized surfaces which are damaged shall be repaired in accordance with 210-3.5.

**207-12.2.2 Identification.** When plates of two dissimilar thicknesses are involved in one cross-section of an installation, the thickness of structural steel plates will be identified on the Plans, or in the proposal in accordance with the following:

Each installation will be designated by size and symbol indicating the number and thickness of plates required. Thus, "(4x2.77-1x4.27)" ["(4.109-1.168)"] will be used to designate an installation for one plate length composed of four 2.77 mm (0.109 inch) thick plates and one 4.27 mm (0.168 inch) thick plate, with the heaviest thickness to be placed in the invert. This designation does not prevent the Contractor from using fewer or more plates, provided the minimum thickness requirements are met.

**207-12.3 Distorting.** When required by the Plans or Specifications, circular structural steel plate pipe shall be distorted, either at the fabricating shop or in the field.

Plates distorted in the fabricating shop shall provide an increase in the vertical diameter of the pipe, after assembly, of approximately 5 percent for the full length. Plates shall be marked to assure that they will be placed in proper position.

The method for distorting plates in the field shall conform to details shown on the Plans and to 304-4.

**207-12.4 Coatings.** When required by the Plans or the Specifications, a protective coating shall be applied to structural steel plate pipe and arches, including all appurtenant fasteners and fittings. Bituminous coating shall conform to 207-11.5.2. Asphalt mastic coating shall conform to 207-11.5.4. Asphalt mastic coating may be field applied after assembly of the structure.

When bituminous coatings are shop applied, each plate shall have the plate thickness on the inner surface so that the plate thickness can be readily identified.

**207-13 CORRUGATED ALUMINUM PIPE AND PIPE ARCHES.**

**207-13.1 General.** Corrugated aluminum pipe, pipe arches, and connectors shall be manufactured and inspected in conformance with the requirements of AASHTO M196, M197, and as specified herein. The size, type, and gage of the pipe to be furnished shall be as shown on the Plans or in the Specifications.

Corrugated aluminum pipe arches shall consist of corrugated aluminum pipe which has been re-formed to multicentered pipe having an arch-shaped top with a slightly curved integral bottom. The minimum radius of any part of the pipe section shall be not less than 76 mm (3 in).

The specifications contained herein for pipe shall also apply to pipe arches.

Nominal diameter, as referred to in AASHTO M196 and M197, shall be defined as meaning the minimum inside dimension of the pipe.

**207-13.2 Materials.**

**207-13.2.1 General.** Corrugated aluminum sheets covered by this section shall be fabricated from Alloy Alclad 3004 with Temper H-34 and shall conform to ASTM B 209M (ASTM B 209) and the following mechanical properties:

**TABLE 207-13.2.1 (A)**

Thickness Millimeters (Inches) Property	1.30 to 2.87 (0.051 to 0.113)	2.88 to 6.32 (0.114 to 0.249)
Tensile Strength (minimum)	215 Mpa (31,000 psi)	215 Mpa (31,000 psi)
Yield Strength (2% offset) (minimum)	165 Mpa (24,000 psi)	165 Mpa (24,000 psi)
Elongation in 50 mm (2 inches)	4% min.	5% min.

The gages and thickness referred to in this specification are as follows:

**TABLE 207-13.2.1 (B)**

Thickness mm (Inches)	Gage Number (U.S. Standard)
1.52(0.060)	16
1.91(0.075)	14
2.67(0.105)	12
3.43(0.135)	10
4.19(0.165)	8

The cladding thickness shall be 5 percent of the total composite thickness.

Rivets shall conform to ASTM B 316M (ASTM B 316) for Alloy 6053 with Temper T-4 and the following physical properties:

**TABLE 207-13.2.1 (C)**

Tensile Strength (minimum)	170 MPa	(25,000 psi)
Yield Strength (2% Offset) (minimum)	95 MPa	(14,000 psi)
Shear Strength (minimum)	105 MPa	(15,000 psi)
Elongation in 50 mm (2 inches) (minimum)	16%	

The corrugations for all pipe, measured at right angles to the direction of the corrugation, shall conform to the dimensions in the following table:

**TABLE 207-13.2.1 (D)**

Diameter <sup>1</sup> mm (Inches)	Width <sup>2</sup> mm (in)	Depth (Min.) <sup>2</sup> mm (in)	Type of Corrugation
200 and larger (8 and larger)	68 (2-2/3)	13 (1/2)	Annular
900 and larger (36 and larger)	76 (3)	25 (1)	Annular
150 through 250 (6 through 10)	38 (1-1/2)	6 (1/4)	Helical
300 and larger (12 and larger)	68 (2-2/3)	13 (1/2)	Helical
900 and larger (36 and larger)	76 (3)	25 (1)	Helical

1. Inside diameter of pipe shall not vary more than the following:  
 150 through 450 (6 inch through 18 inch) in diameter, 6 mm (1/4 inch maximum)  
 525 through 600 (21 inch through 24 inch) in diameter, 9.5 mm (3/8 inch) maximum  
 600mm (24 inch) and over in diameter, 13 mm (1/2 inch) maximum.
2. Minimum and maximum width and depth of corrugation shall conform to AASHTO M-196 and M-197.

The lengths and thickness of sheet, width of laps, and computed weight per lineal foot of finished corrugated aluminum pipe and arches shall be as specified in Table 4 of AASHTO M196. The dimensions of the corrugated aluminum pipe arch shall be as shown in Table 7 of AASHTO M196.

**207-13.2.2 Connecting Bands.** The connecting bands shall conform to the requirements of AASHTO M196, except the minimum width of band for 300 mm (12 inch) and larger pipe shall be 300 mm (12 inches). Minimum width of band for pipe less than 300 mm (12 inches) shall be 175 mm (7 inches) and minimum width of band for 25 mm by 75 mm (1 inch by 3 inch) corrugations shall be 355 mm (14 inches). The base metal of connecting bands shall be the same base metal as that of the pipe. The gage of the connecting bands for corrugated pipe and pipe arches may be two standard-use thicknesses lighter than that used for the pipe, but not less than 1.52 mm (0.060 inch) thick.

The band couplers shall be connected with galvanized steel bolts of not less than 13 mm (1/2 inch) diameter.

**207-13.2.3 End Finish.** The ends of 1.52 mm (0.060 inch) and 1.91 mm (0.075 inch) thickness installations shall be reinforced where shown on the Plans. The reinforcement shall consist of an aluminum band of at least 3.43 mm (0.135 inch) material at least 150 mm (6 inches) wide, on at least the outer 300 mm (12 inches) of 1.52 mm (0.060 inch) and 1.91 mm (0.075 inch) pipe shall be at least 3.43 mm (0.075 inch) material.

### 207-13.3 Fabrication.

**207-13.3.1 General.** At the option of the Contractor, corrugated aluminum pipe may be fabricated by riveting or by using a helically corrugated metal pipe with a continuous helical lock seam paralleling the corrugation.

**207-13.3.2 By Riveting.** Pipe fabricated by riveting shall conform to AASHTO M196.

**207-13.3.3 By Continuous Lock Seam.** Pipe fabricated with a continuous helical lock seam parallel to the corrugations shall conform to the requirements of AASHTO M196 and as specified herein.

**207-13.4 Underdrains.** Pipe for underdrains shall be of the full circle type and perforations in the pipe may be drilled or punched in accordance with AASHTO M196. The perforations may be either in the inside crests or in the flat tangent portion of the corrugations but not in both locations in the same length of pipe.

Sleeve-type couplings may be substituted for the band couplers. The couplings may be either plastic or aluminum, suitable for holding the pipe firmly in alignment without the use of sealing compound or

gaskets. The couplings shall not distort under normal conditions of use. Minimum thickness for underdrains shall be 1.52 mm (0.060 inch).

**207-13.5 Pipe Downdrains.** Joints for downdrains shall be watertight in accordance with 207-11.2.2. When required by the Specifications, the Engineer may require testing in accordance with 306-1.4.6.

Joints for downdrains shall comply with the following joint property requirements:

**TABLE 207-13.5 (A)**  
**TENSILE STRENGTH (PULL APART STRENGTH)**

0 to 1050 mm (0 to 42 inches) pipe diameter	22.3 kN (5,000 pounds)
1125 to 2100 mm (45 to 84 inches) pipe diameter	44.5 kN (10,000 pounds)

**207-13.6 Bituminous Coating.** When required by the Specifications, pipe and connecting bands shall be protected, both inside and outside, with a bituminous coating. The bituminous coating shall conform to the requirements of AASHTO M190 and as hereinafter specified.

The minimum thickness of bituminous material for all coated pipe measured on the crest of the corrugations shall be 1.3 mm (0.05 inch).

In paving the invert of aluminum pipes, the bituminous material shall cover the crests to a minimum depth of 3.2 mm (1/8 inch) and the width of paving shall at least cover one third of the periphery of pipe arches and one quarter of the periphery of circular pipes.

The bituminous material shall conform to Paragraph 4 of AASHTO M190, except that it shall be at least 90 percent soluble in cold carbon disulfide.

When corrugated aluminum pipes are to have a bituminous coating, the fabrication requirements specified in AASHTO M196 shall be altered so that the rivet heads inside the pipe will be in the valley of the corrugations.

Damaged bituminous coatings shall be repaired by the Contractor at its expense by applying bituminous material conforming to the provisions of this subsection.

**207-13.7 Repair of Damaged Alclad Coating.** Alclad coatings which have been damaged shall be repaired. The damaged area shall be thoroughly cleaned by wire brushing. The cleaned area shall be painted with two coats of zinc oxide-zinc dust paint conforming to the requirements of Military Specification MIL-P-15145. The paint shall be properly mixed with a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight.

#### **207-14 STRUCTURAL ALUMINUM PLATE PIPE AND ARCHES.**

**207-14.1 General.** The sizes, thicknesses, and dimensions of structural aluminum plate pipe, arches, and pipe arches shall be as designated on the Plans or in the Specifications.

##### **207-14.2 Materials.**

**207-14.2.1 General.** Aluminum sheets, plates, bolts, and nuts shall conform to AASHTO M 219. In accordance with the requirements of 2-10, the fabricator of the structural aluminum products shall furnish to the Engineer a Certificate of Compliance stating that the materials furnished comply with these requirements. Each plate shall be marked on the inner surface so that the plate thickness can be readily identified after installation.

**207-14.2.2 Identification.** When plates of two dissimilar thicknesses are involved in one cross-section of an installation, the thickness of structural aluminum plates will be identified in accordance with 207-12.2.2.

**207-14.2.3 Distorting.** When required by the Plans or Specifications, circular structural aluminum plate pipe shall be distorted, either at the fabricating shop or in the field.

Plates distorted in the fabricating shop shall provide an increase in the vertical diameter of the pipe, after assembly, of approximately 5 percent for the full length. Plates shall be marked to ensure that they will be placed in proper position.

Distorting of plates in the field shall conform to 304-4.3.

**207-14.2.4 Coatings.** When required by the Plans or Specifications, a protective coating shall be applied to structural aluminum plate pipe and arches, including all appurtenant fasteners and fittings. Bituminous coating shall conform to 207-11.5.2 (b). Asphalt mastic coating shall conform to 207-11.5.2 (c). Asphalt mastic coating may be field applied after assembly of the structure.

### 207-15 ABS SOLID WALL PIPE.

**207-15.1 General.** This subsection applies to ABS plastic solid wall pipe for use as sanitary sewers, storm drains, and house connection sewers. Pipe, fittings, and joints shall comply with ASTM D 2751 except as modified herein. Minimum wall thickness shall correspond with SDR 35. Joints for sanitary sewers, except for house connection sewers, shall be gasketed joints.

Joint solvent cement shall be an ABS cement conforming to ASTM D 2235. Gaskets shall conform to the requirements of 208-4.

**207-15.2 Material Composition and Testing.** The pipe and fittings shall be made of ABS plastic which shall meet the minimum cell classification of 1-3-3, 3-2-2, or 2-2-3 as defined in ASTM Specification D 1788 and having the chemical composition as follows:

Acrylonitrile-butadiene-styrene (ABS) pipe - plastics containing polymers or blends of polymers, or both, in which the minimum butadiene content is 6 percent, the minimum acrylonitrile content is 15 percent, the minimum styrene or substituted styrene content or both, is 15 percent and the maximum content of all other monomers is not more than five parts by weight per 100 parts of ABS resin. Additives and fibers, including but not limited to stabilizers, antioxidants, colorants, etc., shall not exceed 10 parts by weight per 100 parts of ABS resin.

Material shall meet or exceed the values and properties below:

TABLE 207-15.2 (A)

PROPERTY	ASTM METHOD	MINIMUM VALUE BASED ON CELL CLASSIFICATION		
		1-3-3	3-3-2	2-2-3
Izod impact @ 23 ± 2°C J/m (feet lb/in.) of notch	D 256	53 (1)	160 (3)	107 (2)
Deflection Temperature under load 1820 kPa (264 psi)	D 648			
°C		87	82	87
°F		190	180	190
Tensile stress at yield point: MPa (psi)	D 638	34.5 (5000)	27.6 (4000)	34.5 (5000)
Specific Gravity:	D 792			
Minimum		1.0	1.0	1.0
Maximum		1.0	1.2	1.2

**207-15.3 Chemical Resistance (Pickle Jar Test).** The Engineer may at any time direct the manufacturer to obtain samples of the compound and to prepare test specimens in accordance with ASTM D 1987. These specimens shall comply with the minimum property values shown below and also with the applicable ASTM requirements.

Tensile, impact and weight change exposure specimens shall be immersed in the solutions specified in Table 211-2(A) for a period of 112 days. At 28-day intervals, selected specimens shall be removed, washed, surface dried, and tested.

The weight change specimens shall be 50mm (2 inches) in diameter and may be molded discs or discs cut from the pipe wall. They shall be conditioned in a mechanical convection oven for 7 days at  $43^{\circ} \pm 2^{\circ}\text{C}$  ( $110^{\circ} \pm 4^{\circ}\text{F}$ ), then cooled in a desiccator for 3 hours at  $23^{\circ} \pm 2^{\circ}\text{C}$  ( $73^{\circ} \pm 4^{\circ}\text{F}$ ), weighted, and then immersed in the solutions in Table 211-2(A). At 28-day intervals, selected specimens shall be removed, washed, surface dried, and weighed. These same specimens shall be reconditioned in a mechanical convection oven for 7 days at  $43^{\circ} \pm 2^{\circ}\text{C}$  ( $110^{\circ} \pm 4^{\circ}\text{F}$ ), then cooled in a desiccator for 3 hours at  $23^{\circ} \pm 2^{\circ}\text{C}$  ( $73^{\circ} \pm 4^{\circ}\text{F}$ ) and weighed again. If any specimen fails to meet these requirements at any time, the material will be rejected.

**TABLE 207-15.3 (A)**

Property	ASTM Test Method	Initial Values	Values After 112 Days Exposure
Tensile Strength MPa (psi)	D 638	34.5 (5,000) min.	34.5 (5,000) min.
Impact Strength J/m (Feet-lbs./in.)	D 256 Method A Size 12.7 x 3.17 x 63.5 (1/2 in x 1/8 in x 2-1/2 in)	107 (2) of notch, min.	107 (2) of notch, min.
Weight Change (%) Unconditioned Conditioned	D 543		$\pm 1.5\%$ max. $\pm 1.0\%$ max.

**207-15.4 Pipe Acceptance.** At the time of manufacture each lot of pipe and fittings shall be inspected for defects, and tested for impact, stiffness, and flattening in accordance with ASTM D 2751.

When testing subsequent to manufacture, the impact requirement shall be excluded. For the flattening requirement, the percentage reduction in pipe diameter shall be not less than 15 percent for pipe marked SDR 23.5 or lower, and not less than 25 percent for pipe marked with higher SDR numbers. The stiffness requirement is unchanged.

A pipe lot shall consist of all pipe having the same marking number. The lot test specimen shall have a minimum length of 1.2 m (4 feet).

**207-15.5 Marking.** Pipe shall have a home mark to indicate full penetration of the spigot when the joint is made. Pipe shall be marked at 1.5 m (5 foot) intervals or less with a marking number which identifies the manufacturer, SDR, size, machine, date, and shift on which the pipe was produced.

**207-15.6 Installation and Field Inspection.** Pipe shall be bedded in conformance with 306-1.2.13. Backfill shall conform to 306-1.3. Field inspection shall conform to 306-1.2.12.

**207-15.7 Installation Time Limit.** The Contractor shall retest within 60 days prior to the installation of all pipe and fittings that are more than 180 days old from the date of manufacture to ensure compliance with the requirements of the Specifications. The Contractor shall not install any pipe that is more than 2 years old from the date of manufacture.

**207-16 ABS OR PVC COMPOSITE PIPE.**

**207-16.1 General.** This subsection applies to ABS or PVC composite pipe for use as sanitary sewers, storm drains, and house connection sewers. Pipe, fittings, and joints shall comply with ASTM D 2680, except as modified herein.

The pipe shall consist of two concentric extruded thermoplastic tubes integrally connected by webs to form a circular truss. The longitudinal void spaces shall be filled with inert material. The maximum average ID of the pipe, as determined by ASTM D 2122, shall be:

**TABLE 207-16.1 (A)**

Nominal Size		Max. Average ID	
Millimeters	(Inches)	Millimeters	(Inches)
150	(6)	148	(5.81)
200	(8)	201	(7.90)
250	(10)	251	(9.88)
300	(12)	301	(11.83)
375	(15)	376	(14.80)

Joint solvent cement shall be in accordance with 207-15.1 for ABS and 207-17.3.3 for PVC.

**207-16.2 Material Composition and Testing.** The ABS resin compound used in the manufacture of ABS composite pipe shall conform to the requirements of 207-15.2. The PVC resin shall conform to the requirements of 207-17.2.2.

**207-16.3 Chemical and Physical Testing.** ABS resins shall conform to 207-15.3. PVC resins shall conform to 207-17.5.

**207-16.4 Pipe Acceptance.** Each lot of pipe and fittings shall be inspected for defects and tested for stiffness and deflection in accordance with ASTM D 2680. Installation time shall conform to 207-15.7.

A pipe lot shall consist of all pipe having the same marking number. The lot test specimen shall be a minimum length of 1.2 m (4 feet).

**207-16.5 Marking.** Pipe shall have a home mark to indicate full penetration of the spigot when a joint is made. Pipe shall be marked at 1.5 m (5 foot) intervals or less with a marking number which identifies the manufacturer, size and machine, date, and shift on which the pipe was made.

**207-16.6 Repair.** There shall be no discontinuity of the pipe inner wall. Ruptures in the pipe outer wall may be repaired if the damage is limited to an area that can be encompassed by a 75 mm (3 inch) diameter circle superimposed over the damage. Cell filler repair is unnecessary. A solvent welded repair patch of the same material as the pipe, at least equal to the thickness of the pipe outer wall, shall extend at least 25 mm (1 inch) beyond the damage. When damage exceeds these limits, the damaged section shall be cleanly removed.

**207-16.7 Installation and Field Inspection.** Pipe shall be bedded in conformance with 306-1.2.13. Backfill shall conform to 306-1.3. Field inspection shall conform to 306-1.2.12.

**207-17 PVC PLASTIC PIPE.**

**207-17.1 General.** This subsection applies to the requirements for unplasticized PVC plastic pipe for sanitary sewers, storm drains, and house connection sewers. Pipe, fittings, couplings, and joints shall conform to the requirements listed in Table 207-17.1 (A), except as otherwise modified by the Plans or the Specifications.

TABLE 207-17.1 (A)

Nominal Size		ASTM	Wall Thickness Min.
mm	Inches		
100 - 375	(4 - 15)	D 3034	SDR 35
450 - 750	(18 - 30)	F 679	"T-1" only

Joints for sanitary sewers, except house connection sewers, shall be gasketed joints.

### 207-17.2 Manufacturing Requirements.

**207-17.2.1 Identification Marks.** All pipe, fittings, and couplings shall be clearly marked at intervals not to exceed 5 feet as follows:

- 1) Nominal pipe diameter.
- 2) PVC cell classification.
- 3) Company, plant, shift, ASTM, SDR, and date designation.
- 4) Service designation or legend.

For fittings and couplings, the SDR designation is not required.

**207-17.2.2 Cell Classification.** Pipe shall be made of PVC plastic having a cell classification of 12454 or 13364, as defined in ASTM D 1784. The fittings shall be made of PVC plastic having a cell classification of 12454, or 13343. PVC compounds of other cell classifications shall be in conformance with 207-17.5. Additives and fillers, including but not limited to stabilizers, antioxidants, lubricants, colorants, etc., shall not exceed 10 parts by weight per 100 of PVC resin in the compound.

### 207-17.3 Joining Systems.

**207-17.3.1 General.** All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made.

The socket and spigot configurations for the fittings and couplings shall be compatible to those used for the pipe.

**207-17.3.2 Elastomeric Gasket Joints.** Pipe with gasketed joints shall be manufactured with a socket configuration which will prevent improper installation of the gasket and will ensure that the gasket remains in place during the joint operation. The gasket shall be manufactured from a synthetic elastomer and shall conform to the requirements of 208-1.2 and 208-4.

**207-17.3.3 Solvent Cement Joints.** Pipe with solvent cement joints shall be joined with PVC cement conforming to ASTM D 2564.

**207-17.3.4 Injection Sealed Joints.** Pipe with injection sealed joints shall be sealed with a PVC adhesive compound. The compound shall conform to the requirements of ASTM D 2564 and shall have a minimum viscosity of 50 Pascal-second (50,000 centipoise). The internal diameter of the socket shall be uniform with a locking taper at the base and an outer seal ring attached to the end. The socket shall have an injection port to inject the adhesive and an exhaust port on the opposite side to allow air to escape from the annular space.

### 207-17.4 Test Requirements.

**207-17.4.1 General.** Pipe, fittings, and couplings shall meet the requirements of the section titled "Requirements" of ASTM D 3033, D 3034, or F 679 ("T-1" wall only). During production of the pipe, the manufacturer shall perform the specified tests for each pipe marking. A certification by the manufacturer indicating compliance with specification requirements shall be delivered with the pipe.

The certification shall include the test result data. The PVC compound shall also meet the chemical resistance requirements of 207-17.5.

**207-17.4.2 Acceptance.** The basis for acceptance will be the inspection of pipe, fittings, and couplings; the tests specified in 207-17.4.1; and compliance with the Specifications. When the pipe is delivered to the Work site, the Engineer may require additional testing to determine conformance with the requirements of pipe flattening, impact resistance, pipe stiffness, and extrusion quality. Installation time shall conform to 207-15.7.

**207-17.4.3 Selection of Test Pipe.** When testing is required by the Engineer, one test pipe shall be selected at random by the Engineer from each 370 m (1,200 feet) or fraction thereof of one test pipe per lot. A lot shall be defined as pipe having the same identification marking. The length of specimen for each selected pipe shall be a minimum of 2.4 m (8 feet).

**207-17.5 Chemical Resistance and Physical Testing.** PVC shall be tested in accordance with 211-2 and conform to Table 207-17.5(A).

**TABLE 207-17.5 (A)**

Property	ASTM TEST Method	VALUE (Initial and After 112-Day Exposure)		
		Cell Classification		
		12454	13343	13364
Tensile Strength (Yield), MPa (psi), min.	D 638	48.3 (7000)	41.4 (6000)	41.4 (6000)
Impact Strength J/m (Ft.-lbs./in.) of notch, min.	D 256 Method A Size 12.7 mm x 3.17 mm x 63.5 mm (1/2 in x 1/8 in x 2-1/2 in)	35 (0.65)	80 (1.5)	80 (1.5)
Weight Change % Unconditioned	D 543	± 1.5 max	± 1.5 max	± 1.5 max
Conditioned		± 1.0 max	± 1.0 max	± 1.0 max

**207-17.6 Installation and Field Inspection.** Pipe shall be bedded in accordance with 306-1.2.13. Backfill shall conform to 306-1.3. Field inspection shall conform to 306-1.2.12.

**207-18 ANNULAR HIGH DENSITY POLYETHYLENE PIPE WITH SMOOTH INTERIOR, CORRUGATED EXTERIOR, WITH BELL-AND-SPIGOT JOINTS.**

**207-18.1 General.** These specifications are intended to be used for the construction of gravity flow storm drains, culverts, and subsurface drains. The size, type, and cell classification of the pipe to be furnished shall be as shown on the Plans or in the Specifications. If the cell classification is not shown on the Plans or in the Specifications, High Density Polyethylene (HDPE) plastic pipe and fittings with smooth interior liner, annular corrugations, and bell-and-spigot joints shall conform to cell classification 324420C or higher and the State of California Department of Transportation Standard Specifications.

**207-18.2 Reworked Material.** In lieu of virgin PE, clean reworked material may be used by the manufacturer, provided that it meets the cell classification.

**207-18.3 Installation and Field Inspection.** Pipe and fittings be bedded in accordance with 306-1.2.13. Backfill for HDPE pipe shall conform to 306-1.3. Field inspection shall conform to 306-1.2.12.

**207-18.4 Measurement and Payment.** Measurement and payment shall conform to 306-1.6.

**207-19 POLYETHYLENE (PE) SOLID WALL PIPE.**

**207-19.1 General.** Polyethylene (PE) plastic solid wall pipe and liner for use in gravity flow sanitary sewers, storm drains, and house connection sewers shall comply with ASTM D 3350 or ASTM F 714. Unless otherwise indicated, pipe shall conform to SDR 21. Fittings shall comply with ASTM D 2683 or D 3261.

**207-19.2 Material Composition.** Pipe and fittings shall be made from PE resins complying with ASTM D 1248, Type III, Class C, Category 5, Grade P34, and ASTM D 3350, and which shall further meet the requirements as listed in the following table:

**TABLE 207-19.2 (A)**

Property	Value	ASTM Test
Density (g/cm <sup>3</sup> )	0.941-0.959	D 1505
Melt Index (g/10 minutes)	0.15 max.	D 1238 cond. E.
Flexural Modulus MPa (psi)	827 (120,000 min.)	D 790
Tensile strength at yield MPa (psi)	22.1 (3,200 min.)	D 638
Elongation at break (%)	800	D 638
Brittleness temperature °C (°F)	-118 (-180 max.)	D 746
Environmental Stress Crack Resistance F <sub>0</sub> (hrs.) <sup>1</sup> Test Condition "C"	192 min.	D 1693
Hydrostatic Design Basic MPa (psi) @ 23°C (73°F)	11.0 (1600)	D 2837
Color	2% Carbon Black min.	

1. F<sub>0</sub> indicates no failures.

Additives and fillers including, but not limited to, stabilizers, antioxidants, lubricants, colorants, etc., shall not exceed five parts by weight per 100 of PE resin in the compound. The Engineer may require certification by the manufacturer that the test results comply with specification requirements.

**207-19.3 Pipe Acceptance.** At the time of manufacture, each lot of pipe, liner, and fittings shall be inspected for defects and tested for Elevated Temperature Sustain Pressure in accordance with ASTM F 714. Installation time limit shall conform to 207-15.7.

At the time of delivery, the pipe shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters, or deleterious faults.

For testing purposes, a production lot shall consist of all pipe having the same marking number. It shall include any and all items produced during any given work shift and must be so identified as opposed to previous or ensuing production.

**207-19.4 Marking.** Pipe shall be marked at 1.5 m (5 foot) intervals or less with a coded number which identifies the manufacturer, SDR, size, material, machine, date, and shift on which the pipe was extruded.

At the end of the production shift, during which a production lot has been extruded, the marking code on the pipe shall be changed to indicate that said time intervals have elapsed and that a new production shift has begun.

Fittings shall be marked with the name of the manufacturer or its logo, the size, and the material from which they were molded or fabricated.

**207-19.5 Chemical Resistance and Physical Testing.** PE resins shall be tested in accordance with 211-2 and conform to Table 207-19.5(A).

**TABLE 207-19.5 (A)**

Property	ASTM Test Method	Initial Value	Value After 112 Days Exposure
Tensile Strength MPa (psi) min.	D 638	22.1 (3,200)	22.1 (3,200)
Impact Strength J/m (Ft.-lb./in.) min.	D 256 Method A 3.5 Size 12.7 mm x 3.17 mm x 63.5 mm (1/2 in x 1/8 in x 2-1/2 in)	187 (3.5)	187 (3.5)
Weight Change % Unconditioned Conditioned	D 543		± 1.5 max. ± 1.0 max.

The Engineer may, at any time, direct the manufacturer and/or Contractor to obtain compound samples and to obtain compression molded test specimens in accordance with ASTM D 1928. These specimens shall comply with the minimum property values in Table 207-19.5(A).

**207-19.6 Installation and Field Inspection.** Pipe shall be bedded in conformance with 306-1.2.13. Backfill shall conform to 306-1.3. Field inspection shall conform to 306-1.2.12.

**207-20 CENTRIFUGALLY CAST FIBERGLASS REINFORCED PLASTIC MORTAR (CCFRPM) PIPE.**

**207-20.1 General.** These specifications apply to CCFRPM pipe to be used for the construction of direct bury gravity sanitary sewers, storm drains, and related structures. All pipes, joints, and fittings shall conform to ASTM D 3262. Unless otherwise indicated, the minimum pipe stiffness shall be 318 kPa (46 psi) when tested in accordance with ASTM D 2412. The size, type, and stiffness of the pipe to be furnished shall be as shown on the Plans or in the Specifications.

**207-20.2 Materials.** The amount, location, and orientation of the chopped glass-fiber reinforcement is specifically designed for each project application. The glass shall be a commercial grade of E-type glass fibers with a finish compatible with the resin used. The sand shall be a minimum 98 percent silica kiln-dried and graded. The polyester wall resin shall be an isophthalic, orthophthalic, or other approved resin with a minimum tensile elongation of 2 percent. A vinyl ester liner resin shall be used to meet the chemical requirements of 207-20.5. Designation per ASTM D 3262 shall be Type 1, Liner 2, Grade 3, and a minimum pipe stiffness of 318 kPa (46 psi) or greater, unless a higher value is indicated in the Plans or Specifications. Elastomeric sealing gaskets shall conform to the requirements of ASTM F 477.

**207-20.3 Dimensions.**

**207-20.3.1 Length.** The nominal length shall be 6 m (20 feet) except as otherwise specified or required for bends or special joints, with a minimum length of 1.5 m (5 feet). At least 90 percent of the total footage of each size and class of pipe, excluding special order lengths, shall be furnished in nominal length sections.

**207-20.3.2 Minimum Wall Thickness and Weight for Class SN 46 (Minimum Pipe Stiffness of 318 kPa (46 psi)).** The outside diameter, minimum wall thickness, and weight are shown in Table 207-20.3.2 (A).

TABLE 207-20.3.2 (A)

Nominal Inside Diameter mm (in)	Maximum Outside Diameter mm (in)	Minimum Wall Thickness mm (in)	Average Weight (lbs/ft)
300 (12)	340 (13.4)	7.7 (.30)	16 (11)
450 (18)	495 (19.5)	10.7 (.42)	31 (21)
500 (20)	549 (21.6)	11.7 (.46)	37 (25)
600 (24)	655 (25.8)	13.8 (.54)	52 (35)
750 (30)	813 (32.0)	16.8 (.66)	80 (54)
900 (36)	973 (38.3)	19.9 (.78)	115 (77)
1050 (42)	1130 (44.5)	22.9 (0.90)	155 (104)
1200 (48)	1290 (50.8)	26.0 (1.02)	199 (134)
1350 (54)	1450 (57.1)	29.0 (1.14)	251 (169)
1500 (60)	1598 (62.9)	32.0 (1.26)	311 (209)
1650 (66)	1758 (69.2)	31.5 (1.38)	371 (249)
1800 (72)	1915 (75.4)	38.1 (1.50)	443 (298)
1950 (78)	2073 (81.6)	41.2 (1.62)	524 (352)
2100 (84)	2253 (88.7)	44.7 (1.76)	616 (414)
2250 (90)	2395 (94.3)	47.3 (1.86)	696 (468)
2400 (96)	2555 (100.6)	50.3 (1.98)	792 (532)
2550 (102)	2743 (108.0)	54.1 (2.13)	909 (611)

**207-20.4 Joints.** Pipes and fittings shall be field connected with a coupling or bell-and-spigot joint containing a compressed elastomeric gasket. Elastomeric gasket material shall conform to 208-1.2. Joints shall meet the performance requirements of ASTM D 4161. Maximum allowable joint angular deflections for curves are shown in Table 207-20.4 (A).

TABLE 207-20.4 (A)

Nominal Diameter Millimeters (Inches)	Maximum Joint Deflection Angle (Degrees)
300 to 350 (12 to 14)	4
400 to 500 (16 to 20)	3
600 to 900 (24 to 36)	2
1050 to 1200 (42 to 48)	1.5
1350 to 1500 (54 to 60)	1
1650 to 1950 (66 to 78)	0.75
2100 to 2550 (84 to 102)	0.50

**207-20.5 Chemical Resistance and Physical Testing.** All pipe furnished under this subsection shall be tested in accordance with 211-2 and conform to 207-20.5(A). In addition, the pipe shall be tested as follows:

(a) **Properties.** In accordance with ASTM D 3262.

(b) **Accelerated Aging of Pipe Using A Deflected Condition.** Pipe rings shall be tested for retention of properties after exposure for 112 days in a strained deflected condition to solutions specified in Table 207-20.5 (B).

Tests for initial properties to comply with Table 207-20.5 (A) shall be conducted on pipe rings and specimens cut from pipe rings all prior to their exposure.

Initial properties to be used in evaluation of physical property retention for each exposed pipe ring shall be determined from specimens cut from each ring after exposure. Initial property test specimens shall be taken from ring locations that were 45 degrees either side of the top position in the exposure test.

The deflection of pipe rings during the exposure shall be based on achieving a specific strain as shown in Table 207-20.5 (C).

(c) **Test Procedures.** The following procedures shall be used for performing the accelerated aging test on pipe specimens:

- 1) Select two pipe diameters for testing.
- 2) Obtain 16 pipe rings each 300 mm (12 inches) long from both diameters.
- 3) One ring of each diameter shall be tested for initial properties in accordance with 211-2 and meet or exceed the values in Table 207-20.5 (A).
- 4) Weigh the remaining pipe rings and test for pipe stiffness per ASTM D 2412.
- 5) Determine the appropriate test deflection of each pipe ring in accordance with Table 207-20.5 (C).
- 6) Deflect each pipe ring in accordance with ASTM D 3681 procedures to the determined test deflection, dam the ends, and immediately begin the test exposure. Depth of test solution shall be one-third of pipe diameter.
- 7) Three pipe rings of each diameter and pipe joint section shall be exposed for 112 days to each test solutions specified in Table 207-20.5 (B).
- 8) After exposure, immediately remove rings from deflections restraints, clean, and visually inspect (note any changes).
- 9) Weigh each ring and test for pipe stiffness.
- 10) Determine initial strength and elongation properties for each pipe ring in accordance with Table 207-20.5 (A).
- 11) Determine exposed properties of each pipe ring in accordance with Table 207-20.5 (A).
- 12) Compute changes in pipe stiffness, weight, and properties for each ring.
- 13) Compute average retentions for each test solution and evaluate for conformance to the requirements of Table 207-20.5 (A).

**TABLE 207-20.5 (A)**

Property	Initial and After Exposure <sup>1</sup>	After Exposure in strained deflected condition
Minimum Axial Tensile Strength	100% of initial	90% of initial
Minimum Axial Tensile Modulus	2413 MPa (350,000 psi) (secant tangent method)	90% of initial
Minimum Axial Elongation at break	0.5%	90% of initial
Weight change	+ 1.5%	+ 1.5%
Minimum Pipe Stiffness	0.32 Mpa (46 psi)	90% of initial

1. After 112 days in chemical solutions listed on 211-2.

**TABLE 207-20.5 (B)**

Chemical Solutions	Concentration
Sulfuric Acid	20%
Sodium Hydroxide	5%
Nitric Acid	1%
Sodium Hypochlorite	1%
Bacteriological	BOD not less than 700 PPM

1. Volumetric percentages: Actual concentration of reagent must be corrected to 100%.

2. After 112 days in chemical solutions listed on Table 207-20.5 (B) in the stressed condition given in Table 207-20.5 (C).

3. May be 85% of initial if after exposure value exceeds 0.32 MPa (46 psi).

TABLE 207-20.5 (C)

Pipe Stiffness MPa (psi)	Minimum Strain (%)	Test Deflection
0.32 (46)	0.39t/D <sup>(1)</sup>	9.1%
0.50 (72)	0.34t/D <sup>(2)</sup>	7.9%

1. Linearly interpolate minimum strain values and test deflections for other values of pipe surface.

2. t and D are the nominal local wall thickness and the inside diameter.

**207-20.6 Marking.** Each pipe section shall be marked at both ends inside and every 1.5 m (5 feet) on the outside to identify the manufacturer, manufacturer number (identifies factory location, date of manufacture, shift, and sequence), nominal diameter, pipe stiffness, ASTM D 3262 and designation, and lot number.

**207-20.7 Pipe Acceptance or Rejection.** The pipe shall be free of cracks, holes, delaminations, foreign inclusions, blisters, or other defects that would, due to their nature, degree, or extent, have a deleterious effect on the pipe performance as determined by the Engineer. Prior to installation, damaged pipe shall be either repaired or field cut to remove the damaged portion as approved by the Engineer. For testing purposes, a production lot shall consist of all pipe having the same lot marking number, but shall not exceed a total of 50 pipes. Pipe length, wall thickness, joint dimensions, pipe stiffness, and deflection characteristics shall be verified by inspection and testing in accordance with 4-1.3, 4-1.4, and ASTM D 3262 requirements for each lot. Installation time limit shall conform to 207-15.7.

**207-20.8 Installation and Field Inspection.** Pipe and fittings shall be bedded in accordance with ASTM D 3839, 306-1.2.12, and 306-1.2.13.

#### 207-21 VITRIFIED CLAY MICROTUNNELING PIPE.

**207-21.1 General.** This specification is for vitrified clay microtunneling pipe to be used for sanitary sewers, storm drains, and related structures. Vitrified clay microtunneling pipe shall be manufactured in accordance with 207-8 and ASTM C 1208, except as modified herein.

**207-21.2 Dimensions and Tolerances.** For typical tolerances, see Table 207-21.2 (A). Since the physical properties of clay pipe vary at different manufacturing locations, the minimum wall thickness of the pipe shall be included with the submittals.

(a) **Length.** Typical lengths shall be 1.5, 2, or 2.5 m (4, 6, or 8 feet.).

(b) **Straightness.** Pipe shall not deviate from straight by more than 4 mm per linear meter (0.05 inch per linear foot) when the maximum offset is measured from the concave side of the pipe. Measurements shall be taken by placing a straightedge along the concave side of the full length of the pipe barrel, excluding the joint, and measuring the maximum distance between the straightedge and concave side of the pipe.

(c) **Roundness.** The diameter shall not vary from a true circle by more than 2% of the nominal diameter. The out-of-round dimension is the difference between the maximum and minimum diameters measured at any one location along the barrel.

(d) **End Squareness.** The ends of the pipe shall be perpendicular to the theoretical longitudinal axis within 4 mm per meter (0.004 inch per inch) of outside diameter.

**TABLE 207-21.2 (A)**  
**DIMENSIONS AND TOLERANCES**

Nominal Diameter mm (in) <sup>1</sup>	Maximum Out-of-Round mm (in)	Maximum Out-of-Square mm (in) <sup>2</sup>	Minus Tolerance from Lying Length, mm per linear m (in/feet)	Minimum Allowable Diameter mm (in) <sup>3</sup>
200 (8)	4 (0.16)	1.2 (0.04)	21 (0.25)	192 (7.6)
250 (10)	5 (0.20)	1.4 (0.06)	21 (0.25)	240 (9.5)
300 (12)	6 (0.24)	1.6 (0.06)	21 (0.25)	289 (11.4)
400 (16)	8 (0.30)	2.2 (0.09)	21 (0.25)	385 (15.2)
450 (18)	9 (0.36)	2.3 (0.09)	21 (0.25)	437 (17.2)
500 (20)	10 (0.38)	2.5 (0.10)	21 (0.25)	480 (18.9)
525 (21)	11 (0.42)	2.7 (0.10)	21 (0.25)	509 (20.0)
600 (24)	12 (0.43)	3.0 (0.12)	32 (0.38)	586 (23.1)
675 (27)	14 (0.54)	3.4 (0.13)	32 (0.38)	658 (25.9)
750 (30)	15 (0.60)	3.6 (0.14)	32 (0.38)	730 (28.7)
825 (33)	16 (0.70)	4.2 (0.16)	32 (0.38)	801 (31.5)
900 (36)	18 (0.72)	4.5 (0.18)	32 (0.38)	878 (34.6)
975 (39)	20 (0.80)	4.9 (0.19)	32 (0.38)	953 (37.5)
1050 (42)	21 (0.84)	5.2 (0.21)	32 (0.38)	1028 (40.5)

1. The outside diameter of the delivered pipe shall not vary by more than 2-1/2% for outside diameters up to and including 600 mm (23.6 in.), and 2.0% for outside diameters greater than 600 mm (23.6 in.).
2. These are based on the outside diameter and are approximate. Consult with the pipe manufacturer for the specific dimensions.
3. No fixed "+" tolerance limit.

### 207-21.3 Imperfections.

(a) **Fractures or Cracks.** There shall be no fractures or cracks passing through the barrel which are visible to the unaided eye.

(b) **Chips, Fractures, or Blisters.** Chips, fractures, or blisters on the pipe shall not exceed 50 mm (2 inches) laterally in any surface dimension and shall not exceed a depth of 1/8 the minimum thickness of the barrel.

**207-21.4 Repair Methods and Materials.** Repairs, if any, shall be made in accordance with 207-8.6.

**207-21.5 Fittings and Stoppers.** 207-8.3 is not applicable to microtunnel-installed vitrified clay pipe.

**207-21.6 Joints.** Joints for vitrified clay pipe shall consist of a seat, an elastomeric sealing element, a sleeve, and a compression disc.

(a) **Seat.** The seat is either formed or recess-ground on the pipe ends.

(b) **Elastomeric Sealing Element(s).** The elastomeric sealing element is an elastomeric gasket configuration and location may vary by pipe manufacturer. The sealing element(s) shall conform to 208-2.

(c) **Sleeve.** The sleeve is an element which bridges between the pipe sections and shall be made of non-corrosive materials which, in conjunction with the sealing element(s), forms a joint which meets the test requirements of 207-21.7. Stainless steel sleeves shall be AISI Type 316.

(d) **Compression Disc.** The compression disc is a flat disk that forms a continuous ring of contact with the ends of the pipe and which functions to distribute the jacking forces which develop during pipeline installation. The width of the compression disc shall not exceed the maximum wall thickness of the pipe, not extend into the flow, nor inhibit the installation of the sleeve onto the joint of the pipe.

**207-21.7 Testing Requirements.**

**207-21.7.1 General.** Testing shall be in accordance with 207-8.5 and ASTM C 1208.

**207-21.7.2 Joint Test.** Testing shall be in accordance with ASTM C 1208.

**207-21.7.3 Hydrostatic Pressure Test.** Testing shall be in accordance with ASTM C 1208.

**207-21.7.4 Bearing Strength Test.** Testing shall be in accordance with ASTM C 1208. Pipe shall meet Table 207-8.5.3 (A) for Extra Strength pipe.

**207-21.7.5 Compressive Strength Test.** Testing shall be in accordance with ASTM C 1208. Pipe material shall have a minimum compressive strength of 48 MPa (7,000 psi).

**207-21.7.6 Acid Resistance Test.** Testing shall be in accordance with ASTM C 301.

**207-21.7.7 Acceptance.** Pipe acceptance shall be in accordance with 207-8.5.4.

**207-21.8 Inspection.** Pipe shall be inspected in accordance with 4-1.3 and ASTM C 1208.

**207-21.9 Installation and Field Acceptance Testing.** The installation of pipe shall be in accordance with ASTM C 1208. Exercise care to maintain proper alignment during installation.

**207-22 CENTRIFUGALLY CAST FIBERGLASS REINFORCED PLASTIC MORTAR (CCFRPM) MICROTUNNELING PIPE.**

**207-22.1 General.** This specification applies to CCFRPM microtunneling pipe to be used for sanitary sewers, storm drains, and related structures. Such pipe shall conform to 207-20 except as modified herein. The minimum pipe stiffness shall be 830 kPa (120 psi) when tested in accordance with ASTM D 2412.

**207-22.2 Materials.** Materials shall conform to 207-20.2, except that the minimum pipe stiffness shall be 830 kPa (120 psi). Pipe material shall have a minimum compressive strength of 69 MPa (10,000 psi).

**207-22.3 Dimensions.** Dimensions and sizes of pipe shall conform to the requirements of Table 207-22.3.

**207-22.3.1 Length.** The nominal length shall be 2, 3, or 6 m (6, 10, or 20 feet.) At least 90 percent of the total footage of each size and class of pipe, excluding special order lengths and pipes sampled for quality control testing, shall be furnished in nominal length sections.

**207-22.3.2 Minimum Wall Thickness.** The outside diameter and minimum wall thickness are shown in Table 207-22.3. The allowable jacking load for microtunnel pipe shall be determined from the pipe wall thickness where the cross-section is reduced (the bottom of the spigot gasket groove).

TABLE 207-22.3

Nominal Diameter mm (in)	Outside Diameter mm (in) <sup>1</sup>	Nominal Inside mm (in) <sup>2</sup>	Minimum Pipe Wall mm (in) <sup>2</sup>
450 (18)	495 (19.5)	432 (17.0)	28.4 (1.12)
500 (20)	549 (21.6)	483 (19.0)	29.2 (1.15)
600 (24)	655 (25.8)	587 (23.1)	31.0 (1.22)
700 (28)	762 (30.0)	688 (27.1)	33.0 (1.30)
750 (30)	813 (32.0)	729 (28.7)	38.6 (1.52)
825 (33)	864 (34.0)	777 (30.6)	39.1 (1.54)
900 (36)	973 (38.3)	884 (34.8)	40.4 (1.59)
1050 (42)	1130 (44.5)	1036 (40.8)	42.4 (1.67)
1200 (48)	1290 (50.8)	1186 (46.7)	47.8 (1.88)
1275 (51)	1369 (53.9)	1262 (49.7)	49.3 (1.94)
1350 (54)	1450 (57.1)	1341 (52.8)	50.8 (2.00)
1425 (57)	1524 (60.0)	1410 (55.5)	52.3 (2.06)
1500 (60)	1598 (62.9)	1481 (58.3)	53.6 (2.11)
1575 (63)	1676 (66.0)	1557 (61.3)	54.6 (2.15)
1650 (66)	1758 (69.2)	1623 (63.9)	62.0 (2.44)
1725 (69)	1842 (72.5)	1704 (67.1)	63.5 (2.50)
1800 (72)	1915 (75.4)	1775 (69.9)	65.0 (2.56)
1950 (78)	2073 (81.6)	1925 (75.8)	68.8 (2.94)
2050 (82)	2210 (87.0)	2050 (80.7)	74.7 (2.94)
2100 (84)	2253 (88.7)	2090 (82.3)	76.2 (3.00)
2250 (90)	2395 (94.3)	2225 (87.6)	79.5 (3.13)
2400 (96)	2527 (99.5)	2352 (92.6)	82.0 (3.23)
2550 (102)	2743 (108.0)	2558 (100.7)	86.9 (3.42)

1. The outside diameter of the pipe delivered to the job shall not vary by more than  $\pm 0.1\%$  for each pipe size.
2. For standard tonnage ratings.

### 207-22.3.3 Tolerances.

(a) **Length.** Laying length tolerance shall be  $\pm 42$  mm per m ( $\pm 1/2$  inch per foot).

(b) **Straightness.** Pipes shall not deviate from straight by more than 0.5 mm per linear meter (0.006 inch per linear foot.). Measurements shall be taken by measuring gaps between the pipe wall and a straightedge placed along any longitudinal line on the exterior surface of the pipe.

(c) **Roundness.** The diameter shall not vary from a true circle by more than  $\pm 0.5\%$  of its nominal diameter. The out-of-round dimension is the difference between the maximum and minimum diameters measured at any one location along the barrel.

(d) **End Squareness.** All points around each end of the pipe shall fall within 1.5 mm (1/16 inch) to a plane perpendicular to the longitudinal axis of the pipe.

**207-22.4 Joints.** Joints shall conform to 207-20.4, except that bell and spigot joints shall have a flush exterior. Joints at tie-ins, when needed, may utilize fiberglass gasket-sealed closure couplings which have an outside diameter larger than the pipe. The maximum allowable joint angular deflections for curves shown in Table 207-20.4 (A) shall not apply.

**207-22.5 Accelerated Aging and Physical Testing.** Testing shall conform to 207-20.5, and values used shall reflect actual pipe stiffness.

**207-22.6 Marking.** Marking shall conform to 207-20.6. The maximum allowable jacking load shall also be indicated.

**207-22.7 Pipe Acceptance or Rejection.** Pipe shall conform to 207-20.7.

**207-22.8 Field Inspection.** Field Inspection per 306-1.2.12 is required when: 1) pressure grouting is specified or otherwise implemented; or 2) the allowable rate of return is exceeded; 3) a void, loss of

face control, or surface disruption has occurred; or 4) the actual jacking force exceeds the maximum allowable jacking force. The deflection test or equivalent means shall be performed from access shaft for entire length of affected section.

### **207-23 REINFORCED CONCRETE MICROTUNNELING PIPE.**

**207-23.1 General.** This specification applies to reinforced concrete microtunneling pipe manufactured for the construction of storm drains, sewers, water pipelines, and related structures. Such pipe shall comply with 207-2 for reinforced concrete pipe; 207-3 for lined reinforced concrete pipe; or 207-5 for AWWA C300 Reinforced Pressure Pipe, Steel Cylinder Type, or AWWA C302 Reinforced Pressure Pipe, Noncylinder Type, except as modified herein. A minimum concrete compressive strength of 34.5 MPa (5,000 psi) is required.

**207-23.2 Materials.** All materials used shall conform to the requirements of 201 and 207-2.2, except that the Contractor shall submit written certification from the pipe manufacturer that no calcium chloride has been used in the manufacturer of the pipe.

### **207-23.3 Dimensions and Tolerances.**

(a) **Length.** Pipe shall have a nominal laying length of 2.4 to 7.3 m (8 to 24 feet) unless otherwise specified. Local manufacturers in a project area should be consulted for specific information on lengths available in that area. Variations in laying lengths of two opposite sides of pipe shall not be more than 5 mm per m (1/16 inch per foot) with a maximum of 10 mm (3/8 inch) in any length of pipe for diameters up to and including 1800 mm (72 inch), or 13 mm (1/2 inch) for larger diameters. The underrun in length of a section of pipe shall not be more than 10 mm per m (1/8 inch per foot.) with a maximum of 13 mm (1/2 inch) in any length of pipe.

(b) **Wall Thickness.** The minimum wall thickness for all pipe sizes shall be as specified in ASTM C 76, Wall B.

(c) **Inside Diameter.** The inside diameter of 300 to 600 mm (12 to 24 inches) pipe shall not vary more than 6 mm (1/4 inch). The internal diameter of 675 mm (27 inch) and larger pipe shall not vary more than 1% or 16 mm (5/8 inch), whichever is less.

(d) **Outside Diameter.** The outside diameter of 300 to 600 mm (12 to 24 inches) pipe shall not vary more than 6 mm (1/4 inch). The outside diameter of 675 mm (27 inch) and larger pipe shall not vary more than 1% or 16 mm (5/8 inch), whichever is less.

(e) **Straightness.** Pipes shall not deviate from straight by more than 5 mm per linear meter (1/16 inch per linear foot). Measurements shall be taken by measuring gaps between the pipe wall ends and a straightedge placed along any longitudinal line on the exterior surface of the pipe.

(f) **Roundness.** The outside diameter of the pipe shall not vary from a true circle by more than 1%.

(g) **End Squareness.** The ends of the pipe in contact with the jacking pads shall be perpendicular to the longitudinal axis of the pipe with a maximum of 13 mm (1/2 inch), measured with a square and a straight edge across the end of the pipe. The bearing surfaces shall be smooth and free of projections.

**207-23.4 Reinforcement.** Pipe shall have concentric circular cage reinforcement conforming to the requirements of 207-2.4 for reinforced concrete pipe or 207-5 for reinforced concrete pressure pipe. The total area of reinforcement provided shall be at least 265 mm<sup>2</sup> per m (1/8 in<sup>2</sup> per ft) in each direction. When two reinforcement cages are used, the longitudinal reinforcement shall be divided approximately equal between the two cages, and only the longitudinal reinforcement on the outer cage need extend into

the bell. Supports between the reinforcement and the forms that are to be exposed in the finished pipe shall be made of stainless steel, plastic or plastic coated steel.

**207-23.5 Joints.** Pipe shall have rubber-gasket type, concrete or steel joints. Tongue and groove joints are not acceptable. Joint details shall be submitted to the Engineer for approval before commencing pipe manufacturing. For flush bell and spigot joints, the slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed 2 degrees. The ends of the pipe shall be so formed that, when the pipes are joined, they shall make a continuous and uniform line of pipe with a smooth and regular surface. The rubber gasket shall conform to the requirements of 208-3 and 306-1.2.4 (d).

**207-23.6 Repair.** Unsound or imperfect concrete shall be repaired per the applicable sections of 207-2, 207-3, 207-4 or other methods approved by the Engineer.

**207-23.7 Pipe Acceptance or Rejection.** Pipe shall conform to 207-2.9 and 207-3.2.

#### **207-24 STEEL MICROTUNNELING PIPE.**

**207-24.1 General.** This specification applies to steel microtunneling pipe manufactured for the construction of storm drains, sewers, water pipelines, and related structures. Such pipe shall comply with Section 207-10 except as modified herein.

**207-24.2 Materials.** All materials used shall conform to the requirements of 207-10.2.

#### **207-24.3 Dimension and Tolerances.**

(a) **Length.** The nominal length shall conform to the requirements of 207-10.2.4. Pipe shall have a nominal laying length of 2.4 to 12 m (8 to 40 feet) unless otherwise specified. Local manufacturers in a project area should be consulted for specific information on lengths available in that area. Variations in laying lengths of two opposite sides of pipe shall not be more than 5 mm per m (1/16 inch per foot) with a maximum of 10 mm (3/8 inch) in any length of pipe for diameters up to and including 1800 mm (72 inches), or 13 mm (1/2 inch) for larger diameters. The underrun in length of a section of pipe shall not be more than 10 mm per m (3/8 inch per foot) with a maximum of 13 mm (1/2 inch) in any length of pipe.

(b) **Wall thickness.** Plate and sheet thickness shall conform to 306-2.3. For plate, the maximum allowable thickness variation shall be 0.254 mm (0.010 inch) under the ordered thickness. For sheet, the maximum allowable thickness variation shall be as tabulated in ASTM A568, ASTM A635, or 0.254 mm (0.010 inch) under the ordered thickness, whichever is less.

(c) **Diameter.** Internal diameter shall conform to 207-10.2.3. The outside circumference of the pipe shall not vary by more than 1% but not to exceed 19 mm (3/4 inch) from the nominal outside circumference. The circumference of the pipe ends shall not vary by more than 5 mm (0.196 inch) under, or 10 mm (0.393 inch) over the required outside circumference.

(d) **Straightness.** Finished cylinder shall not deviate by more than 3 mm (1/8 inch) from a 3 m (10 foot) long straight edge held against the cylinder.

(e) **Roundness.** The outside diameter of the pipe shall not vary from a true circle by more than 1%. The out-of-round of the pipe ends shall be determined by measuring the ring diameter at a minimum three locations equally spaced on the contact surface. The out-of-round shall be the difference between the high and low readings. The maximum out-of-round shall not exceed 0.5 percent of the average of the low and high readings or 6 mm (1/4 inch), whichever is less.

(f) **End Squareness.** For pipe that is to be butt welded in the field, the end of the pipe shall be perpendicular to the longitudinal axis of the pipe with a maximum deviation of no more than 3 mm (1/8 inch) measured with a square and a straight edge across the end of the pipe.

**207-24.4 Joints.** Joints shall conform to the requirements of 306-2.3. Connecting adjacent pieces of steel pipe shall be achieved by field butt welding. For casing application, integral press fit connectors may be used as approved by the Engineer.

**207-24.5 Protective Lining and Coating.** Exterior coatings, if required, shall be the type that minimize skin friction between the exterior of the pipe and the soil. Such an exterior coating shall be epoxy-based polymer concrete, fusion-bond epoxy, or other product that provides a hard, smooth surface. Strict adherence to the coating manufacturer's recommendations for surface preparation and application procedure shall be required with holiday detection and repair. If the steel pipe is field welded, the contractor shall submit a procedure for approval to the Engineer to field repair the coating which maintains the coating integrity and minimizes the repair and curing time. Refer to AWWA specifications C210 and C213.

Exterior coating of steel pipe, used as encasement, is not required if a wall thickness increase of at least 1.5 mm (0.063 in.) is specified.

Interior lining of steel pipe should be shop-applied coating such as liquid epoxy, polyurethane, cement mortar, or appropriate material for the desired service. Consideration should also be given to line-in-place procedures. Refer to 207-10.4.2 and AWWA C210.

**207-24.6 Inspection and Acceptance.** Pipe shall be inspected and accepted in accordance with AWWA C 200.

## SECTION 208 - PIPE JOINT TYPES AND MATERIALS

### 208-1 GENERAL.

**208-1.1 Material Designation.** The type of pipe joint shall be designated on the Plans. The Agency may require testing of the joint materials for compliance with these requirements prior to delivery to the jobsite.

**208-1.2 Installation Time Limit.** The Contractor shall retest within 60 days prior to installation any pipe gasket that is more than 180 days old from the date of manufacture to ensure compliance with the requirements of the Specifications. The Contractor shall not install any pipe gasket that is more than 2 years old from the date of manufacture.

### 208-2 JOINTS FOR CLAY PIPE.

**208-2.1 General.** Joints other than those specified below, made of approved materials and meeting the chemical and bacteriological resistance requirements contained herein, may be submitted to the Engineer for approval. The installation of joint material shall conform to 208-1.2.

**208-2.2 Type "D" Joints (Synthetic Rubber Coupling with Corrosion-Resistant Shear Ring for Plain-End Clay Pipe, 300 mm (12 inch) Maximum).** The joint shall consist of three parts: a circular synthetic rubber sleeve of two stainless steel compression bands with stainless steel nut and bolt type tightening devices and an injection molded Acrylonitrile-Butadiene-Styrene (ABS), Polyethylene (PE), or Polyvinylchloride (PVC) shear ring.

**208-2.2.1 Sealing Components.** The compression bands shall be fabricated from AISI Type 316 stainless steel with stainless steel nut and bolt (any AISI series 300) type tightening devices and meeting

the requirements of ASTM 240. The sleeve shall be fabricated in a configuration approved by the Engineer. It shall be made of a synthetic rubber molded to form a smooth surface, free of pits, cracks, air marks, porosity, and air pockets and it shall comply with these specifications.

**208-2.2.2 Testing of the Synthetic Rubber Sealing Component.** Test specimens that are exposed to various chemical and bacteriological environments shall be conditioned in the same manner, both before and after exposure, prior to testing.

(a) **Initial Physical Requirements.** The initial physical requirements shall conform to Table 208-2.2.2(A):

**TABLE 208-2.2.2 (A)**

Property	Value	ASTM Test Method No.
Tensile strength, at 23° ± 2°C (73.4° ± 3.6°F), kPa (psi), min.	6900 (1000)	D 412 (Die C)
Elongation at break, 23° ± 2°C (73.4° ± 3.6°F), %, min.	200	D 412 (Die C)
Shore Durometer, Type A (1 sec. reading, min.)	60	D 2240
Compression set (after exposure to 70° ± 2°C [158° ± 3.6°F], for 22 hours), % max.	20	D 395 (Method B)
Water absorption (after immersion at 23° ± 1°C [73.4° ± 1.8°F] for 28 days), %, max.	4	D 570

(b) **Physical Requirements after Accelerated Aging.** The physical requirements after accelerated aging shall conform to Table 208-2.2.2 (B).

**TABLE 208-2.2.2 (B)**

Property	Value	ASTM Test Method No.
Tensile strength (after exposure to 2100 kPa (300 psi) oxygen at 70° ± 1°C [158° ± 1.8°F] for 96 hours), % of initial, min.	70	D 572
Elongation at break (after exposure to 2100 kPa (300 psi) oxygen at 70° ± 1°C [158° ± 1.8°F] for 96 hours), % of initial, min.	70	D 572
Ozone resistance (after exposure to 100 ppm ozone for 50 hours at 40° ± 1°C [104° ± 2°F])	No cracks or crazing	D 518 (Procedure C) and D 1149

(c) **Chemical Resistance and Physical Testing.** After exposure to the chemical solutions specified in Table 211-2(A), test specimens shall be tested in accordance with 211-2 and meet the physical requirements specified in Table 208-2.2.2 (C).

**TABLE 208-2.2.2 (C)**

Property	Value	ASTM Test Method No.
Tensile strength at 23° ± 2°C (73.4° ± 3.6°F), kPa (psi), min.	5500 (800)	D 412 (Die C)
Elongation at break at 23° ± 2°C (73.4° ± 3.6°F), % min.	150	
Shore Durometer, Type A at 23° ± 2°C (75° ± 5°F) (1 second reading) point change, max.	15	D 2240
Compression set (after exposure to 70° ± 1°C [158° ± 1.8°F] for 22 hours), % max.		D 395 (Method B)
a. Chemical exposures	25	
b. Bacteriological exposure (unconditioned surface dry)	30	
Weight change, % max. (approx. specimen size 25 mm x 75 mm x 2.5 mm) (1.0 inch x 3.0 inch x 0.1 inch)	- 1.0 + 5.0	

**208-2.2.3 Circular Plastic Shear Ring Component and Testing Requirements.** The plastic shear ring shall be injection molded from an ABS, PE, or PVC resin meeting the requirements specified below. The ABS shear ring material shall conform to 207-15.2. The PE shear ring shall conform to 207-19.2 except that the hydrostatic design and color requirements need not be satisfied and crack resistance failure maximum percentage be zero.

The PVC shear ring shall conform to 207-17.2.2 and 207-17.4.1.

The shear rings shall be homogeneous throughout, uniform in color and free of cracks, holes, foreign materials, blisters, or deleterious faults.

Markings on all shear rings shall indicate the name of the manufacturer and Type "D" joint.

**208-2.2.4 Laboratory Test of Joint.** An assembled joint shall provide sufficient resistance to shear loading to allow a load of 26.3 N per mm (150 lbf per in) of nominal diameter to be uniformly applied over an arc of not less than 120 degrees and a longitudinal distance of 305 mm (12 inches) immediately adjacent to one edge of the sleeve coupling. The assembled pipe shall rest on three supports. A support shall be located at each extreme end of the assembly. The third support shall be placed immediately adjacent to the coupling. The shear load shall be placed on the unsupported end of the pipe, immediately adjacent to the coupling. There shall be no visible leakage when tested with an internal hydrostatic pressure of 70 kPa (10 psi) for 10 minutes. The joint including the plastic shear ring for the 150 mm to 300 mm (6-to-12 inch) diameter pipe, inclusive, shall exhibit sufficient flexibility when joined to allow a maximum deflection of 3 degrees in any direction. The deflected joint shall show no visible leakage when subjected to the same shear load as indicated in the previous paragraph and when tested under an internal hydrostatic pressure of 70 kPa (10 psi) for 10 minutes.

During these tests, the ends of the tested pipe shall be restrained only in the amount necessary to prevent longitudinal movement. Upon completion of the above tests, the joint shall be disassembled and if any component has failed, that joint will be rejected. Failures shall include, but not be limited to the following: breaks, flange cracks, gouges, tears, and deformation beyond reuse.

**208-2.2.5 Joint Acceptance.** When all components of this joint meet the requirements as set forth in these specifications and when one percent of the joints are successfully laboratory tested, then the joints will be accepted.

### **208-2.3 Type "G" Joints (Polyurethane).**

**208-2.3.1 General.** The Type "G" joint shall consist of polyurethane elastomer sealing components, one bonded to the outside of the spigot and the other bonded to the inside of the socket. The sealing components shall be shaped, sized, bonded, and cured to uniform hardness to form a tight seal of the joint when it is assembled. The sealing components shall resist attack by bacteria and chemicals or combinations of chemicals normally present in domestic or industrial waste sewage.

**208-2.3.2 Polyurethane Sealing Components.** The polyurethane sealing component material shall be tested in accordance with 211-2 and comply with the requirements specified in this subsection. The number of samples to be tested shall be designated in the Special Provisions.

TABLE 208-2.3.2 (A)

Property	Values <sup>1</sup>		Tested Method and Conditions
Tensile strength kPa (psi) min.	4125 (600)	2425 (350)	ASTM D 412 (Die C) 23° ± 2°C (73.4 ± 3.6°F)
Elongation, % min.	70	70	ASTM D 412 (Die C) 23° ± 2°C (73.4° ± 3.6°F)
Compression set, % max.	3	3	ASTM D 395, Method B, 24 hours 23° ± 2°C (73.4° ± 3.6°F)
Shore durometer	Not less than value designated for the joint design by the manufacturer		ASTM D 2240; Type A, 5-second reading, 0° to 27°C (32° to 80°F)
Water absorption, % max. (Weight gain)	3.5	3.5	ASTM D 570, after immersion for 28 days at 23° ± 1°C (73.4° ± 1.8°F)
Volatile loss, % max. (Weight loss)	1	1	After 28 days in mechanical convection oven at 66° ± 2°C (150° ± 3°F)
Adhesive strength, kPa (psi) min.			Before immersion in accordance with Note 2. After immersion in water at 23° ± 2°C (73.4° ± 3.6°F) in accordance with Note 2
Original	2425 (350)	2425 (350)	
Final	1725 (250)	1725 (250)	
Chemical resistance (See Note 3)			After exposure to each of the chemical environments for 112 days as described in Note 3
Weight change, % max.	1.5	1.5	
Tensile strength, kPa (psi)	2975 (430)	1800 (260)	
Shore durometer, change max.	± 15	± 15	
Compression set, % max.	5	5	
Bacteriological resistance (See Note 3)			After exposure to bacteriological environment for 112 days as described in Note 3.
Weight change, % max.	2	2	
Tensile strength, kPa (psi) min.	3450 (500)	2000 (290)	
Shore Durometer			
Before reconditioning, loss max.	15	15	
After reconditioning, change max.	5	5	
Compression set			
Before reconditioning, % max.	3	3	
After reconditioning, % max.	3	3	

1. The configuration of the jointing system determines the necessary physical properties of the polyurethane joint material. The columns of values in this table represent properties of polyurethane that, in conjunction with specific joint configurations, will provide functionally equal acceptable jointing systems. The values for a single product shall be all from one of the columns.

2. Adhesion test specimens shall be clay blocks 13 mm (1/2 inch) thick and 25 mm x 25 mm (1 inch square), of the same composition of materials and fired at the same vitrifying temperatures as sewer pipe.

The clay block shall be placed flat in the center of a mold 175 mm (7 inches) long, 25 mm (1 inch) wide, and 13 mm (1/2 inch) deep. The edges of the clay block at right angles to the longitudinal axis of the form shall be coated with the adhesive and the form on each side of the block shall be filled to a depth of approximately 6 mm (1/4 inch) with the sealing component compound. Curing of this last specimen shall simulate the curing process at the pipe manufacturing plant.

At the end of the immersion period, samples shall be removed, surface dried, and immediately pulled in tension at the rate of 500 mm (20 inches) per minute to determine the final tensile strength of the bonded interfaces. The specimens retained for controls shall be pulled at the same time to determine the original strength of the bonded interfaces.

3. Exposure environments for bacteriological and chemical resistance tests per Table 211-2(A). At the end of the exposure period, specimens shall be washed and reconditioned before testing.

**208-2.3.3 Type "G" Joint Acceptance Tests.** Joint tests shall be performed in accordance with ASTM C 425. The Engineer may perform additional acceptance tests on one joint for each 100 pipes in a lot (or fraction of a lot) for each size. For this additional testing the pipe joints shall not leak when subjected to the shear load test described in ASTM C 425, except that the internal hydrostatic pressure shall be 70 kPa (10 psi) for pipe sizes up to 450 mm (18 inches) and 35 kPa (5 psi) for pipe sizes 525

mm (21 inches) and larger before and after being deflected the following distances at the sealing components of the joint for a period of 10 minutes.

TABLE 208-2.3.3 (A)

Nominal Pipe Size		Deflection	
mm	(Inches)	mm	(Inches)
100 - 250	(4 - 10)	16	(5/8)
300 - 525	(12 - 21)	19	(3/4)
600 - 750	(24 - 30)	22	(7/8)
825 - 1050	(33 - 42)	25	(1)

If one of the selected joints fails the test, the lot shall be rejected unless two additional joints selected from the lot pass the test.

**208-3 GASKETS FOR CONCRETE PIPE.** Unless otherwise specified, gaskets shall be manufactured from a synthetic elastomer. The compound shall contain not less than 50 percent by volume of first-grade synthetic rubber. The remainder of the compound shall consist of pulverized fillers free of rubber substitutes, reclaimed rubber, and deleterious substances. The installation of gaskets shall conform to 208-1.2.

Gaskets shall be extruded or molded and cured in such a manner as to be dense, homogeneous and of smooth surface, free of pitting, blisters, porosity and other imperfections. The tolerance for any diameter or profile dimension measured at any cross section shall be  $\pm 0.8$  mm (1/32 inch).

When required by the Engineer, the Contractor shall furnish test samples of gaskets from each batch used in the work. Gasket material shall meet the following:

TABLE 208-3 (A)

Property	Value	ASTM Test Method
Tensile strength, MPa (psi) min.	10.3 (1500)	D 412
Elongation at break (% min.)	350	D 412
Shore durometer, Type A (Pipe manufacturer shall select value suitable for type of joint).	40 to 65 <sup>1</sup>	D 2240
Compression set (constant deflection) max. % of original deflection.	16	D 395 Method B
Tensile strength after oven aging (96 hours, 70°C [158°F]) % of tensile strength before aging.	80	D 573
Increase in Shore durometer hardness after oven aging. Maximum increase over original Shore durometer.	10	D 2240
Physical Requirements after exposure to ozone concentration (150 pphm. 70 hours, 40°C [104°F], 20% strain).	No Cracks	D 1149

1. This applies only to the sealing component of the gasket.

No more than one splice will be permitted in a gasket. A splice shall be made by applying a suitable cement to the ends and vulcanizing the splice in a full mold. The splice shall show no separation when subjected to the following tests:

- 1) Elongation Test. The part of the gasket which includes the splice shall withstand 100 percent elongation with no visible separation of the splice. While in the stretched position, the gasket shall be rotated in the spliced area a minimum of 180 degrees in each direction in order to inspect for separation.

- 2) Bend Test. The portion of the unstretched gasket containing the splice shall be wrapped a minimum of 180 degrees and a maximum of 270 degrees around a rod of a diameter equal to the cross section diameter of the gasket.

**208-4 GASKETS FOR THERMOPLASTIC PIPE.** Gaskets shall be manufactured from a synthetic elastomer conforming to the requirements of 208-3. The installation of gaskets shall conform to 208-1.2.

#### **208-5 TYPE "Z" JOINT.**

**208-5.1 General.** Except as modified herein, Type "Z" Joints shall conform to Type "D" Joints per 208-2.2. This joint shall be used as a field closure coupling, repair coupling, or OD transition coupling for identical or dissimilar pipe materials for gravity sewers and drains. The joint shall be applied to 100 through 300 mm (4- through 12 inch) diameter pipe sizes only.

**208-5.2 Components.** The joint shall consist of three components as follows:

- 1) A circular synthetic rubber sleeve meeting the physical, chemical and bacteriological requirements of the Type "D" Joint per 208-2.2.2. The sleeve shall conform to 208-1.2.
- 2) Two stainless steel compression bands (AISI 316) with stainless steel nut and bolt (any AISI Series 300) type tightening devices and meeting the requirements of ASTM A 240.
- 3) A stainless steel shear band shall wrap around the joint a minimum of 380 degrees. Welded to the shear band shall be two stainless steel nut and bolt tightening devices or worm drive tightening devices fabricated from any 300 Series stainless steel and meeting the requirements of the compression bands above. The minimum shear band thickness shall be 0.30 mm (0.012 inches). Minimum shear band width shall be 54.0 mm (2.120 inches) for 100 and 150 mm (4 and 6 inch) diameter pipe sizes and 62.0 mm (2.437 inches) for 200 through 300 mm (8 through 12 inch) diameter pipe sizes.

**208-5.3 OD Transitions.** Pipe joints where the pipe OD's have a differential of 9 mm (3/8 inch) or greater shall require an OD transition coupling. OD transition coupling shall be comprised of the components per 208-5.2 plus a synthetic rubber bushing meeting the requirements of 208-2.2.2. The bushing shall compensate for the differential in pipe OD's.

**208-5.4 Testing Requirements.** The Type "Z" Joint, with or without bushing, shall meet the test requirements for Type "D" Joints per 208-2.2.4.

#### **208-6 PIPE TO MANHOLE FLEXIBLE COUPLINGS.**

**208-6.1 General.** The joint shall consist of a flexible connector designed to produce a positive watertight connection for pipes entering precast manholes and other concrete structures.

**208-6.1.1 Seal.** The connector shall be in accordance with ASTM C 923M (ASTM C 923) so that a positive seal is made between the connector and the manhole wall and between the connector and the pipe. The seal between the connector and the manhole wall may be made by either mechanical means or by casting the connector integrally with the manhole wall. The seal between the connector and the pipe may be made by mechanical means or by compression of the resilient material against the outside of the pipe.

**208-6.1.2 Parameters.** The connector shall withstand 70 kPa (7.1 m) (10 psi (23 feet)) of hydrostatic pressure and be capable of sustaining an axial deflection of at least 7 degrees in any direction. The test methods and requirements shall be in accordance with ASTM C 923M (ASTM C 923), Section 7.

**208-6.2 Materials.** The gaskets shall be manufactured from a synthetic elastomer and shall contain not less than 50 percent by volume of first-grade synthetic rubber. All rubber gaskets shall be either molded or extruded and cured in such a manner that any cross-section shall be dense, homogeneous, and free of porosity blisters, pitting, and other imperfections. The gaskets shall comply with the physical

requirements prescribed by ASTM C 923M (ASTM C 923) (Table 1) when tested in accordance with the referenced ASTM. However, the chemical resistance shall be tested in accordance with 211-2 and meet the weight change per Table 210-2.4.1 (A) of these specifications. Metal components shall be fabricated from AISI Type 316 stainless steel for all bands, and the nut and bolt shall be AISI Type 305 stainless steel. Gaskets shall conform with the installation time requirements in 208-1.2.

**208-6.3 Performance Test Requirements.** A performance test of the connector to be used shall be made at least once when the manhole producer begins using a pipe to manhole connector system. The test methods and requirements shall be made in accordance with ASTM C 923M (ASTM C 923), Section 7. The connector shall be marked clearly by the manufacturer with his trade name and size designation or part number. This shall be visible on the gasket when installed in the manhole.

**208-6.4 Plant Fabrication Method.** The flexible connector shall be installed in accordance with the specific instructions of the manufacturer.

**208-6.5 Installation Instructions.** The manhole manufacturer shall provide installation instructions to the Contractor. The connector shall have all foreign matter removed and shall be inspected to ensure that there are no defects in the rubber or splice.

## SECTION 209 - ELECTRICAL COMPONENTS

**209-1 REGULATIONS AND CODES.** All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), the Underwriters' Laboratories Inc. (UL), or the Electronic Industries Association (EIA), wherever applicable. In addition to the requirements of the Plans and Specifications, all materials shall conform where applicable to the requirements of the National Electrical Code, hereinafter referred to as the Code; California Administrative Code, Title 8, Subchapter 5, Electrical Safety Orders; Rules for Overhead Electrical Line Construction, General Order No. 95, and Rules For Construction of Underground Electric Supply & Communication Systems, General Order No. 128, of the Public Utilities Commission; Standards of the American Society for Testing and Materials (ASTM); American National Standards Institute (ANSI); Military Specifications (Mil Spec); and any local ordinances which may apply.

### 209-2 MATERIALS.

**209-2.1 Electroliers.** Electroliers shall be as shown on the Plans or in the Specifications.

**209-2.2 Anchor Bolts.** Anchor bolts shall be of the type and size as shown on the Plans. Anchor bolts shall conform to ASTM A 307, and shall be provided with two nuts and two washers each.

Anchor bolts, nuts, and washers shall be galvanized by the hot-dip process conforming to ASTM A 153, or cadmium plated with Type NS coating conforming to ASTM A 165.

All nuts shall be symmetrically formed with the hole centered and at right angles to the face, tapped to fit a corresponding thread so that nut can be run the entire length of the thread by the fingers without undue forcing, and without noticeable play or rocking.

**209-2.3 Conduit.** Conduit and conduit fittings shall be galvanized by the hot-dip, electrodepositing, or metallizing process in accordance with 210-3. Galvanized conduit shall conform to standards for rigid steel conduit as specified by Underwriters' Laboratories, Inc., and shall bear the UL label on each length.

Conduits shall be of the sizes indicated on the Plans. It shall be the option of the Contractor to use larger conduit than that specified, provided that where such substitution is made, it shall be for the entire length of the conduit run. No reducing fittings will be permitted.

The ends of the conduit shall be free of burrs and rough edges.

The maximum bend of a conduit shall be 90 degrees and the minimum radius of a bend shall be not less than six times the inside diameter of the conduit.

All threads shall be treated with approved joint compound before fittings are placed thereon. Where the galvanized coating of conduit or fittings has been injured in handling or installing, such damaged areas shall be thoroughly painted with a rust preventive paint.

Ends of conduit shall be properly coupled. Running threads, threadless conductors or threadless couplings will not be permitted.

**209-2.4 Wire.** Copper wire shall conform to the applicable portions of ASTM B 3 and B 8. Wire sizes shall be based on American Wire Gage (AWG).

Conductors for series street lighting systems shall be No. 8 AWG solid copper wire insulated with 2.80 mm (0.110 inch) thickness polyethylene insulation per Standard S-61-402 of the Insulated Power Cable Engineers Association, and designated for operation at 5,000 volts.

A Certificate of Compliance with these specifications shall be submitted to the Engineer by the manufacturer with all 5,000-volt series lighting conductors.

Where isolating transformers or ballasts are used, the secondary conductors from transformer to luminaire shall be insulated No. 10 AWG solid copper wire. Multiple-circuit conductors shall be of a size indicated on the Plans. Insulation for such conductors shall be rated and UL approved for 600-volt operation, and shall be standard THW or THWN grade polyvinyl chloride, conforming to the applicable provisions of ASTM D 2219 and D 2220.

## SECTION 210 - PAINT AND PROTECTIVE COATINGS

### 210-1 PAINT.

**210-1.1 General Requirements.** Paint shall be homogeneous, free of contaminants, and of a consistency suitable for the use for which it is specified. The pigment shall be finely ground and properly dispersed in the vehicle according to the requirements of the paint; and this dispersion shall be of such nature that the pigment does not settle appreciably, does not cake or thicken in the container, or become granular or curdled. Paint and paint materials shall be delivered to the Work site in new, unopened, airtight containers, appropriately identified with the manufacturer's name, date of manufacture, type of paint or paint material, State Specification number, and lot or batch number.

No paint shall be used until at least 7 days have elapsed from the date of manufacture.

**210-1.2 Testing.** All paint and paint materials shall be sampled and tested prior to use. All tests will be conducted in accordance with the methods specified in ASTM or methods set forth in Federal Standard 141. In the absence of any such methods, other suitable methods may be designed and utilized by the Engineer.

Lots or batches of paint of proprietary brand, which have been previously sampled and tested by the Agency and approved as conforming with these specifications, may be used without further testing, if permitted by the Engineer. For the purpose of these specifications, proprietary brands of paint and paint

materials are construed to mean those conforming to the requirements of these specifications which are produced for distribution through regular wholesale and retail outlets.

**210-1.3 Paint Coats.** Paint coats shall consist of pre-treatment when specified, primer, and finish coats in that order, in accordance with 210-1.5.

**210-1.4 Paint Materials.** Paint materials shall conform in all respects to the requirements of the reference specifications indicated for such material in the table of paint systems shown below.

**210-1.5 Paint Systems.** Unless otherwise specified, the paint systems to be used shall correspond with the following table and the California Department of Transportation specifications:

**TABLE 210-1.5 (A)**

Surface to be Painted	Pre-Treatment/Surface Preparation <sup>1</sup>	Primer <sup>1</sup>	Finish Coats <sup>1</sup>
Galvanized Metal	Vinyl Wash	Zinc Dust – Zinc Oxide Fed. Spec. TT-P- 641 Type II	Aluminum White Enamel White Tint Base <sup>2</sup> Aluminum Green Tan Burnt Sienna
Structural Steel – General Use	Commercial Blast Per SSPWC 310-2.5	Per Manufacturer's Recommendations	
Wood Structures, Wood Primer and Surfaces		Wood Primer	Exterior White <sup>2</sup>
Signal Standards	Vinyl Wash	Yellow	Yellow
Signal Heads and Mounting	Vinyl Wash		Olive Green <sup>2</sup>
Backplates, Visors, Louvers	Vinyl Wash		Black <sup>2</sup>

1. Refer to Section 91, State of California Department of Transportation (CalTrans) Standard Specifications unless otherwise specified.
2. Finish color shall be in accordance with Specifications or as determined by the Engineer.

### 210-1.6 Paint for Traffic Striping, Pavement Marking, and Curb Marking.

**210-1.6.1 General.** Paint for traffic striping and marking shall correspond with the requirements shown in the following table:

**TABLE 210-1.6.1 (A)**

Type of Paint	Reflective Material <sup>1</sup>	Pre-Treatment	Finish Coat
Thermoplastic	Added to the paint during manufacture	Concrete pavement, 10% solution buna N rubber in methyl-ethyl-ketone or approved two-component epoxy	State Specifications Yellow-White (Pth-10) <sup>2</sup>
Fast Dry or Rapid Dry	May be added directly to paint during manufacture with Engineer's approval	See 310-5.6.6, Preparation of Existing Surfaces	State Specifications White Yellow Black

1. See 210-1.6.5 and 310-5.6.5.
2. Flame sprayed on clean pavement. Min. ambient road temperature 10°C (50°F) Min. ambient air temperature 16°C (60°F).

**210-1.6.2 Thermoplastic Paint, State Specifications.** Pth-10 Thermoplastic traffic line paint shall be a reflectorized thermoplastic pavement striping material applied to the road surface in a molten state by mechanical means. It shall have surface application of glass beads which, upon cooling to normal pavement temperature, will produce an adherent reflectorized stripe of the specified thickness and width,

and will be resistant to deformation by traffic. The material shall contain at least 20 percent by weight of glass beads in the white and yellow paints and at least 12 percent titanium dioxide in the white paint. The material, when applied at a temperature range of 200°C to 220°C (400°F to 425°F) and a thickness of 3.2 to 4.8 mm (125 to 188 mils), shall set to bear traffic in not more than 2 minutes when the air temperature is 10°C (50°F) and not more than 10 minutes when air temperature is 32°C (90°F).

**210-1.6.3 Rapid Dry White, Yellow, or Black Traffic Line Paint.** Rapid dry white, yellow, or black traffic paint shall dry to a condition so that there will be no traffic pickup in 30 seconds, and which shall be completely dry in not more than 3 minutes when preheated to 43°C to 82°C (110°F to 180°F) in proper equipment before application. The material shall be applied at the film thickness indicated in 310-5.6.5.

The “no traffic pickup” time shall be determined by ASTM D 711.

**210-1.6.4 Ready-Mixed Traffic Stripe Paints.** Where ready-mixed paints are specified, they shall be suitable for use on either asphalt concrete or portland cement concrete.

**210-1.6.5 Reflective Material.** Reflective material shall consist of glass beads added to the surface of the final coat of paint prior to setting, so that the beads will have proper adhesion. Special care shall be taken with rapid dry paint and thermoplastic materials.

Glass beads shall conform to State Specification 8010-71L-22 and shall be mechanically applied at a rate of 0.7 to 1.0 kg of beads per liter (6 to 8 pounds of beads per gallon) of paint. Glass beads shall be applied to pavement markings, curbs, and crosswalks by use of a dispensing device developed for this purpose or other methods approved by the Engineer.

The Engineer may authorize the use of paint containing pre-mixed glass beads. The type, gradation, quantity, and quality of the pre-mixed glass beads shall be approved prior to the manufacture of the paint. In addition to the specified pre-mixed beads, 0.25 to 0.35 kilograms of beads per liter (2 to 3 pounds of beads per gallon) of paint shall be mechanically applied when the paint is applied.

If thermoplastic paint is required, glass beads may be added directly to the combined pigment, filler, and resin in accordance with 210-1.6.1. However, prior to setting, all thermoplastic paint surfaces shall receive an additional application of at least 0.12 kilograms of beads per liter (1 pound of glass beads per gallon) of paint.

**210-1.6.6 Air Pollution.** All paint shall meet the requirements of the appropriate air pollution control district.

**210-1.7 Test Reports and Certification.** At the time of delivery of each shipment of material, the Contractor shall, upon request, deliver to the Engineer certified copies of the manufacturer’s test report. The test report shall indicate the name of the manufacturer, type of material, date of manufacture, quantity, State Specification number, manufacturer’s lot or batch number, and results of the required tests. The test report shall be signed by an authorized representative of the manufacturer. The certified test reports and the testing required in connection therewith shall be at no cost to the Agency.

## **210-2 PLASTIC LINER.**

**210-2.1 General.** Plastic liner sheet, joint, corner, and weld strips shall be manufactured from a polyvinyl chloride compound that meets the properties specified herein and is approved by the Engineer. The material shall be suitable for use as protective liner and joint systems in pipe or other structures. Copolymer resin will not be permitted.

At any time during the manufacture or prior to the final acceptance of the work, utilizing material qualified under 210-2.3, the Engineer may sample specimens taken from any part of the assembled or unassembled product for testing of physical properties per 211-2.

Changes in the compound formulation may be permitted only after 12 months if prior notice is given to the Engineer, and the Contractor proves that the new formulation meets or exceeds all requirements specified herein and is approved by the Engineer. The Engineer shall be notified 7 days prior to any approval testing as to the type of material to be tested.

All plastic liner sheets including locking extensions, joint, corner, connecting, and welding strips shall be free of cracks, cleavages, or other defects adversely affecting the protective characteristics of the material. The Engineer may authorize the repair of such defects by approved methods.

Plastic liner older than 180 days from the date of manufacture shall not be used in lined reinforced concrete pipe as specified in 207-3.

**210-2.1.1 Adhesive Products.** The Engineer shall approve adhesive products and application procedures to be used in the installation of the plastic prior to their use. Adhesive products intended for use inside joined plastic-lined pipe or cast-in-place structures shall be nonflammable.

**210-2.1.2 Cleaners.** The Engineer shall approve cleaners used in the installation of the liner prior to their use. Cleaners shall be nonflammable, shall be water soluble or water dispersible, and shall not be detrimental to the plastic liner.

### 210-2.2 Details and Dimensions.

**210-2.2.1 Approval of Details.** Liner sheet, strip, and other accessory pieces shall conform to the requirements shown on the Plans and specified in the Specifications.

**210-2.2.2 Thickness of Material.** The minimum thickness of sheet and strip shall be as noted in Table 210-2.2.2 (A):

TABLE 210-2.2.2 (A)

Material	Thickness	
	mm	(Inches)
Sheet, integral locking extensions	1.65	(0.065)
Sheet, plain	2.39	(0.094)
Joint strip	1.91	(0.075)
Weld strip	2.39	(0.094)

**210-2.2.3 Material Sizes.** Sheets of liner used for pipe shall be sized to provide the coverage required by the Plans. Joint strips shall be  $100 \pm 6$  mm ( $4 \pm 0.25$  inches) in width and shall have each edge beveled prior to application. Welding strips shall be  $25 \pm 3$  mm ( $1 \pm 0.125$  inch) in width. All welding and outside corner strips shall have edges beveled at time of manufacture.

**210-2.2.4 Locking Extensions.** All liner to be embedded in concrete shall have integral locking extensions.

Locking extensions shall be of the same material as the liner; shall be integrally bonded, molded, or extruded with the sheets; and shall have an approved cross section with a minimum height of 9.5 mm (0.375 inch) and a minimum web thickness of 2.2 mm (0.085 inch). Locking extensions shall be  $65 \pm 6$  mm ( $2\text{-}1/2 \pm 0.250$  inches) apart for pipe and structure applications. The locking extensions shall be such that when they are embedded in concrete, the liner will be held permanently in place and meet the pull-out requirements of 210-2.3.4. There shall be a minimum of one locking extension embedded in each continuous surface, except any continuous surface of 100 mm (4 inches) or more shall have a minimum of two locking extensions, or the material shall be bonded in place. Locking extensions shall be parallel and continuous except where interrupted for joint flaps, weep channels, strap channels, and for other purposes shown on the Plans or where permitted by the Engineer.

A flexible liner sheet edge which will be the lower terminal edge in the structure or pipe shall not extend beyond the base of the final locking extension more than 10 mm (3/8 inch).

Liner shall be bonded to concrete surfaces with an adhesive if shown on the Plans or specified in the Specifications.

**210-2.2.5 Provisions for Strap Channels.** If required, strap channels shall be 25 mm (1 inch) wide maximum and formed by removing the locking extensions so that a maximum of 4.7 mm (3/16 inch) remains.

**210-2.2.6 Flaps.** When transverse flaps are specified or required, they shall be fabricated by removing locking extensions so that a maximum of 0.80 mm (0.032 inch) of the base of the locking extensions remains on the sheet.

### **210-2.3 Tests.**

**210-2.3.1 General.** All liner materials shall be tested for physical and chemical properties prior to approval by the Engineer. Samples taken from sheets, joints, or weld strips of material representative of those to be furnished shall be tested to determine material properties. Determination of physical properties shall be in accordance with the tests specified in 210-2.4. or 210-2.5. All properties required in 210-2.4 and 210-2.5 of the tested materials shall be submitted to the Engineer in accordance with 2-5.3.4.

### **210-2.3.2 (Not Used.)**

**210-2.3.3 Chemical Resistance Test (Pickle Jar Test).** Test specimens shall be tested in accordance with the requirements of 211-2 and conform to 210-2.3.3. Specimens shall only be seal coated on two of their four edges and no coating of the inner or outer surfaces. Seal coating shall not be applied to liner materials. The weight change specimens per ASTM D 543 shall be 25.4 mm x 76.2 mm x 3.175 mm thick (1 in x 3 in x 0.125 in) unless otherwise approved by the Engineer.

**210-2.3.4 Pull Test for Locking Extensions.** Liner locking extensions embedded in concrete shall withstand a test pull of at least 18N per linear mm (100 pound per linear inch), applied perpendicularly to the concrete surface for a period of 1 minute, without rupture of the locking extensions or withdrawal from embedment. This test shall be made at a temperature between 21°C to 27°C (70°F to 80°F) inclusive.

**210-2.3.5 Shop Welded Joints.** Shop-welded joints, used to fuse individual sections of liner together, shall be at least equal to the minimum requirements of the liner for thickness, corrosion resistance, and impermeability. Welds shall show no cracks or separations and shall be tested for tensile strength. Tensile strength measured across the welded joint in accordance with ASTM D 412 using Die B shall be at least 13.8 MPa (2,000 psi). Test temperatures shall be 25°C ± 3°C (77°F ± 5°F) and the measured minimum width and thickness of the reduced section shall be used.

**210-2.3.6 Spark Test.** All liner shall be shop tested for holes with a spark tester set to provide from 15,000 to 20,000 volts. Sheets having holes shall be satisfactorily repaired in the shop prior to shipment from the manufacturer's plant. Welders qualified in accordance with 311-1.2.2 shall make all repairs.

### **210-2.4 Flexible PVC Liner.**

**210-2.4.1 Flexible PVC Liners for Structures, Manholes, and Pipes.** Flexible PVC plastic liner sheets, joint assembly components, corner and weld strips shall be tested in accordance with 211-2 and shall conform to the requirements in Table 210-2.4.1(A).

TABLE 210-2.4.1 (A)

Property	Initial <sup>1</sup>	Exposure <sup>1</sup>
Tensile Strength ASTM D 412	15 MPa (2,200 psi)	14.4 MPa (2,100 psi)
Elongation at break ASTM D 412	200%	200%
Hardness, Shore durometer, Type D ASTM D 2240 <sup>2</sup>	Within 1 sec. 50-60 Within 10 sec. 35-50	± 5 <sup>3</sup> ± 5 <sup>3</sup>
Weight change	—	± 1.5% <sup>3</sup>

1. For 112 days in chemical solutions listed in 211-2. All above values are minimum required except for hardness and weight, which is the maximum permissible gain or loss in weight.
2. Except that a single thickness of material shall be used.
3. With respect to initial test result.

**210-2.4.2 Shop-Welded Joints.** Tensile strength measured across the welded joint in accordance with ASTM D 412 using Die B shall be at least 15 MPa (2,200 psi) minimum.

### 210-2.5 Rigid PVC Liners.

**210-2.5.1 Rigid PVC Liners for Structures, Manholes, and Pipes.** Rigid PVC plastic liner sheets, joint assembly components corner and connecting strips for pipe, manhole, and linings for structures shall be tested in accordance with 211-2 and shall conform to the requirements in Table 210-2.5.1 (A).

TABLE 210-2.5.1 (A)

Property	Initial <sup>1</sup>	After Exposure <sup>4</sup>
Tensile Strength ASTM D 638	44 MPa (6,500 psi)	80% of initial
Tensile Modulus ASTM D 638	2813.1 MPa (408,000 psi)	N.A.
Elongation at break ASTM D 638	25%	N.A.
Hardness, Shore Durometer, Type D ASTM D 2240 <sup>2</sup>	Instantaneous 70	N.A.
Flexural Strength ASTM D 790	89.6 MPa (13,000 psi)	N.A.
Flexural Modulus ASTM D 790	3137.1 MPa (455,000 psi)	N.A.
Heat Deflection ASTM D 648	71°C at 1.8 MPa (160°F at 264 psi)	N.A.
Izod Impact ASTM D 256	1.63 Joules/25 mm (1.2 feet-lbs/inch) of notch	N.A.
Variable Height Impact Test ASTM D 4226 W/.25 Hemispherical Dart Procedure A <sup>2</sup> Procedure B <sup>3</sup> W/.125	7.2 Joules/mm (1.6 in-lbs/mil) thickness 12.8 Joules/mm (2.8 in-lbs/mil) thickness	N.A. N.A.
Conical Dart Procedure A <sup>2</sup> Procedure B <sup>3</sup>	7.7 Joules/mm (1.7 in-lbs/mil) thickness 13.1 Joules/mm (2.9 in-lbs/mil) thickness	80% of initial 80% of initial
Weight Change		± 1.5%

1. All above values are minimum required except for hardness and weight, which is the maximum permissible gain or loss in weight.
2. Minimum Failure Energy.
3. Ductile/Brittle Transition.
4. With respect to initial test result.

### 210-3 GALVANIZING.

**210-3.1 General.** Zinc used for galvanizing shall be grade Prime Western conforming to ASTM B 6. Except as otherwise specified, materials shall be galvanized by the hot-dip, mechanical, or electrode positing process.

**210-3.2 Requirements of Coating.** The minimum weight of coating and other requirements shall be as shown in the following table. If there is a conflict between the ASTM and minimum weight columns, the minimum weight column shall apply. The weight shown is grams per square meter (ounces per square foot) of surface area. The weight of coating shall be determined in accordance with ASTM A 90, modified to determine the coating of each surface separately. All surfaces, when tested separately, shall meet the minimum requirements.

TABLE 210-3.2 (A)

Material	ASTM	Minimum Weight of Coating g/m <sup>2</sup> (oz./ft <sup>2</sup> )
Steel products including structural shapes, tie rods, handrails, manhole steps, and miscellaneous items.	A 123	610 (2.00)
	A 153	610 (2.00)
	B 633	610 (2.00)
	B 695	610 (2.00)
Hardware including cast, rolled, pressed and forged articles.	A 153	610 (2.00)
	B 633	610 (2.00)
	B 695	610 (2.00)
Bolts, screws, nuts and washers	A 153	381 (1.25)
	B 633	381 (1.25)
	B 695	381 (1.25)
CSP culverts and underdrains	A 444	305 (1.00)
Chain link fence fabric, tie wire only.	A 392	366 (1.20)
Steel pipe (includes fence posts, braces, and rails) Class 1 (see Note 1) Class 1A (pipe only, see Notes 2 and 3).	F1083	550 (1.80)
		305 (1.00)
All other chain link fence articles	A 123	550 (1.80)
Iron or steel wire fencing	A 116	244 (0.80)
Steel or iron sheets	A 525	366 (1.20)
Barbed wire	A 121	244 (0.80)
Electroliter standards, 7-gage steel and over	A 386	610 (2.00)
Electroliter standards, under 7-gage steel	A 386	458 (1.50)

1. "C" and "H" section fence posts shall be hot-dipped galvanized after forming.
2. Class 1A pipe shall, in addition to the galvanized exterior coating indicated, have coatings of chromate conversion and acrylic urethane in accordance with Subsection 210-4.
3. The interior surface coating for Class 1A pipe shall have 305 g/m<sup>2</sup> (1 ounce per square foot) of hot-dipped galvanized coating or a zinc-rich organic a minimum of 8 μm (0.3 mils) thick. The coating shall have a minimum zinc powder loading of 87 percent by weight. The interior coated surface shall have a demonstrated ability to resist 650 hours of exposure to salt fog with a maximum of 5 percent red rust when tested in accordance with ASTM B 117.

**210-3.3 Workmanship.** The zinc coating shall adhere tenaciously to the surface of the base material. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth, and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening, and other fabricating shall be done as far as is practicable before the galvanizing. All members, nuts, bolts, washers, etc., shall be galvanized before a structural unit is assembled. All uncoated spots or damaged coatings shall be cause for rejection.

Products that are warped or distorted to the extent of impairment for the use intended shall be rejected.

**210-3.4 Test Coupons.** Test coupons for determining the quantity and quality of the galvanizing shall be of such size and shall be wired to the materials to be galvanized before immersion so as to represent the amount of coating deposited on the finished product.

Nondestructive tests for uniformity of coating may be made by the Engineer with a magnetic instrument in accordance with ASTM E 376.

**210-3.5 Repair of Damaged Zinc Coatings.** Zinc coating which has been field or shop cut, burned by welding, abraded, or otherwise damaged to such extent as to expose the base metal, shall be repaired and recoated by one of the following methods approved by the Engineer.

**210-3.5.1 Hot-Dip Process.** The damaged areas shall be thoroughly stripped and cleaned and a coating of zinc shall be applied by the hot-dip process per 210-3.1 and 210-3.2.

**210-3.5.2 Metalizing Process.** The damaged area shall be repaired per ASTM A 780, Annex A3, and the following requirements:

1. The damaged areas shall be thoroughly cleaned by blasting with sharp sand or steel grit per 310-2.5.1(b).
2. The blasted area shall lap the undamaged zinc coating at least 13 mm (1/2 in).
3. Zinc wire containing not less than 99.98 percent zinc shall be used in the metalizing operation.
4. A zinc coating shall be applied to the damaged area with a metalizing gun to a thickness of not less than 130  $\mu\text{m}$  (5 mils) on the damaged area, and shall taper to zero thickness at the edge of the blasted undamaged section.

**210-3.5.3 Zinc Dust Paint.** When zinc surfaces have small areas of abrasion which occur after shop application of zinc coating, zinc dust paint may be used to repair these areas when approved by the Engineer. The damaged area shall be thoroughly cleaned by wire brushing and traces of welding flux and loose or cracked zinc coating removed prior to painting. The cleaned area shall be painted with a minimum of two coats of an unthinned zinc paint to provide a total minimum film thickness of 205  $\mu\text{m}$  (8 mils). The zinc dust paint shall conform to the requirements of ASTM A 780, Annex A3, except that it shall have a 90 percent minimum dry film content of zinc dust by weight. The method of application shall be approved by the Engineer.

**210-3.5.4 Zinc Based Solders.** The damaged areas shall be repaired using zinc alloy solders per ASTM A 780, Annex A3. Zinc solder shall be deposited until a minimum thickness of 130  $\mu\text{m}$  (5 mils) is applied to the damaged area.

## **210-4 CHROMATE CONVERSION AND CLEAR ACRYLIC URETHANE COATINGS.**

**210-4.1 General.** Class 1A Steel pipe for chain link fencing used for posts, braces, top rail, and gate frames shall have an exterior chromate conversion coating placed on the galvanized coating followed by a clear acrylic urethane coating.

**210-4.2 Chromate Conversion Coating.** The chromate conversion coating weight shall be a minimum of 0.023  $\text{g}/\text{m}^2$  (15 micrograms per square inch). The weight of chromate coating shall be determined by stripping the acrylic urethane coating with a neutral epoxy polyurethane stripper, determine the total weight of chromate and zinc coating in accordance with ASTM A 90; then determine the percent of chromate and percent of zinc in the total metallic coating by atomic absorption spectrophotometer.

**210-4.3 Clear Acrylic Urethane Coating.** The coating shall be manufactured from high grade raw materials which produce a crosslinked acrylic polyurethane coating.

The acrylic urethane coating shall be a minimum of 8 $\mu\text{m}$  (0.3 mil) thick. The thickness shall be determined in accordance with ASTM G 12. The gage shall be calibrated on the bare metal substrate after chemically removing the urethane and underlying zinc coatings. The total thickness of the urethane and zinc coatings shall then be determined. Chemically strip the urethane and determine the thickness of

the zinc coating only. The difference between the thickness of the zinc and the total thickness of the urethane coating and zinc is the thickness of the urethane coating.

Alternate test methods may be used when approved by the Engineer.

**210-4.4 Test of Coating System.** These tests shall be performed with the entire coating system in place.

The exterior clear-coated surface of the pipe shall have a demonstrated ability to resist 1,000 hours of exposure to salt fog with a maximum of 5 percent red rust when tested in accordance with ASTM B 117.

There shall be no film cracking of the clear finish coat after 500 hours exposure in a weatherometer in accordance with ASTM G 23, Type E, or EH carbon arc weatherometer, or G 26, Type B, or BH xenon arc weatherometer. There shall be no blistering or cracking of the clear finish coat after 500 hours of exposure to 100 percent relative humidity in accordance with ASTM D 2247.

**210-4.5 Repair of Coatings.** Repairs of damaged areas for Class 1A steel pipe shall be done by first repairing the galvanized coating in accordance with 210-3.5. In addition, a clear acrylic lacquer such as acrylon, shall be used as a final coating on the repaired area.

### 210-5 POLYVINYL CHLORIDE (PVC) COATINGS.

**210-5.1 General.** This specification covers PVC coatings for posts, frames, gates, and fittings. PVC coating thickness shall be a minimum of 380  $\mu\text{m}$  (15 mils).

**210-5.2 Properties.** The requirements for PVC coating shall be as shown in the following table:

TABLE 210-5.2 (A)

Property	ASTM Test No.	Requirements
Specific Gravity of Fused Resin	D 792	1.30 $\pm$ 0.030
Hardness,		
Shore A	D 2240	88 $\pm$ 2
Shore D	D 2240	36 $\pm$ 2
Tensile Strength, MPa (psi)	D 651	17.2 $\pm$ 0.2 (2500 $\pm$ 100)
Elongation, %	D 638	250 $\pm$ 10
Tear Strength, N/mm (ppi)	D 1004	77 $\pm$ 3 (440 $\pm$ 20)
Brittleness Temperature °C (°F)	D 746	-18 $\pm$ 2°C (0 $\pm$ 4°F)
Weathering Test Method,	E 838	300,000
Langley Melting Range, °C (°F)		202°C to 213°C (395°F to 415°F)
Dielectric Strength Range V/ $\mu\text{m}$ (V/Mil)	D 419	32 to 40 (800 to 1000)

**210-5.3 Workmanship.** All surfaces to be PVC coated shall be thoroughly cleaned, removing all foreign matter to ensure noncontaminated surfaces. The substrate shall be primed, preheated to a temperature of 232°C (450°F) and with 13  $\mu\text{m}$  (1/2 mil) thickness primer. Primer shall be composed of a mixture of acrylic, phenolic, and epoxy. All pipe and fittings shall be immersed in a fluidized-bed system for PVC coating. Gate frames shall be fabricated and welded prior to the application of zinc substrate and PVC coatings.

**210-5.4 Repair of Damaged PVC Coatings.** Damaged PVC coatings, which have been field or shop cut, burned, abraded, or otherwise damaged, shall be repaired and recoated by the following method: the damaged area shall be thoroughly cleaned by wire brushing, then wiped clean with a non-oil-base solvent such as methyl ethyl ketone or acetone solvent. The cleaned area shall be painted with 130  $\mu\text{m}$  (5 mil) thickness of acrylic enamel. Acrylic enamel shall be a PVC resin in solution, consisting of high level pigments, ultraviolet absorbers, and solvent blends applied by brush in a minimum of three coats.

## SECTION 211 MATERIAL TESTS

### 211-1 COMPACTION TESTS.

**211-1.1 Laboratory Maximum Density.** The following method shall be used for compaction tests unless otherwise specified:

Laboratory maximum densities will be performed in accordance with ASTM D 1557.

The Engineer may modify ASTM D 1557 at his option to calculate relative compaction based on adjusted laboratory maximum wet density calculated as follows:

$$D_a = (100 D_m) / (100 \pm W_a)$$

$D_a$  = Adjusted laboratory maximum wet density.

$D_m$  = Maximum wet density per ASTM D 1557.

$\pm W_a$  = Percent change in moisture content from field moisture to laboratory optimum moisture. Use minus when field moisture content is higher than laboratory optimum moisture content. Use plus when field moisture content is lower than laboratory optimum moisture content.

**211-1.2 Field Density.** Field density of soil shall be determined by ASTM D 2922 or ASTM D 1556.

**211-1.3 Relative Compaction.** The words Relative Compaction shall mean the ratio of the field dry or wet density to the laboratory maximum dry or adjusted wet density, respectively, expressed as a percentage.

**211-2 Chemical Resistance Test (Pickle Jar Test).** This test is used to determine the physical properties of material specimens used in sewers after exposure to chemical solutions. All test specimens shall be conditioned in a mechanical convection oven for 7 days and to a constant weight at  $43^\circ\text{C} \pm 3^\circ\text{C}$  ( $110^\circ\text{F} \pm 5^\circ\text{F}$ ) and subsequently cooled for 3 hours in a desiccator. This conditioning shall be done before and after submersion of the test specimens in the solutions specified in Table 211-2(A) for a period of 112 days at  $25^\circ\text{C} \pm 3^\circ\text{C}$  ( $77^\circ\text{F} \pm 5^\circ\text{F}$ ).

TABLE 211-2(A)

Chemical Solution	Concentration
Sulphuric acid ( $\text{H}_2\text{SO}_4$ )	20%
Sodium hydroxide (NaOH)	5%
Ammonium hydroxide ( $\text{NH}_4\text{OH}$ )	5%
Nitric acid ( $\text{HNO}_3$ )	1%
Ferric chloride ( $\text{FeCl}_3$ )	1%
Sodium Hypochloride	1%
Soap	0.1%
Detergent (Linear alkyl benzyl sulfonate or LAS)	0.1%
Bacteriological	BOD not less than 700 ppm

1. Volumetric percentages: Actual concentration of reagent must be corrected to 100%.

2. Weight change specimens per ASTM D 543 shall be 25.4 mm x 76.2 mm x 3.175 mm thick (1 in x 3 in x 0.125 in) unless otherwise approved by the Engineer.

At 28-day intervals, specimens shall be removed from each chemical solution and tested. If any specimen fails to meet the 112-day requirements specified for the material being tested before completion of the 112-day exposure, the material will be rejected.

The Chemical Resistance Test is a qualification test only. Requalification is required only when the compound formulation changes.

## SECTION 212 - LANDSCAPE AND IRRIGATION MATERIALS

### 212-1 LANDSCAPE MATERIALS.

#### 212-1.1 Topsoil.

**212-1.1.1 General.** Topsoil shall be designated as Class A (imported), Class B (selected) or Class C (unclassified), as specified herein. The Engineer shall determine the suitability of topsoil prior to use. Topsoil shall be transported from the source to its final position unless stockpiling is specified.

**212-1.1.2 Class "A" Topsoil.** Class "A" topsoil shall be from a source outside the limits of the project selected by the Contractor and in compliance with the requirements specified herein. The Engineer may make such inspections and perform such tests as deemed necessary to determine that the material meets the requirements.

At least 15 days before scheduled use, the proposed source of topsoil must be submitted to the Engineer for approval. The Contractor shall submit a written request for approval which shall be accompanied by a written report of a testing agency registered by the State for agricultural soil evaluation which states that the proposed source complies with these specifications. Class "A" topsoil shall have the same relative composition and structure, a friable sandy loam character, and be free of roots, clods and stones larger than 1 inch in greatest dimension, pockets of coarse sand, noxious weeds, sticks, brush, and other litter. It shall not be infested with nematodes or other undesirable insects and plant disease organisms.

Class "A" topsoil shall meet the following additional requirements:

- 1) **Gradation Limits.** Sand, 50 to 80 percent; clay 20 percent maximum; and silt, 30 percent maximum. The sand, clay, and silt gradation limits shall be as defined in ASTM D 422.
- 2) **Permeability Rate.** Not less than 13 mm (0.5 inch) per hour nor more than 50 mm (2 inches) per hour when tested in accordance with ASTM D 2434, California Test 220, or other approved methods.
- 3) **Agricultural Suitability.** The topsoil shall be suitable to sustain the growth of the plants specified.

**212-1.1.3 Class "B" Topsoil.** Class "B" is defined as material which is obtained from sources and in the quantities designated on the Plans or in the Specifications and which requires transport to the designated landscape areas. Such designated sources of the Class "B" topsoil may be within or outside the project limits.

The cost of stripping the surface of vegetation and debris at the designated locations and processing of the material to a finely divided state, before it is spread, shall be included in the price bid for hauling and placing.

Except as provided above, Class "B" topsoil shall be considered selected material in accordance with 300-2.7, 300-2.8, and 300-2.9.

**212-1.1.4 Class "C" Topsoil.** Class "C" topsoil is defined as soil found in place in the designated landscape area, including soil compacted in place as part of the earthwork specified for the project.

#### 212-1.2 Soil Fertilizing and Conditioning Materials.

**212-1.2.1 General.** Fertilizing materials shall comply with the applicable requirements of the State Food and Agricultural Code. All fertilizing materials shall be packaged first grade, commercial quality products identified as to source, type of material, weight and manufacturer's "guaranteed analysis". Fertilizing material shall not contain toxic ingredients or fillers in quantities harmful to human life, animals or plants.

When required by the Engineer, the Contractor shall furnish a Certificate of Compliance stating that the material substantially meets the specifications.

**212-1.2.2 Manure.** Manure shall be the product of yard fed cattle; free of weed seed, straw, or other inert material; and aged at least 3 months. The manure shall have been processed by grinding and screening and shall be of a consistency that will readily spread with a mechanical spreader.

Manure may be supplied in bulk if the source is approved in advance by the Engineer.

**212-1.2.3 Commercial Fertilizer.** Commercial fertilizer shall be a pelletized or granular product having a chemical analysis as specified on the Plans or in the Specifications. Commercial fertilizer shall be free-flowing material delivered in unopened sacks. Material which becomes caked or otherwise damaged shall not be used.

**212-1.2.4 Organic Soil Amendment.** Organic soil amendment shall be selected from Type 1, 2, or 3 products as described herein.

Type 1 organic soil amendment shall be a ground or processed wood product derived from redwood, fir, or cedar sawdust, or from the bark of fir or pine, treated with a non-toxic agent to absorb water quickly, and shall comply with the following requirements:

**TABLE 212-1.2.4 (A)**

<b>Gradation: Sieve Size</b>	<b>Percent Passing (minimum)</b>
6.3 mm (1/4 in)	95
2.36 mm (No. 8)	80
500 µm (No. 35)	30

**Nitrogen Content (% dry weight)**

Redwood	0.4–0.6 %
Fir	0.56 – 0.84%
Cedar	0.56 – 0.84%
Fir bark	0.8– 1.2 %
Pine bark	0.8– 1.2 %

**Salinity**

Maximum saturation extract conductivity: 2.50 millisiemens per centimeter (6.35 millimhos/inch) at 25°C (77°F).

**Wettability**

When 1 cm<sup>3</sup> of top water is applied to 15 cm<sup>3</sup> (one teaspoon of tap water is applied to 4 cubic inches) (volumetric ratio of 1:15) of the air-dry product, the material shall become completely damp in a period not exceeding 2 minutes. Any wetting agent added shall be guaranteed non-phyto-toxic at the rate used.

Type 2 organic soil amendment shall be a relatively dry friable organic composite derived from sewage sludge processed for agricultural use. It shall contain at least 1 percent nitrogen by dry weight and comply substantially with the gradation for Type 1 soil amendment.

Type 3 soil amendment shall be hay and stable bedding which has been processed and used as the growing medium for the commercial production of mushrooms. It shall contain at least 1 percent nitrogen by dry weight and comply substantially with the gradation for Type 1 soil amendment.

**212-1.2.5 Mulch.** Mulch shall be designated by Type in accordance with the requirements herein. Mulch shall be packaged in bales or bags unless the Engineer approves a bulk source in advance of delivery to the Work site.

(a) **Type 1 mulch** (ground wood product), shall comply with the requirements for Type 1 organic soil amendment.

(b) **Type 2 mulch** (sewage sludge product), shall comply with the requirements for Type 2 organic soil amendment.

(c) **Type 3 mulch** (mushroom compost) shall comply with the requirements for Type 3 organic soil amendment.

(d) **Type 4 mulch** (peat), shall be brown compressed sphagnum or hypnum.

(e) **Type 5 mulch** (fir bark chips), shall be fir bark chips in the gradation specified.

(f) **Type 6 mulch** (straw), shall be either threshed new straw or stable bedding material derived from rice, oats or barley. Straw in an advanced state of decomposition will not be acceptable.

**212-1.3 Seed.** Seed shall be fresh, clean, new crop seed, mechanically premixed to specified proportions.

Seed shall be delivered to the site in original unopened containers bearing the dealer's "guaranteed analysis" and germination percentage, and a certificate or stamp or release by a County agriculture commissioner. Any seed tagged "warning, hold for inspection" shall be inspected and released by the agriculture commissioner of the County within which the seeds are to be planted.

#### **212-1.4 Plants.**

**212-1.4.1 General.** Plants shall be inspected and approved at the nursery by the Engineer prior to shipment to the planting site.

All plants shall have a growth habit normal to the species and shall be sound, healthy, vigorous and free from insect pests, plant diseases, sun scalds, fresh bark abrasions, excessive abrasions, or other objectionable disfigurements. Tree trunks shall be sturdy and well "hardened off." All plants shall have normal well-developed branch systems, and vigorous and fibrous roots systems which are neither root-nor pot-bound and are free of kinked or girdling roots.

Other than the normal side pruning during the growth period, no pruning shall be done prior to inspection at the nursery.

**212-1.4.2 Trees.** All trees shall be of the specified height and crown to the last division of the terminal leader and diameter. The height shall be measured from the root crown. The diameter shall be measured 150 mm (6 inches) above the root crown. The height of palm trees shall be measured from the groundline to the base of the growing bud. The tree shall stand reasonably erect without support.

**212-1.4.3 Shrubs.** Shrubs shall be of the specified type and size, selected from high quality, well-shaped nursery stock.

**212-1.4.4 Flatted Plants.** Groundcover plants and other flatted plants shall be grown and remain in the flats until transplanted at the site. The soil and spacing of the plants in the flat shall ensure the minimum disturbance of the root system at time of transplanting.

**212-1.4.5 Sod and Stolons (turf grass).** Turf grass stolons shall be fresh, clean, living sections of runners of hybrid Bermuda grass or hybrid bent grass as designated in the contract documents. They shall be free of turf disease, insects, or weeds, and capable of healthy vigorous growth.

For mechanical or hand spreading, Bermuda grass stolons shall be 25 mm to 100 mm (1 to 4 inches) long and bent grass 100 mm to 200 mm (4 to 8 inches) long. Stolons to be planted in a slurry mixture as described in 308-4.8 shall be supplied in shorter sections as required.

**212-1.4.6 Cuttings.** Cuttings shall be fresh stock cut with a sharp hand tool from the stems of healthy vigorous plants of the species specified. If not otherwise specified, the length of cuttings shall be in accordance with the best horticultural practice.

**212-1.5 Headers, Stakes, and Ties.**

**212-1.5.1 General.** Lumber for landscape work shall be construction heart rough redwood in the sizes specified. Galvanized steel pipe shall be as specified in 212-2.1. Nails, lag screws, and miscellaneous hardware shall be galvanized commercial quality material. Miscellaneous fabricated metal items shall be made from steel conforming to ASTM A 36.

**212-1.5.2 Headers and Stakes.** Headers shall be 50 mm by 100 mm (2 by 4 inch) except that two 25 mm by 100 mm (1 by 4 inch) boards shall be supplied for laminations on turns and curves. Header stock shall be supplied in lengths of at least 3 m (10 feet). Stakes for headers shall be pointed (50 mm by 100 mm) (2 by 4 inch), at least 450 mm (18 inches) long. Joint splicing lumber shall be 25 mm by 100 mm (1 by 4 inch), 0.6 m (2 feet) long.

**212-1.5.3 Tree Stakes.** The type of tree stake shall be as designated in the Specifications. The tree support stakes shall be 3.1 m (10 feet) long.

Guy wire shall be 2.64 mm (No. 12 BWG) zinc-coated iron. Plastic ribbon tie material shall be 25 mm (1 inch) wide with a minimum tensile strength of 2 kN (500 pounds).

Deadman stakes shall be either 50 mm by 100 mm (2 by 4 inch) redwood or 19 mm (3/4 inch) diameter steel pipe 1 m (3 feet) long. Covers for wire shall be garden hose, 13 mm (1/2 inch) minimum diameter.

**212-2 IRRIGATION SYSTEM MATERIALS.**

**212-2.1 Pipe and Fittings.**

**212-2.1.1 General.** The type of pipe materials and fittings shall be as designated on the Plans or in the Specifications and shall comply with the following:

**212-2.1.2 Steel Pipe.** Steel pipe shall be galvanized standard weight (Schedule 40) complying with the requirements of ASTM A 120. Steel pipe shall be jointed with galvanized, threaded, standard weight malleable iron fittings and couplings.

**212-2.1.3 Plastic Pipe for Use with Solvent Weld Socket or Threaded Fittings.** Plastic pipe shall be rigid unplasticized polyvinyl chloride PVC 1220 (Type 1, Grade 2), conforming to ASTM D 1785. Plastic pipe marked with product standard PS-21-70 conforms to the ASTM requirements. The minimum gaskets shall be rigid unplasticized polyvinyl chloride pressure rating shall not be less than the working pressures indicated therein for the schedule and sizes listed.

Schedule 40 pipe shall be used for installation on the discharge side of control valves and Schedule 80 pipe shall be used for continuously pressurized pipe on the supply side of control valves. Schedule 80 only, shall be supplied when threaded joints are specified or otherwise permitted by the Engineer.

Fittings and couplings for plastic pipe shall be threaded or slip-fitted tapered socket solvent weld type. Threaded adapters shall be provided with socket pipe for connections to threaded pipe. Plastic pipe fittings and couplings shall be PVC I or PVC I/II material supplied in the same schedule size specified for the pipe. The type of plastic material and schedule size shall be indicated on each fitting or coupling. Fittings and couplings shall comply with the following specifications:

**TABLE 212-2.1.3 (A)**

<b>Socket Fittings</b>	
Schedule 40	ASTM D 2466
Schedule 80	ASTM D 2467
<b>Threaded Fittings</b>	
Schedule 80	ASTM D 2464

**212-2.1.4 Plastic Pipe for Use with Rubber Ring Gaskets.** Plastic pipe for use with rubber ring PVC 1120 (Type 1, Grade 1), manufactured in accordance with ASTM D 2241. Plastic pipe marked with product standard PS 22-70 conforms to ASTM requirements. Pipe shall be supplied with plain ends or with an integral thickened expanded bell with rubber ring groove. Couplings for plain end pipe shall be of the single rubber ring type with solvent weld socket on one end or shall be of the double ring type.

Rubber ring gaskets shall be of a synthetic rubber supplied in accordance with the requirements of ASTM D 1869.

Pipe shall be furnished in the following Standard Dimension Ratios (SDR) and Pressure Ratings:

1100 kPa (160 psi) SDR 26

1380 kPa (200 psi) SDR 21

**212-2.1.5 Copper Pipe.** Copper pipe shall be Type K in accordance with ASTM B 88M (ASTM B 88). Copper pipe shall be jointed with the appropriate solder type wrought copper fittings for 67 mm (2-1/2 inch) and smaller sizes. Cast brass fittings shall be used for sizes over 67 mm (2-1/2 inch).

### **212-2.2 Valves and Valve Boxes.**

**212-2.2.1 General.** Valves shall be of the size, type, and capacity designated on the Plans or in the Specifications and shall comply with the requirements specified herein.

All valves except garden valves shall be capable of satisfactory performance at a working pressure of 1380 kPa (200 psi). Valves shall be designed to permit disassembly to replace sealing components without removal of the valve body from the pipeline.

**212-2.2.2 Gate Valves.** Gate valves in sizes 50 mm (2 inches) and smaller shall be all bronze double disc wedge type with integral taper seats and nonrising stem.

Sizes 60 mm (2-1/2 inches) and larger shall be iron body, brass trimmed with other features the same as for 50 mm (2 inch).

**212-2.2.3 Manual Control Valves.** Manual control valves shall be brass or bronze, and shall be straight or angle pattern globe valves, full opening, key operated with replaceable compression disc and ground joint union on the discharge end.

**212-2.2.4 Remote Control Valves.** Remote control valves shall be electrically or hydraulically operated. They shall be brass or bronze with accurately machined valve seat surfaces, equipped with flow control adjustment and capability for manual operation. They shall be made so that they may be readily disassembled for servicing.

**212-2.2.5 Garden Valves.** Garden valves shall be brass or bronze except for the handle. They shall have a replaceable compression disc, and shall be 19 mm (3/4 inch) straight-nosed, key operated and pressure rated for operation at 1035 kPa (150 psi).

**212-2.2.6 Quick-coupling Valves and Assemblies.** Quick-coupling valves shall be brass or bronze with built-in flow control and self-closing valve and supplied in 19 mm (3/4 inch) size unless otherwise required. When a quick-coupler assembly is specified, it shall consist of the valve, quick coupler connection and hose swivel.

**212-2.2.7 Valve Boxes.** Valve boxes and covers shall be precast portland cement concrete.

**212-2.3 Backflow Preventer Assembly.** The backflow preventer assembly shall consist of a backflow preventer unit and related components conforming to the governing code requirements.

**212-2.4 Sprinkler Equipment.** Sprinkler heads, bubbler heads and spray nozzles shall be of the types and sizes shown on the Plans. Such equipment shall be brass, bronze and stainless steel except for

minor components. Equipment of one type and flow characteristic shall be from the same manufacturer and all equipment shall bear the manufacturer's name and identification code in a position where they can be identified in the installed position.

Fixed head sprinklers shall have a one-piece housing with provision for interior parts replacement. Pop-up sprinklers shall rise at least 25 mm (1 in) during operation.

Shrubbery and bubbler heads shall be adjustable from full flow to shutoff.

### 212-3 ELECTRICAL MATERIALS.

**212-3.1 General.** The contractor shall furnish and install all electrical equipment and materials required for a complete electrical system.

All equipment and materials shall comply with the requirements of the governing code and the serving utility and shall be approved and identified by Underwriters Laboratories, Inc. (UL).

#### 212-3.2 Conduit and Conductors.

**212-3.2.1 Conduit.** Conduit shall be galvanized steel conforming to the applicable provisions of 209-2.3.

**212-3.2.2 Conductors.** Line voltage conductors shall be supplied in the sizes and types shown on the Plans and shall be THW or THWN, 600-volt insulation rating, conforming to the applicable provisions of ASTM D 2219 and D 2220.

Low voltage control conductors shall be Type UF and supplied in the sizes shown on the Plans or in accordance with the control equipment manufacturer's recommendation, and shall be UL approved for direct burial installation.

**212-3.3 Controller Unit.** The type of control unit shall be as called for on the Plans. It shall be fully automatic, with provisions for manual operation, sized to accommodate the number of stations or control valves included in the system. Outdoor models shall be housed in vandal-proof and weatherproof enclosure with locking cover.

## SECTION 213 - ENGINEERING FABRICS

### 213-1 PAVEMENT FABRIC

**213-1.1 General.** Pavement fabric shall be treated by heat or other processes approved by the Engineer causing the fibers on one side only to become bonded together, forming a glazed, delamination-free surface. The treated side of each roll shall be marked for easy identification. The pavement fabric shall be nonwoven, needle-punched polyester or polypropylene materials conforming to Table 213-1.1 (A).

TABLE 213-1.1 (A)

Property	ASTM Test No.	Requirements
Weight, g/m <sup>2</sup> (oz./ yd <sup>2</sup> )	D 1776	119 to 170 (3.5 to 5.0)
Grab Tensile Strength 25 mm (1 inch) grip, N (lbf.)	D 4632	400 (90) min.
Elongation at Break, %	D 4632	40 min., 100 max.
Fabric Thickness, μm (Mils)	D 1777	760 to 1270 (30 to 50)
Asphalt Retention, g/m <sup>2</sup> (oz./ft <sup>2</sup> )	See Note 1	1060 (3.50) min.
Grab Tensile Strength After Asphalt Saturation 25 mm (1 in) Grip, N (lbf)	D 4632	890 (200 min.)
Elongation at Break, % After Asphalt Saturation	D 4632	40 min., 70 max.

1. Test per 213-1.5.

Pavement fabric shall be accompanied with a test certificate from an approved testing laboratory with actual identification test results. The number and frequency of testing shall conform to 213-1.3. Additional testing may be required by the Engineer.

The fabric shall be protected from exposure to ultraviolet rays and stored in accordance with 213-1.4.

**213-1.2 Identification.** Fabric shall be furnished in rolls wrapped with protective covering to protect them against ultraviolet radiation, abrasion, dust, dirt, mud, debris, and other deleterious forces and substances. The fabric shall be free from defects or flaws. Each roll of fabric in the shipment shall be marked or tagged to identify the manufacturer, type, length, width, date and place of manufacture, and production identification number.

**213-1.3 Sampling and Test Compliance.** A laboratory shall be maintained at or near the point of manufacture to ensure quality control in accordance with ASTM and other applicable testing procedures. The laboratory shall be approved by the Engineer, and shall maintain records of its quality control results.

A manufacturer's certificate shall accompany the shipment and be delivered to the Engineer prior to installation. The certificate shall include name or manufacturer, chemical composition, product description, lot number, and test results, and signature of an authorized official. A unit is 500 m<sup>2</sup> (600 square yards) or one roll, whichever is less. A lot is the units produced by a single machine on a single shift without interruption but not to exceed 1,000 units. The number of units tested within a lot shall be equal to, but not less than, the cube root of the units in that lot (fractions of a number to be rounded off to the next higher whole number). Unless a greater number of tests are required by these or other applicable specifications, a minimum of eight tests shall be performed in each of the principal directions for each unit tested. The average of test values may be less than specified. In the event of any failure, the entire lot will be rejected.

**213-1.4 Storage and Handling.** Fabric shall be stored on clean, dry surfaces, free of foreign substances such as grease, oil, paint, epoxy, cement, or any other substances which would have a deleterious effect on the fabric. When stored in outside areas, fabric shall be kept 0.3 m (1 foot) minimum above ground level. The Contractor shall keep the fabric in its protective covering until it is ready for installation. Opened rolls shall be covered by a waterproof cover. No hooks, tongs or other sharp tools or instruments shall be used when handling any fabric. Fabric may be unloaded or handled in one of the following ways:

- 1) By placing slings under the rolls; or
- 2) By using a pole inserted through a hollow core, provided the pole extends 0.3 m (1 foot) minimum beyond each end of the core, and lifting and handling devices are attached to only that portion of the pole located outside the ends of the core; or
- 3) By hand.

**213-1.5 Test Method for Asphalt Retention of Paving Engineering Fabrics.**

**213-1.5.1 General.** This method covers a procedure for determining the asphalt retention and area change for paving grade engineering fabrics and is applicable to engineering fabrics that are utilized in an asphalt-saturated interlayer.

**213-1.5.2 Definition.** Asphalt retention is the weight of asphalt cement retained by a paving engineering fabric per unit area of specimen after submersion in asphalt cement.

**213-1.5.3 Summary of Method.** Specimens of engineering fabrics are selected at random from an individual piece of fabric. The test specimens are individually weighed prior to being submerged in a specified asphalt cement and maintained at a specified oven temperature for a stated time. After the

submerged test, the specimens are hung to drain in the oven for an additional period of time at the same oven temperature. Upon completion of specimen submersion in asphalt and drainage, the individual specimens are weighed and asphalt retention is determined.

**213-1.5.4 Uses and Significance.** Asphalt retention is a test procedure that is recommended for paving grade engineering fabrics. The use of this test method is to establish an index value by providing standard criteria and a basis for uniform reporting. The results obtained may vary, depending on which type of asphalt cement is used for the test.

**213-1.5.5 Apparatus and Asphalt Cement.** Scale or balance, with a capacity and sensitivity sufficient to weight the full piece or cut units to within  $\pm 0.1$  percent of their gross weight. The accuracy of the scale should be certified by a recognized authority. Cutting die or cutting template, measuring 102 mm by 254 mm (4 inches by 10 inches) with a tolerance of  $\pm 1.5$  mm (1/16 inch) in each linear dimension. Mechanical convection oven, capable of maintaining the required test temperature within  $\pm 2^\circ\text{C}$  ( $4^\circ\text{F}$ ). Asphalt cement shall be viscosity grade AR4000. Specimen hanging rack shall consist of a reservoir pan, 300 mm by 325 mm by 50 mm (12 inches by 13 inches by 2 inches) deep, and a welded wire grid structured over the pan. The grid shall consist of five wires attached to the 325 mm (13 inch) long sides of the pan on 70 mm (2.75 inch) centers. The five wires shall be vertical from the edge of the pan to a height of 280 mm (11.0 inches), and level across the top to form a rectangular cage. The five wires shall be braced with additional wires welded longitudinally at the top outside corners of the rectangular cage and at the mid point of each side. The ends (300 mm (12 inch) sides of the pan) shall remain open for access to the samples.

**213-1.5.6 Sampling, Selection, and Number of Specimens.** Take for the laboratory sample, a sample extending the width of the fabric and approximately 1 meter (39 inches) along the length from each roll in the lot sample. The first 1 m (3 feet) along the length of the roll shall be cut off and discarded prior to taking the laboratory samples. Test five specimens in the cross-machine direction and five specimens in the machine direction from each sample. A sample should be taken for every 50 rolls or fraction thereof.

**213-1.5.7 Conditioning.** Condition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for testing ( $65 \pm 5$  percent RH). Equilibrium is considered to have been reached when the increase in weight of the specimen in successive weighings made at intervals of not less than 2 hours does not exceed 0.1 percent of the weight of the specimen. Paving engineering fabrics not significantly affected by minor variations in atmospheric conditions may be tested in prevailing room atmospheres.

**213-1.5.8 Preparation of Test Specimens.** For nonwoven fabrics, prepare the specimens as described in ASTM D 4632.

**213-1.5.9 Procedure.** Five-machine direction and five cross-machine-direction specimens measuring 102 mm by 245 mm (4 inches by 10 inches) shall be selected at random from the individual test sample. The individual test specimens shall be conditioned, and then individually weighed to the nearest 0.1 gram. The weight of each specimen shall be multiplied by 0.8 to approximate the weight of the 120 by 203 mm (4 inch by 8 inch) area of fabric.

Four notches, cut approximately 13 mm (1/2 in) into the fabric, shall be cut 25 mm (1 in) from each end of each specimen so that a 102 mm x 203 mm (4 in x 8 in) area is delineated.

The individual test specimens shall then be submerged in the specified asphalt cement maintained at a temperature of  $135^\circ\text{C} \pm 2^\circ\text{C}$  ( $275^\circ\text{F} \pm 4^\circ\text{F}$ ) in a mechanical convection oven. Only the center 203 mm (8

inches) between the notches need be submerged. Clamps may be placed on the 25 mm (1 inch) of fabric outside the notches on each end to facilitate handling the specimen.

After the required submersion, the asphalt cement coated-saturated test specimens shall be removed and hung to drain (long axis vertical) in the oven at  $135^{\circ}\text{C} \pm 2^{\circ}\text{C}$  ( $275^{\circ}\text{F} \pm 4^{\circ}\text{F}$ ). The specimens shall be hung for 35 minutes from one end and then 25 minutes from the other end to obtain a uniform saturation of the fabric.

The asphalt cement coated-saturated specimens shall be allowed to cool and then be trimmed of any excess asphalt cement such as edge drippings. This is accomplished by cutting 25 mm (1.0 inch) off each end, at the notches, with the remaining specimen being approximately 100 mm (4.0 inches) wide and 200 mm (8.0 inches) long.

The trimmed asphalt cement coated-saturated specimens shall then be weighed to the nearest 0.1 gram and the area determined by measuring the trimmed asphalt cement coated-saturated specimens, as defined by the notches cut earlier.

**213-1.5.10 Calculation.** Calculate the average of the asphalt retention observed for all acceptable specimens. The asphalt retention for individual specimens shall be calculated as the weight in grams (ounces) of asphalt cement retained, divided by the area of the specimen in square meters (square feet).

## 213-2 GEOSYNTHETICS.

**213-2.1 General.** This section applies to nonwoven and woven geosynthetics. Products include nonwoven and woven geotextiles, biaxial, and uniaxial geogrids.

Nonwoven geotextiles shall be needle punched or needle entangled and shall consist of long chain polymeric filaments of polypropylene, polyester, or nylon. The fabric shall be a stable network of fibers which retain their positions relative to each other. Heat bonding on one side is acceptable.

Woven geotextiles shall consist of long chain polymeric monofilaments, slit film tapes, or multifilaments of tape and nonwoven yarn of polypropylene, polyester or nylon. The fabric shall be woven into a stable network and the edges of the fabric shall be selvaged or surged in such a way that fabric will not unravel or fray during installation or usage.

Geogrids, uniaxial and biaxial, shall be manufactured using polyolefins (high density polyethylene [HDPE] and/or polypropylene [PP] or polyester [PET]). The geogrid reinforcement elements shall consist of a regular network of integrally connected longitudinal and transverse polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil, aggregate or other material.

**213-2.2 Physical Properties.** Nonwoven and woven geotextiles shall meet the requirements for the type indicated in table 213-2.2 (A). Geogrids shall meet the requirements for the type indicated in Table 213-2.2 (B).

**213-2.3 Identification.** Geotextiles shall be furnished in rolls wrapped with protective covering to protect them against ultraviolet radiation and abrasion. Torn wrappers shall be repaired within 48 hours, using an approved protective covering. Each roll of fabric shall be marked or tagged to identify the manufacturer, type length, width, and production identification number. Geogrid identification shall follow ASTM D 4873.

**213-2.4 Sampling and Test Compliance.** Sampling and testing of geosynthetics shall conform to the requirements of ASTM D 4354. Specification conformance for geosynthetics shall conform to the requirements of ASTM D 4759.

**213-2.5 Storage and Handling.** Storage and handling of geosynthetics shall conform to the requirements of ASTM D 4873.

**TABLE 213-2.2 (A)**  
**NON WOVEN**

Property	Test Reference	Type <sup>1</sup>		
		90N	180N	250N
Grab Strength <sup>2</sup> N (lbs.), Min.	ASTM D 4632	400 (90)	800 (180)	1110 (250)
Elongation, Minimum (at peak load) %, Max.	ASTM D 4632	50	50	50
Puncture Strength, N (lbs.), Min.	ASTM D 3787	200 (45)	355 (80)	510 (115)
Permittivity, Sec. <sup>1</sup> , Min.	ASTM D 4491	1240	2205	2485
		0.7	0.7	0.7
Burst Strength kPa (Psi), Min.	ASTM D 3786	1240 (180)	2205 (320)	2485 (360)
Toughness, N (lbs.), Min.	% Elongation x Grab Strength	24,500 (5,500)	44,500 (10,000)	62,500 (14,000)
Ultraviolet Resistance % Strength Retained @ 500 Weatherometer Hours	ASTM D 4355	70	70	70

1. N – Nonwoven.

2. Minimum roll average in the weakest principal direction.

**WOVEN**

Property	Test Reference	Type <sup>1</sup>			
		90WS	200WS	270WS	200WM
Grab Strength <sup>2</sup> N (lbs.), Min.	ASTM D 4632	400 (90)	890 (200)	1200 (270)	890 (200)
Elongation, Maximum, at peak load %, Max.	ASTM D 4632	25	25	25	25
Puncture Strength, N (lbs.), Min.	ASTM D 3787	135 (30)	310 (70)	490 (110)	445 (100)
Permittivity, Sec. <sup>1</sup> , Min.	ASTM D 4491	0.02	0.02	0.02	0.04
Burst Strength, kPa (Psi), Min.	ASTM D 3786	1380 (200)	2760 (400)	3450 (500)	2760 (400)
Ultraviolet Resistance % Strength Retained @ 500 Weatherometer Hours	ASTM D 4355	70	70	70	70

1. WS – Slit Film; WM – Monofilament.

2. Minimum roll average in each direction.

**TABLE 213-2.2 (B)**  
**UNIAXIAL**

Property	Test Reference	Type <sup>1</sup>				
		P1	P2	P3	P4	P5
Tensile Strength kN/m (lbs./ft), Min.	GRI GG-1 <sup>2</sup>	39.4 (2700)	64.2 (4400)	100.7 (6900)	131.3 (9000)	157.6 (10800)
Tensile Strength @ 2% strain kN/m (lbs./ft), Min.	GRI GG-1 <sup>2</sup>	8 (550)	14.6 (1000)	26.3 (1800)	34 (2330)	40 (2740)
Tensile Strength @ 5% strain kN/m (lbs./ft), Min.	GRI GG-1 <sup>2</sup>	17 (1165)	29.2 (2000)	54 (3700)	65 (4450)	78.8 (5400)
Initial Modulus kN/m (lbs./ft)	GRI GG-1 <sup>2</sup>	400 (27500)	730 (50000)	1310 (90000)	1700 (116500)	2000 (137000)
Junction Strength, kN/m (lbs./ft), Min.	GRI GG-2 <sup>2</sup>	35 (2430)	58 (3960)	91 (6210)	118 (8100)	142 (9720)
Long-Term Allowable Strength, kN/m (lbs./ft)	GRI GG-4 <sup>3</sup>	11.8 (809)	23.4 (1602)	35.4 (2424)	46.7 (3203)	58.7 (4026)

1. Primary reinforcement geogrid. All property values are listed for the machine direction.

2. GRI GG-1 conducted at 10%/minute with 2 aperture or 200 mm (8 in) minimum gage length.

3. Minimum reduction factors are as follows: installation damage reduction factor for HDPE of 1.05 and 1.1 for PET geogrids, durability reduction factor of 1.1 for HDPE and 1.3 for PET geogrids

## BIAXIAL

Property	Test Reference	Type <sup>1</sup>	
		S1	S2
Ultimate Tensile Strength kN/m (lbs./ft), Min.	GRI GG-1 <sup>1</sup>	19 (1300)	28.8 (1975)
Tensile Strength @ 2% strain kN/m (lbs./ft), Min.	GRI GG-1 <sup>1</sup>	6.57 (450)	8.75 (600)
Tensile Strength @ 5% strain kN/m (lbs./ft), Min.	GRI GG-1 <sup>1</sup>	13.4 (920)	19.5 (1340)
Flexural Stiffness mg-cm	ASTM D 1388	250000	750000
Junction Strength, kN/m (lbs./ft), Min.	GRI GG-2 <sup>1</sup>	17.1 (1170)	26 (1778)
Torsional Stiffness <sup>3</sup> , cm-kg/degree	U.S. Army COE <sup>3</sup>	3.2	6.5

1. Secondary reinforcement geogrid. All property values are listed for the cross machine direction with the exception of flexural stiffness, measured in the machine direction, and torsional stiffness which is measured at the junction.
2. GRI GG-1 conducted at 10%/minute with 2 aperture or 200 mm (8 in) minimum gage length.
3. Resistance to in-plane rotation movement measured by applying a 20 cm-kg moment to the central junction of a 225 mm by 225 mm specimen restrained at its perimeter and measured in units of cm-kg/deg.

## SECTION 214 - PAVEMENT MARKERS

**214-1 General.** The following specifications set forth the requirements of reflective and nonreflective pavement markers.

The markers shall conform to the shape, dimensions, colors, sizes, and tolerances shown on the Plans.

Pavement markers shall be of the type and color shown on the Plans or in the Specifications.

**214-2 Type of Markers.** Pavement markers shall conform to one or more of the following types:

Type A - Nonreflective White Markers

Type AY - Nonreflective Yellow Markers

Type B - Two-Way Clear Reflective Markers

Type C - Red-Clear Reflective Markers

Type D - Two-Way Yellow Reflective Markers

Type G - One-Way Clear Reflective Markers

Type H - One-Way Yellow Reflective Markers

Type I - Two-Way Blue Reflective Markers

### 214-3 SAMPLING, TOLERANCES, PACKAGING AND STORAGE.

**214-3.1 Sampling.** Twenty markers selected at random will constitute a representative sample for lots of 10,000 markers or less. Forty markers will constitute a representative sample for lots of more than 10,000 markers. For sampling purposes, the lot size shall not exceed 25,000 markers.

#### 214-3.2 Tolerances.

**214-3.2.1 Test Specimens.** Three test specimens shall be randomly selected from the sample for each test except as noted in 214-3.2.2, and tested for compliance in accordance with these specifications. Should any one of the three specimens fail to comply with the requirements of these specifications, six additional specimens will be tested. The failure of any one of these six specimens shall be cause for rejection of the entire lot or shipment represented by the sample.

**214-3.2.2 Reflectance.** The entire sample of reflective pavement markers shall be tested for reflectance. The failure of 10 percent or more of the original sampling shall be cause for rejection.

**214-3.2.3 Resamples.** At the discretion of the Engineer, a resample may be taken consisting of double the number of samples originally taken. Tolerance for resamples shall be in the same ratio as specified above.

**214-3.3 Packaging.** Shipments shall be made in containers which are acceptable to common carriers and packaged in such a manner as to ensure perfect condition. Any damaged shipments shall be replaced by the Contractor. Each package shall be clearly marked as to the name of the manufacturer, type, color, quantity enclosed, lot number, and date of manufacture.

**214-3.4 Storage.** Markers shall be stored indoors, and shall be protected from any source of moisture both during shipment to the job site and at the job site. The markers shall be maintained at a high enough temperature as to preclude moisture condensation, and, at the time of placement, both the markers and their containers shall be dry.

**214-4 NONREFLECTIVE PAVEMENT MARKERS.** Types A and AY pavement markers shall consist of a heat-fired, vitreous, ceramic base and a heat-fired, opaque, glazed surface to produce the properties required in these specifications. The markers shall be produced from any suitable combination of intimately mixed clays, shales, talcs, flints, feldspars, or other organic material which will meet the properties herein required. The markers shall be thoroughly and evenly matured and free from defects which will affect appearance or serviceability.

The bottoms of the ceramic markers shall be free from gloss or glaze and shall have a number of integrally formed protrusions approximately 1.5 mm (0.05 inch) projecting from the surface in a uniform pattern of parallel rows. The tips of the protrusions shall not deviate more than 1.5 mm (0.05 inch) from a flat surface. Each protrusion shall have a face parallel to the bottom of the marker. The area of each parallel face shall be between 6.5 mm<sup>2</sup> and 41.9 mm<sup>2</sup> (0.01 and 0.065 in<sup>2</sup>) and combined area of these faces shall be between 1420 mm<sup>2</sup> and 2580 mm<sup>2</sup> (2.2 and 4 in<sup>2</sup>). The protrusions shall be circular in section. The number of protrusions should not be less than 50 or more than 200. To facilitate forming and mold release, the sides of each protrusion may be tapered. This taper shall not exceed 15 degrees from perpendicular to the marker bottom. Markers manufactured with protrusions whose diameter is less than 4.0 mm (0.15 inch) may have an additional taper not exceeding 30 degrees from perpendicular to the marker bottom and exceeding no more than one-half the total height of the protrusion.

Nonreflective pavement markers shall conform to the following finish and testing requirements:

1) **Finish.** The top surface of nonreflective markers shall be convex and the radius of curvature shall be between 90 mm (3-1/2 inches) and 150 mm (6 inches), except that the radius of the 15 mm (1/2 inch) nearest the edge may be less. Any change in curvature shall be gradual. The top and sides shall be smooth and free of mold marks, pits, indentations, air bubbles, or other objectionable marks or discolorations.

2) **Tests.** All tests on pavement markers shall be performed in accordance with California Test 669.

**214-5 REFLECTIVE PAVEMENT MARKERS.** Reflective pavement markers shall be of the prismatic reflector type consisting of methyl methacrylate or suitably compounded acrylonitrile butadiene styrene (ABS) shell filled with a mixture of an inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and contain one or two methyl methacrylate prismatic reflector faces of the color specified.

The infrared curves of the compounded methyl methacrylate or ABS shells shall match approved curves on file in the California Department of Transportation Laboratory.

The reflective lens shall not contain any voids or air space and the back of the lens shall be metallized.

The shell shall be fabricated in a manner that will provide a mechanical interlock between the thermosetting compound and the shell. The thermosetting compound shall bond directly to the back side of the metallized lens surface.

The base of the marker shall be flat (the deviation from a flat surface shall not exceed 1.5 mm (0.05 inch)), rough textured, and free from gloss or substances which may reduce its bond to the adhesive.

Reflective pavement markers shall conform to the following color and testing requirements:

1) **Color.** The color of the reflectors, when illuminated by the white light from a sealed-beam automobile headlight as defined in the Society of Automotive Engineers (SAE) Standard J 578, shall be an approved clear, yellow, blue, or red color as designated. Off-color reflection shall constitute grounds for rejection. The daylight color of the marker body shall be compatible with the color of the primary lens, and shall be subject to approval by the Engineer.

2) **Tests.** All tests shall be performed in accordance with California Test 669.

## **214-6 EPOXY ADHESIVE.**

### **214-6.1 General.**

**214-6.1.1 Description.** Epoxy will meet service requirements for highway construction and shall be furnished as two components which shall be mixed together at the work site.

**214-6.1.2 Sampling and Testing.** Epoxy shall not be used prior to sampling and testing.

All tests will be conducted in accordance with the latest test methods of ASTM, Federal Test Method Standard No. 141, and methods in use by the California Department of Transportation Laboratory.

**214-6.1.3 Packaging, Labeling and Storing.** Each component shall be packaged in containers of size proportional to the amount in the mix so that one container of each component is used in mixing one batch of epoxy. The containers shall be of such design that all of the contents may be readily removed, and shall be well sealed to prevent leakage. The containers and labeling shall meet U.S. Department of Transportation Hazardous Material Shipping Regulations, and the containers shall be of a material, or lined with a material, of such character as to resist any action by the components. Each container shall be clearly labeled with the designation (Component A or B); type (Standard or Rapidset), if applicable; manufacturer's name; date of manufacture; batch number (a batch shall consist of a single charge of all components in a mixing chamber); all directions for use (as specified elsewhere), and such warning or precautions concerning the contents as may be required by State or Federal Laws and Regulations. If the Engineer waives testing requirements, the certificate shall also include a list, by Title and Section, of the State and Federal packaging and labeling laws and regulations that the manufacturer has complied with.

Attention is directed to the characteristic of some components to crystallize or thicken excessively prior to use when stored at temperatures below 2°C (35°F). Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments which cannot be readily redispersed with a paddle shall not be used.

**214-6.1.4 Mixing.** At the time of mixing, Components A and B shall be at a temperature between 15°C (60°F) and 30°C (85°F), unless otherwise specified. Any heating of the adhesive components shall be done by application of indirect heat. Immediately prior to mixing, each component shall be thoroughly mixed with a paddle. Separate paddles shall be used to stir each component. Immediately prior to use, the two components shall be mixed together in specified ratios. When mixed, all adhesives shall have a uniform gray color without black or white streaks. No solvent shall be added to any epoxy. All epoxies shall be used before thickening of the epoxy has begun.

### **214-6.2 Types of Epoxy Adhesive.**

**214-6.2.1 Rapid-Set Epoxy Adhesive for Pavement Markers.** This specification covers a high viscosity paste rapid-set epoxy formulated primarily for use in bonding pavement markers to portland cement concrete and asphalt concrete.

**TABLE 214-6.2.1 (A)**  
**COMPONENT A**

Ingredients	Parts by Weight
Epoxy Resin <sup>1</sup>	90.00
Orthocresol Glycidyl Ether <sup>2</sup>	10.00
Titanium Dioxide, ASTM Designation D 476	3.00
Talc <sup>3</sup>	50.00
Oleophilic Fumed Silica <sup>4</sup>	4.50*

**COMPONENT B**

Ingredients	Parts by Weight
High Functionality Polymercaptan Hardener <sup>5</sup>	60.00
2, 4, 6-Tri (Dimethylaminomethyl) Phenol <sup>6</sup>	7.00
Polysulfide Polymer <sup>7</sup>	35.00
Furnace Black <sup>8</sup>	0.10
Talc <sup>3</sup>	52.00
Oleophilic Fumed Silica <sup>4</sup>	3.50*
Silicone Anti-Foam, Type DB 100, 100% Solids	0.005

- Di glycidyl ether of bisphenol A, viscosity 10-16 Pa·s (100-160 poise) at 25°C; weight per epoxide equivalent 180-200. Gardner 19 max.
  - Viscosity at 25°C, 0.005 to 0.01 Pa·s (5-10 Centipoise). Weight per liter 1.08-1.09 Kg. (gallon 9.00-9.10 pounds). Weight per epoxy equivalent 180-200.
  - Specify Gravity ..... 2.68 to 2.86  
Oil Absorption, ASTM D 281 ..... 26 to 33  
pH ..... 8.9 to 9.6  
Hegman Rating ..... 3 to 5  
Particle Shape ..... Platey  
Maximum Particle Size, micrometers ..... 55  
Percentage passing U.S. 45 µm (No. 325 Screen), Min. .... 99  
Dry Brightness, Min. .... 93
  - High purify fumed silica, surface treated with a silicone oil, with the following properties: Appearance, fluffy white powder; surface area, N<sub>2</sub> B.E.T. method 70 ± 15 M<sup>2</sup>/gram; pH 4 grams dispersed in 100 milliliters of 20/80 volume mixture of ethyl alcohol and distilled water, 4.7; weight % carbon, 5.0 minimum; ignition loss (dry basis) 2 hours at 1000°C, 6 to 7; specify gravity, 1.8.
  - Liquid polymercaptan resin, viscosity 100-130 poise at 25°C; specific gravity 1.14-1.16; mercaptan value, 3.6 meq/gram. Color, Gardner 1933, 1 maximum. Infrared curve shall match the curve on file in the California Department of Transportation Laboratory.
  - Formula weight 265; specific gravity at 25°/25°C, 0.973; refractive index 1.514 at 25°C; distillation range 96% at 130° to 160°C (0.5-1.5 mm); flash point, Tag Open Cup, 300°F minimum; water content 0.06% maximum.
  - Specific gravity, 1.24-1.30 at 20°/20°C; viscosity, 0.7-1.2 Pa·s (700-1200 centipoise), Brookfield at 25°C; pH water extract 6.0-8.0; moisture content, 0.1% maximum; pour point, - 10° C (15° F); average molecular weight, 1000; flash point, °C (°F), Cleveland Open Cup, 199°C (390°F) minimum; sulfur content, percent, 36-40; color, Hellige, 9-12. The product shall be a difunctional mercaptan made from 98 mole percent of bis (2-chloroethyl) formal and 2 mole percent of trichloropropane.
  - Surface area, square meters/gram, 115/130; particle diameter nanometers, 18-30; pH, 7.0-8.5, fixed carbon (moisture free), percent, 96-98; volatile matter, percent, 1-4; oil absorption, stiff paste end-point; CCS/gram, 0.80-0.90.
- \* A range of 4.0 to 5.0 parts is permitted in the A Component and 3.0 to 4.0 parts in the B Component, to achieve the required viscosity and thixotropy. Small preproduction batches should be made to determine the oleophilic silica level best suited for manufacturing equipment used.

**214-6.2.2 Standard-Set Epoxy Adhesive for Pavement Markers.** This specification covers a high viscosity paste standard-set epoxy formulated primarily for use in bonding pavement markers to portland cement concrete and asphalt concrete.

**TABLE 214-6.2.2 (A)**  
**COMPONENT A**

Ingredients	Parts by Weight
Epoxy Resin <sup>1</sup>	87.00
Aliphatic Glycidyl Ether <sup>2</sup>	13.00
Titanium Dioxide, ASTM Designation D 476	3.00
Oleophilic Fumed Silica <sup>3</sup>	6.50*
Talc <sup>4</sup>	34.00

## COMPONENT B

Ingredients	Parts by Weight
N-Aminoethyl Piperazine <sup>5</sup>	23.20
Nonylphenol <sup>6</sup>	52.00
Furnace Black <sup>7</sup>	0.10
Oleophilic Fumed Silica <sup>3</sup>	6.50*
Silicone Anti-Foam, Type DB 100, 100% Solids	0.005

- Di glycidyl ether of bisphenol A, viscosity 10-16 Pa·s (100-160 poise) at 25°C; weight per epoxide equivalent 180-200. Gardner 1933,3 maximum.
  - Aliphatic mono functional reactive glycidyl ether, derived from an aliphatic alcohol. Viscosity at 1-15 centipoise. Weight per epoxide equivalent 220-250. Specific gravity 0.88-0.95.
  - High purify fumed silica, surface treated with a silicone oil, with the following properties: Appearance, fluffy white powder; surface area, N<sub>2</sub> B.E.T. method 70 ± 15 square meters/gram; pH 4 grams dispersed in 100 milliliters of 20/80 volume mixture of ethyl alcohol and distilled water, 4.7; weight % carbon, 5.0 minimum; ignition loss (dry basis) 2 hours at 1000°C, 6 to 7; specify gravity, 1.8
  - Specify Gravity.....2.68 to 2.86  
Oil Absorption, ASTM D 281 .....26 to 33  
pH .....8.9 to 9.6  
Hegman Rating .....3 to 5  
Particle Shape .....Platey  
Maximum Particle Size, micrometers .....55  
Percentage passing U.S. 45 µm (No. 325 Screen), Min. ....99  
Dry Brightness, Min.....93
  - Color (APHA) 50 maximum; amine value 1250-1350 based on titration which reacts with the 3 nitrogens in the molecule; appearance clear and substantially free of suspended matter.
  - Color (APHA) 50 maximum; hydroxyl number 245-255; distillation range, °C at 760 millimeters first drop 295 minimum, 5% 298 minimum, 95% 325 maximum; water, % (K.F.) 0.05 maximum.
  - Surface area, square meters/gram, 115/130; particle diameter nanometers, 18-30; pH, 7.0-8.5, fixed carbon (moisture free), percent, 96-98; volatile matter, percent, 1-4; oil absorption, stiff paste end-point; CCS/gram, 0.80-0.90.
- \* A range of 6.0 to 7.0 parts is permitted in the A Component and B Component, to achieve the required viscosity and shear ratio.

**Tests:** All tests shall be performed in accordance with California Test 425.

## 214-7 BITUMINOUS ADHESIVE.

### 214-7.1 General.

**214-7.1.1 Description.** This specification covers a bituminous type hot-melt adhesive used for placement of pavement markers. The adhesive shall be suitable for bonding ceramic and plastic markers to portland cement concrete, asphaltic concrete, and chip-sealed road surfaces and applicable when road surface and marker temperatures are in the approximate range of 5°C to 70°C (40°F to 160°F). The composition of the adhesive must be such that its properties will not deteriorate when heated to and applied at temperatures up to 220°C (425°F) using either air or oil-jacketed melters.

**214-7.1.2 Sampling and Testing.** Bituminous adhesive shall not be used prior to sampling and testing.

All tests will be conducted with latest ASTM methods and the methods listed herein.

**214-7.1.3 Packaging, Labeling, and Storing.** The adhesive shall be packaged in self-releasing cardboard containers with essentially flat and parallel top and bottom surfaces such that the packages will stack properly. Each package shall have a net weight of either 23 or 27 kg (50 or 60 pounds) and shall weigh within 1 kg (2 pounds) of the stated quantity. Self-releasing cardboard dividers, which will separate each package into sections weighing no more than 7 kg (15 pounds) each, shall be part of the packaging. Each package shall show the manufacturer's name, net weight, and lot or batch number and shall be imprinted with "Bituminous Adhesive For Pavement Markers" or similar wording identifying the contents.

**214-7.1.4 Material Requirements.** The adhesive shall be an asphaltic material with a homogeneously mixed mineral filler and shall comply with the following requirements:

TABLE 214-7.1.4 (A)

ADHESIVE			
Property	Min.	Max.	Test Method No.
Softening Point, C° (°F)	99 (210)	110 (230)	ASTM D 36
Penetration, 100 g, 5 sec., 25°C (77°F)	8	16	ASTM D 5
Flow, mm (inch)	—	5 (0.2)	ASTM D 3407 <sup>1</sup>
Heat Stability Flow, mm (inch)	—	5 (0.2)	See Note 2
Viscosity, 200°C (400°F), Pa·s (Poise)	—	7.5 (75)	ASTM D 2669 <sup>3</sup>
Flash Point, C.O.C., °C (°F)	290 (550)	—	ASTM D 92
Recommended Pouring Temp., °C (°F)	200 (400)	220 (425)	
Shelf Life, years	—	2	
ASPHALT <sup>4</sup>			
Property	Min.	Max.	Test Method No.
Penetration, 100g, 5 sec., 25°C (77°F)	25	—	ASTM D 5
Viscosity, 135°C (275°F), Pa·s (Poise)	1.2 (12)	10 (100)	ASTM D 2171
Viscosity Ratio, 135°C (275°F)	—	2.2	See Note 5
FILLER <sup>6</sup>			
Property	Min.	Max.	Test Method No.
Filler Content, % by weight	65	75	See Note 6
Filler Fineness, % passing			ASTM C 430 <sup>7</sup>
75 µm (No. 200)	85	—	
150 µm (No. 100)	100	—	

- Flow shall be determined according to Section 6, Flow, of ASTM D 3407 with the exception that the oven temperature shall be 70°C ± 1°C (158° ± 2°F) and sample preparation shall be according to Section 7.1 of ASTM D 5.
- Heat Stability Flow shall be determined according to Flow with the exception that 1000 grams of adhesive shall be placed in a loosely-covered quart can, heated to 220°C (425°F) and maintained at this temperature for 4 hours to preparing the sample panel.
- Viscosity is to be determined according to ASTM D 2669 using a spindle speed of 10 rpm. The adhesive shall be heated to approximately 210°C (410°F) and allowed to cool. Viscosity shall be determined at 204° ± 0.5°C (400° ± 1°F).
- Properties of the base asphalt are to be determined on the material obtained from the following extraction and Abson recovery methods. The asphalt shall be extracted by heating the adhesive just to the point where it will easily flow and then transferring 125 to 150 grams into 400 milliliters of trichloroethylene with a temperature of 52°C to 66°C (125° to 150°F). This mixture shall be thoroughly stirred to dissolve the asphalt. The trichloroethylene-asphalt mixture shall be decanted and the asphalt shall be recovered using the Abson recovery methods. ASTM D 1856 as modified by the following. The extraction methods of ASTM D 2712 shall not apply and there shall be centrifuged for a least 30 minutes at 770 times gravity in a batch centrifuge. Decant this solution into the distillation flask, taking care not to include any filler sediment. Apply heat and bubble carbon dioxide slowly to bring the solution temperature to 149°C (300°F). At this point the carbon dioxide flow is increased to 800 to 900 milliliters per minute. The solution temperature maintained at 160° to 168°C (320° to 335°F) with this carbon dioxide flow rate for at least 20 minutes and until the trichloroethylene vapors have been completely removed from the distillation flask. The above extraction-recovery method shall be repeated as necessary to obtain the desired quantity to asphalt. The asphalt recovered shall be used to determine penetration, 135°C (275°F) viscosity, and 135°C (275°F) viscosity ratio.
- The 135°C (275°F) viscosity ratio shall be determined by comparing the 135°C (275°F) viscosity on the base asphalt before and after the Thin-Film Oven Test. The Thin-Film Oven Test shall be performed as in ASTM D 1754. The specific gravity shall be determined by pycnometer as in ASTM D 70 for use in the Thin-Film Oven Test. The 135°C (275°F) viscosity ratio shall be calculated by dividing the viscosity after the Thin-Film Oven Test by the original 135°C (275°F) viscosity.
- The filler material shall be separated from the asphalt to determine Filler content and Filler Fineness. The portion by weight of the adhesive insoluble in 1,1,1-trichloroethylene shall be considered the filler content. Filler Content shall be determined by weighing 10.00 ± 0.01 grams of solid adhesive into a centrifuge flask with approximately 100 milliliters volume such as that specified in ASTM D 1796. Add 50 milliliters of 1,1,1-trichloroethylene to the adhesive, which should be broken up into small pieces in order to speed the dissolution process. Swirl or stir with a fine rod, taking care not to lose any solids. Place the sample flask in a balanced centrifuge and spin using a minimum relative centrifugal force of 150 (as determined in Section 6 of ASTM D 1796) for 10 minutes. Remove the sample flask and decant the solvent, taking care not to lose any solids. Repeat the application of solvent and centrifuging until the solvent becomes clear and the filler a visually free of asphalt. Dry the filler at 71° ± 3°C (160° ± 5°F) to remove solvent and weigh the resulting filler. Filtration of the decanted solvent may be performed to verify that there is no loss of filler. Percent filler content is calculated as follows:

$$\text{Filler Content, \% by wt} = \frac{(\text{Filler wt, gm}) (100)}{\text{Original Adhesive wt, gm}}$$

- Filler Fineness shall be determined according to ASTM C 430 using 75 µm and 150 µm (Nos. 200 and 100) sieves. This method is to be modified by the use of a water-soluble non-ionic wetting agent, such as Triton X-100, to aid the wetting action. Concentration of the surfactant solution shall be approximately 1 percent by weight. The 1-gram dry sample shall be thoroughly wetted in the surfactant solution and allowed to soak for 30 minutes. The filler shall be transferred completely into the sieve cup and water-spray applied for 2 minutes. Surfactant solution may be added as needed and physical means used in disperse any clumped particles. The sample shall then be dried and handled as directed in ASTM C 430.

The following table shows the estimated effects of the monetary policy response to the 2001 recession. The table is organized into two main sections: the top section shows the response to the 2001 recession, and the bottom section shows the response to the 2003 recession. The columns represent different variables, and the rows represent different time horizons. The numbers in the table are the estimated coefficients, and the numbers in parentheses are the standard errors. The asterisks indicate statistical significance at the 10 percent level.

Variable	2001 Recession	2003 Recession
Real GDP	0.000 (0.000)	0.000 (0.000)
Real GDP (2001)	0.000 (0.000)	0.000 (0.000)
Real GDP (2002)	0.000 (0.000)	0.000 (0.000)
Real GDP (2003)	0.000 (0.000)	0.000 (0.000)
Real GDP (2004)	0.000 (0.000)	0.000 (0.000)
Real GDP (2005)	0.000 (0.000)	0.000 (0.000)
Real GDP (2006)	0.000 (0.000)	0.000 (0.000)
Real GDP (2007)	0.000 (0.000)	0.000 (0.000)
Real GDP (2008)	0.000 (0.000)	0.000 (0.000)
Real GDP (2009)	0.000 (0.000)	0.000 (0.000)
Real GDP (2010)	0.000 (0.000)	0.000 (0.000)
Real GDP (2011)	0.000 (0.000)	0.000 (0.000)
Real GDP (2012)	0.000 (0.000)	0.000 (0.000)
Real GDP (2013)	0.000 (0.000)	0.000 (0.000)
Real GDP (2014)	0.000 (0.000)	0.000 (0.000)
Real GDP (2015)	0.000 (0.000)	0.000 (0.000)
Real GDP (2016)	0.000 (0.000)	0.000 (0.000)
Real GDP (2017)	0.000 (0.000)	0.000 (0.000)
Real GDP (2018)	0.000 (0.000)	0.000 (0.000)
Real GDP (2019)	0.000 (0.000)	0.000 (0.000)
Real GDP (2020)	0.000 (0.000)	0.000 (0.000)
Real GDP (2021)	0.000 (0.000)	0.000 (0.000)
Real GDP (2022)	0.000 (0.000)	0.000 (0.000)
Real GDP (2023)	0.000 (0.000)	0.000 (0.000)
Real GDP (2024)	0.000 (0.000)	0.000 (0.000)
Real GDP (2025)	0.000 (0.000)	0.000 (0.000)
Real GDP (2026)	0.000 (0.000)	0.000 (0.000)
Real GDP (2027)	0.000 (0.000)	0.000 (0.000)
Real GDP (2028)	0.000 (0.000)	0.000 (0.000)
Real GDP (2029)	0.000 (0.000)	0.000 (0.000)
Real GDP (2030)	0.000 (0.000)	0.000 (0.000)
Real GDP (2031)	0.000 (0.000)	0.000 (0.000)
Real GDP (2032)	0.000 (0.000)	0.000 (0.000)
Real GDP (2033)	0.000 (0.000)	0.000 (0.000)
Real GDP (2034)	0.000 (0.000)	0.000 (0.000)
Real GDP (2035)	0.000 (0.000)	0.000 (0.000)
Real GDP (2036)	0.000 (0.000)	0.000 (0.000)
Real GDP (2037)	0.000 (0.000)	0.000 (0.000)
Real GDP (2038)	0.000 (0.000)	0.000 (0.000)
Real GDP (2039)	0.000 (0.000)	0.000 (0.000)
Real GDP (2040)	0.000 (0.000)	0.000 (0.000)
Real GDP (2041)	0.000 (0.000)	0.000 (0.000)
Real GDP (2042)	0.000 (0.000)	0.000 (0.000)
Real GDP (2043)	0.000 (0.000)	0.000 (0.000)
Real GDP (2044)	0.000 (0.000)	0.000 (0.000)
Real GDP (2045)	0.000 (0.000)	0.000 (0.000)
Real GDP (2046)	0.000 (0.000)	0.000 (0.000)
Real GDP (2047)	0.000 (0.000)	0.000 (0.000)
Real GDP (2048)	0.000 (0.000)	0.000 (0.000)
Real GDP (2049)	0.000 (0.000)	0.000 (0.000)
Real GDP (2050)	0.000 (0.000)	0.000 (0.000)
Real GDP (2051)	0.000 (0.000)	0.000 (0.000)
Real GDP (2052)	0.000 (0.000)	0.000 (0.000)
Real GDP (2053)	0.000 (0.000)	0.000 (0.000)
Real GDP (2054)	0.000 (0.000)	0.000 (0.000)
Real GDP (2055)	0.000 (0.000)	0.000 (0.000)
Real GDP (2056)	0.000 (0.000)	0.000 (0.000)
Real GDP (2057)	0.000 (0.000)	0.000 (0.000)
Real GDP (2058)	0.000 (0.000)	0.000 (0.000)
Real GDP (2059)	0.000 (0.000)	0.000 (0.000)
Real GDP (2060)	0.000 (0.000)	0.000 (0.000)
Real GDP (2061)	0.000 (0.000)	0.000 (0.000)
Real GDP (2062)	0.000 (0.000)	0.000 (0.000)
Real GDP (2063)	0.000 (0.000)	0.000 (0.000)
Real GDP (2064)	0.000 (0.000)	0.000 (0.000)
Real GDP (2065)	0.000 (0.000)	0.000 (0.000)
Real GDP (2066)	0.000 (0.000)	0.000 (0.000)
Real GDP (2067)	0.000 (0.000)	0.000 (0.000)
Real GDP (2068)	0.000 (0.000)	0.000 (0.000)
Real GDP (2069)	0.000 (0.000)	0.000 (0.000)
Real GDP (2070)	0.000 (0.000)	0.000 (0.000)
Real GDP (2071)	0.000 (0.000)	0.000 (0.000)
Real GDP (2072)	0.000 (0.000)	0.000 (0.000)
Real GDP (2073)	0.000 (0.000)	0.000 (0.000)
Real GDP (2074)	0.000 (0.000)	0.000 (0.000)
Real GDP (2075)	0.000 (0.000)	0.000 (0.000)
Real GDP (2076)	0.000 (0.000)	0.000 (0.000)
Real GDP (2077)	0.000 (0.000)	0.000 (0.000)
Real GDP (2078)	0.000 (0.000)	0.000 (0.000)
Real GDP (2079)	0.000 (0.000)	0.000 (0.000)
Real GDP (2080)	0.000 (0.000)	0.000 (0.000)
Real GDP (2081)	0.000 (0.000)	0.000 (0.000)
Real GDP (2082)	0.000 (0.000)	0.000 (0.000)
Real GDP (2083)	0.000 (0.000)	0.000 (0.000)
Real GDP (2084)	0.000 (0.000)	0.000 (0.000)
Real GDP (2085)	0.000 (0.000)	0.000 (0.000)
Real GDP (2086)	0.000 (0.000)	0.000 (0.000)
Real GDP (2087)	0.000 (0.000)	0.000 (0.000)
Real GDP (2088)	0.000 (0.000)	0.000 (0.000)
Real GDP (2089)	0.000 (0.000)	0.000 (0.000)
Real GDP (2090)	0.000 (0.000)	0.000 (0.000)
Real GDP (2091)	0.000 (0.000)	0.000 (0.000)
Real GDP (2092)	0.000 (0.000)	0.000 (0.000)
Real GDP (2093)	0.000 (0.000)	0.000 (0.000)
Real GDP (2094)	0.000 (0.000)	0.000 (0.000)
Real GDP (2095)	0.000 (0.000)	0.000 (0.000)
Real GDP (2096)	0.000 (0.000)	0.000 (0.000)
Real GDP (2097)	0.000 (0.000)	0.000 (0.000)
Real GDP (2098)	0.000 (0.000)	0.000 (0.000)
Real GDP (2099)	0.000 (0.000)	0.000 (0.000)
Real GDP (2100)	0.000 (0.000)	0.000 (0.000)

# PART 3

## CONSTRUCTION METHODS

### SECTION 300 - EARTHWORK

#### 300-1 CLEARING AND GRUBBING.

**300-1.1 General.** Clearing and grubbing operations preceding construction of debris dams and basins shall comply with 300-6.2.

Clearing and grubbing shall consist of removing all natural and artificial objectionable materials from the right-of-way in construction areas, road approaches, material sites within the right-of-way, areas through which ditches and channels are to be excavated, and such other areas as may be shown in the Specifications. This work shall be performed in advance of grading operations and in accordance with the requirements herein specified, subject to erosion control requirements. Demolition of buildings and structures, other than foundations or slabs, shall be as shown in the Plans or in the Specifications.

The natural ground surface shall be cleared of all vegetable growth, such as trees, logs, upturned stumps, roots of downed trees, brush, grass, weeds, and all other objectionable materials, within the limits of construction.

Grubbing shall extend to the outside excavation and fill slope lines, except that where slopes are to be rounded, the areas shall extend to the outside limits of slope rounding. Within the limits of clearing, all stumps, roots 40 mm (1-1/2 inches) in diameter or larger, buried logs, and all other objectionable material shall be removed 1 m (3 feet) below the existing ground surface or subgrade, whichever is deeper.

No payment will be made to the Contractor for clearing and grubbing outside the stated limits, unless such work is authorized by the Engineer.

Trees and plants that are not to be removed shall be fully protected from injury by the Contractor at its expense. Trees shall be removed in such a manner as not to injure standing trees, plants, and improvements which are to be preserved.

Tree branches which hang within 4.1 m (13.5 feet) above finished roadway grade or within 2.7 m (9 feet) above finished sidewalk or parkway grade shall be cut off to the boles in a workmanlike manner. The Contractor shall remove additional tree branches under the direction of the Engineer, in such a manner that the tree will present a balanced appearance. Scars resulting from the removal of branches shall be treated with a heavy coat of an approved tree sealant.

**300-1.2 Preservation of Property.** Existing improvements, adjacent property, utility and other facilities, and trees and plants that are not to be removed shall be protected from injury or damage as provided for in 7-9.

#### 300-1.3 Removal and Disposal of Materials.

**300-1.3.1 General.** All materials removed shall be disposed of outside of the right-of-way, unless burning is permitted. Burning shall be done only if permitted by local regulations and at such times and in such manner as to prevent the fire from spreading to areas adjoining the right-of-way. In case burning precedes construction operations, the piles may be placed in the most convenient location at the side of the right-of-way and beyond slope lines where they may be burned without damage to the surrounding area. No accumulation of flammable material shall remain on or adjacent to the right-of-way. The roadway and adjacent areas shall be left with a neat and finished appearance.

**300-1.3.2 Requirements.**

(a) **Bituminous Pavement.** Bituminous pavement shall be removed to clean, straight lines. Saw cutting of edges to be joined is optional. Where only the surface of existing bituminous pavement is to be removed, the method of removal shall be approved by the Engineer, and a minimum laying depth of 25 mm (1 inch) of new pavement material shall be provided at the join line. Where bituminous pavement adjoins a trench, the edges adjacent to the trench shall be trimmed to neat straight lines before resurfacing to ensure that all areas to be resurfaced are accessible to the rollers used to compact the subgrade or paving materials.

(b) **Concrete Pavement.** Concrete pavement shall be removed to neatly sawed edges. Saw cuts shall be made to a minimum depth of 38 mm (1-1/2 inches). If a saw cut in concrete pavement falls within 1 m (3 feet) of a construction joint, cold joint, expansion joint, or edge, the concrete shall be removed to the joint or edge. The edges of existing concrete pavement adjacent to trenches, where damaged subsequent to saw cutting of the pavement, shall again be saw cut to neat, straight lines for the purpose of removing the damaged pavement areas. Such saw cuts shall be either parallel to the original saw cuts or shall be cut on an angle which departs from the original saw cut not more than 25 mm (1 inch) in each 150 mm (6 inches).

(c) **Concrete Curb, Walk, Gutters, Cross Gutters, Driveways, and Alley Intersections.** Concrete shall be removed to neatly sawed edges with saw cuts made to a minimum depth of 38 mm (1-1/2 inches). Concrete sidewalk or driveway to be removed shall be neatly sawed in straight lines either parallel to the curb or at right angles to the alignment of the sidewalk. No section to be replaced shall be smaller than 750 mm (30 inches) in either length or width. If the saw cut in sidewalk or driveway would fall within 750 mm (30 inches) of a construction joint, expansion joint, or edge, the concrete shall be removed to the joint or edge, except that where the saw cut would fall within 300 mm (12 inches) of a score mark, the saw cut shall be made in and along the score mark. Curb and gutter shall be sawed to a depth of 38 mm (1-1/2 inches) on a neat line at right angles to the curb face.

**300-1.4 Payment.** The lump sum price, or the price per acre, bid for clearing and grubbing shall include full compensation for removal and disposal of all the resulting materials.

When the Contract does not include a pay item for clearing and grubbing as specified above, and unless otherwise provided in the Specifications, full compensation for any necessary clearing and grubbing required to perform the construction operations specified shall be included in the price bid for other items of work and no additional compensation will be allowed therefore.

**300-2 UNCLASSIFIED EXCAVATION.**

**300-2.1 General.** Unclassified excavation shall consist of all excavation, including roadways, unless separately designated.

**300-2.2 Unsuitable Material.**

**300-2.2.1 General.** Material that is unsuitable for its planned use shall be excavated and disposed of as directed by the Engineer.

The removal and disposal of such unsuitable material will be paid for as unclassified excavation for the quantities involved if the removal of such material is shown on the Plans or in the Specifications.

If the removal of unsuitable material is not shown on the Plans or in the Specifications, the removal and disposal of such unsuitable materials will be paid for at the Contract Unit Price for unclassified excavation. However, if due to the character of the work, the removal and disposal of the unsuitable material is not properly compensable at the Contract Unit Price for unclassified excavation, the work may be paid for in accordance with Section 3.

**300-2.2.2 Wet Material.** If required excavated material is unsatisfactory for the specified use on the project solely because of high moisture content, the Contractor may be directed by the Engineer to either process the material to reduce the moisture content to an optimum condition, or to remove the material and replace it with suitable material. If such high moisture content is not the result of any action on the part of the Contractor, or inaction in protecting the work during the course of the Contract, the work involved will be paid for in accordance with Section 3. Otherwise, the Contractor shall submit to the Engineer for approval, a plan for drying or removing and replacing the wet material, and such work and material shall be at the expense of the Contractor.

**300-2.3 Overshooting.** Excessive blasting will not be permitted. Material outside the authorized cross section which may be shattered or loosened because of blasting shall be removed at the Contractor's expense. The Contractor shall discontinue any method of blasting which leads to overshooting, is hazardous to the public, or is destructive to property or natural features.

**300-2.4 Slides and Slipouts.** Material outside the planned excavation limits which is unstable and constitutes a potential slide as determined by the Engineer, material which has come into the planned excavation limits, and material which has slipped out of new or old fills shall be excavated to designated lines or slopes either by benching or in such manner as directed by the Engineer. Such material may be used in the construction of an unclassified fill or disposed of as directed by the Engineer.

The removal and disposal of slide and slipout material as above specified, not resulting from overshooting as specified in 300-2.3 and not resulting from any act or failure to act on the part of the Contractor, will be paid for at the Contract Unit Price for unclassified excavation for the quantities involved.

However, if due to the character of the work, the removal and disposal of such material is not properly compensable at the Contract Unit Prices for unclassified excavation, the work may be paid for as provided in Section 3.

Payment will be made only for those quantities of slide or slipout material which are actually removed as ordered by the Engineer.

**300-2.5 Slopes.** Excavation slopes shall be finished in conformance with the lines and grades shown on the Plans. All debris and loose material shall be removed. When completed, the average plane of the slopes shall conform to the slopes indicated on the Plans and no point on the completed slopes shall vary from the designated plane by more than 150 mm (6 inches) measured at right angles to the slope. Where excavation is in rock, no point shall vary more than 600 mm (2 feet) from the designated plane of the slope. In no case shall any portion of the slope encroach so as to interfere with the planned use of the facility.

The tops of excavation slopes and the ends of excavations shall be rounded where shown on the Plans, and these quantities will not be included in the quantities to be paid for as excavation. This work will be considered as a part of finishing slopes and no additional compensation will be allowed therefore.

**300-2.6 Surplus Material.** Unless otherwise shown on the Plans or in the Specifications, no surplus excavated material may be disposed of within the right-of-way. The Contractor shall make all arrangements for disposal of the material at offsite locations and shall, upon request, file with the Engineer the written consent of the owner of the property upon which it intends to dispose of such material.

Quantities of surplus material, if shown on the Plans or in the Specifications, are approximate only. The Contractor shall satisfy itself that there is sufficient material available for the completion of the fills before disposing of any indicated surplus material inside or outside the right-of-way. Any shortage of material, caused by premature disposal of the indicated surplus material by the Contractor, shall be replaced by it and no compensation will be allowed for such replacement.

**300-2.7 Selected Material.** Selected material encountered in excavation within the right-of-way shall be used as shown on the Plans, in the Specifications, or as directed by the Engineer. Topsoil excavated within the limits of the project may be considered as a selected material only for the purpose of backfilling areas to be planted.

**300-2.8 Measurement.** The following earthwork operations will be measured as unclassified excavation for the quantities of material involved:

- 1) Excavating the roadway prism including public and private road approaches;
- 2) Connections and driveways;
- 3) Excavating unsuitable material when shown on the Plans or in the Specifications;
- 4) Excavating slides and slipouts not resulting from overshooting;
- 5) Excavating surplus material;
- 6) Excavating selected material and topsoil from within the limits of project and removing such materials from stockpiles when stockpiling is ordered;
- 7) Excavating local borrow.

Measurement of material removed from required stockpiles will be based on the volume it occupies in its final position after compaction.

Excavation in excess of the planned or authorized cross section will not be paid for, except as provided in 300-2.2. and 300-2.4. The Contractor shall backfill and compact unauthorized excavated areas to the original ground elevation or authorized section at its expense.

Care shall be exercised to prevent excavating below grade. Areas excavated below grade shall be filled with suitable material and compacted by the Contractor at its expense.

**300-2.9 Payment.** Payment for all unclassified excavation will be made at the Contract Unit Price per cubic meter (cubic yard). Payment for unclassified excavation shall include compensation for excavating, sloping, rounding tops and ends of excavations, loading, disposing of surplus material, stockpiling, and hauling it to its final location.

Where required by the Plans or Specifications or where directed by the Engineer, the excavating and stockpiling of selected material will be paid for at the Contract Unit Price for unclassified excavation. Removing such selected material from the stockpile and placing it in its final position will also be paid for at the Contract Unit Price for unclassified excavation. The Contractor may stockpile material; however, no separate payment will be made for excavating material from an optional stockpile and placing it in its final position.

No separate payment will be made for excavating topsoil temporarily stockpiled along the top of slopes and placing it in its final position on the slope for erosion control planting work, whether or not required by the Contract Documents or by the Engineer.

### 300-3 STRUCTURE EXCAVATION AND BACKFILL.

**300-3.1 General.** Structure excavation shall consist of the removal of material for the construction of foundations for bridges, retaining walls, headwalls, culverts, or other structures, and other excavation designated on the Plans or in the Specifications as structure excavation. Excavation and backfill for underground conduit construction, including box conduit, shall be in accordance with Section 306.

Structure backfill shall consist of furnishing material, if necessary, and placing and compacting backfill material around structures to the lines designated on the Plans.

Structure excavation and structure backfill shall include the furnishing of all materials and equipment; the construction or installation of all cofferdams and other facilities which may be necessary to perform the excavations and to place and compact the backfill; and the subsequent removal of such facilities, except where they are required or permitted by the Plans or Specifications to remain in place.

**300-3.2 Cofferdams.** Cofferdams for foundation construction shall be carried well below the bottom of the footings and shall be well braced and reasonably watertight. The interior dimensions of cofferdams shall provide sufficient clearance inside the wales for constructing forms and driving piles and to permit pumping outside the forms.

If in the judgment of the Contractor, the clearance provided on the Plans between the outside line of the footing and any pile or interior wall or surface is not sufficient to permit the driving of piles or building of forms, it may provide such necessary clearance by constructing the cofferdam sufficiently large to provide such clearances as may be deemed necessary. Any such enlargement in excess of 0.3 m (1 foot) outside the dimensions of the footing as shown on the Plans shall be considered as being for the sole purpose of expediting the work of the Contractor and such excavation and backfill shall be at the Contractor's expense.

Cofferdams which are tilted or moved out of position by any cause during the process of sinking shall be plumbed or enlarged to provide the necessary clearance and proper pier location and such work shall be at the Contractor's expense.

In tidal waters or in streams at a time of probable flood, cofferdam walls shall be vented at low water elevation to ensure equal hydrostatic head both inside and outside of the cofferdam during the period of pouring and setting of seals.

No shoring will be permitted in cofferdams which will induce stress, shock, or vibration in the permanent structure.

When permitted by the Engineer, cross struts or bracing may extend through foundation concrete. Such struts or bracing below low water will be permitted to remain in place, except in navigable streams or, when shown on the Plans or in the Specifications to be removed. Struts or bracing above low water shall be removed and the resulting space filled with concrete of the same mix as that specified for the surrounding concrete.

For substructure work, the Contractor shall, in accordance with 2-5.3, submit drawings showing the proposed method of cofferdam construction and other details left open to choice or not fully shown on the Plans. The type and clearance of cofferdams, insofar as such details affect the character of the finished work, will be subject to the approval of the Engineer, but other details of design will be left to the Contractor, who shall be responsible for the successful construction of the work.

After completion of the substructure, the cofferdams with all sheeting and bracing shall be removed to at least 0.6 m (2 feet) below the level of the streambed by the Contractor at its expense and such removal shall be performed in a manner that will not disturb or mar the finished concrete or masonry.

**300-3.3 Foundation Material Treatment.** When footing concrete or masonry is to rest upon rock, the rock shall be fully uncovered and the surface thereof shall be removed to a depth sufficient to expose sound rock. The rock shall be roughly leveled off or cut to approximate horizontal and vertical steps, and shall be roughened. Seams in the rock shall be grouted under pressure or treated as the Engineer may direct and the cost thereof will be paid for as extra work.

When no piles are used and footing concrete or masonry is to rest on an excavated surface other than rock, care shall be taken not to disturb the bottom of the excavation. Final removal of the foundation material to grade shall not be made until just before the concrete or masonry is placed. Except when overexcavation is directed by the Engineer, excavation below grade shall be replaced at the Contractor's expense with the same class of concrete specified for the structure and at the time the concrete for the structure is being placed. Where it is determined by the Engineer that it will not be detrimental to the structure, the Contractor may backfill above grade with not less than 90 percent relative compaction and then trim to the specified grade.

Where the original ground is below the specified elevation for footings, the Contractor shall backfill to 150 mm (6 inches) above grade with not less than 90 percent relative compaction and then excavate to the prescribed grade prior to placing concrete.

The excavation for piers and abutments shall be completed to the bottom of the footings before any piles are driven therein, and excess material remaining in the excavation after pile driving shall be removed to the elevation of the bottom of the footings.

When piles are used and ground displacement results from pile driving operations, the Contractor shall at its expense excavate or backfill the footing area to the grade of the bottom of the footing as shown on the Plans with structure backfill material.

**300-3.4 Inspection.** Whenever any structure excavation is completed, the Contractor shall notify the Engineer who will make an inspection of the foundation. No concrete or masonry shall be placed until the foundation has been approved by the Engineer.

**300-3.5 Structure Backfill.**

**300-3.5.1 Requirements.** Structure backfill shall not be placed until the structure has been inspected by the Engineer and approved for backfilling. No backfill material shall be deposited against the back of concrete abutments or concrete retaining walls, until the concrete has developed not less than the specified 28-day compressive strength. Backfill at the inside of bridge wingwalls shall be placed before railing bases on the wingwalls are constructed.

Material used for structure backfill shall have a sand equivalent of not less than 20 and shall have the following grading:

**TABLE 300-3.5.1 (A)**

Sieve Size	Percent Passing
100 mm (4 in)	100
4.75 mm (No. 4)	35 - 100
600 $\mu$ m (No. 30)	20 - 100

Structure backfill shall be placed in accordance with 300-4.5 and shall be mechanically compacted to a minimum relative compaction of 90 percent.

Where consolidation of structure backfill by jetting is permitted by the Plans or Specifications, the following conditions shall apply:

- 1) Backfill material shall be placed and consolidated in layers not exceeding 1.2 m (4 feet) in thickness.
- 2) The jetting shall be performed without softening the embankment and in a manner that excess water will not be impounded.
- 3) Jetting methods shall be supplemented by the use of vibratory or other consolidation equipment when necessary to obtain 90 percent relative compaction.
- 4) The upper 0.9 m (3 feet) below finished subgrade shall be mechanically compacted in roadway areas.

**300-3.5.2 Pervious Backfill.** Pervious backfill material shall be placed behind bridge abutments, wingwalls, and retaining walls as shown on the Plans and in accordance with the following requirements.

Pervious backfill material shall consist of gravel, crushed gravel, crushed rock, natural sands, manufactured sand, or combinations thereof and shall conform to the following grading requirements:

**TABLE 300-3.5.2 (A)**

Sieve Size	Percent Passing
19 mm (3/4 in)	100
9.5 mm (3/8 in)	80 - 100
150 $\mu$ m (No. 100)	0 - 8
75 $\mu$ m (No. 200)	0 - 3

That portion of filter material passing a 4.75 mm (No. 4) sieve shall have a sand equivalent of not less than 60.

All weep holes shall be backed with 0.06 m<sup>3</sup> (2 cubic feet) of material conforming to the requirements for No. 3 Concrete Aggregate as specified in 200-1.4; securely tied in a burlap sack; and placed in such a manner that the backing covers the weep holes and extends at least 300 mm (12 inches) above the bottom of the opening. A 200 mm (8 inch) square section of 6 mm (1/4 inch) galvanized or aluminum screen having a minimum wire diameter of 0.8 mm (0.03 inch) shall be firmly attached at the back of each weep hole before the material is placed.

Pervious backfill material shall be placed in layers along with and by the same methods specified for structure backfill. Pervious backfill material at any one location shall be approximately the same grading, and, at locations where the material would otherwise be exposed to erosion, shall be covered with at least a 0.3 m (1 foot) layer of earthy material approved by the Engineer.

**300-3.6 Payment.** Unless otherwise provided in the Specifications of the Bid, no payment will be made for structure excavation or backfill. The cost thereof shall be considered as included in the price bid for the construction or installation of the item to which such excavation or backfill is incidental or appurtenant. Unless otherwise shown on the Plans, the quantity of the structure excavation, where paid for as a separate item or not, shall be that volume in place included within the vertical plane 0.3 m (1 foot) outside of and parallel with the outermost horizontal dimensions of the structure and the surface of the existing ground, final ground surface, or proposed street subgrade, whichever is lower, and the footing subgrade. Structure backfill will be measured to the finished ground surface, or to the proposed street subgrade, whichever is lower, within the limits specified above.

### **300-4 UNCLASSIFIED FILL.**

**300-4.1 General.** Unclassified fill shall consist of all fill unless separately designated. Construction of unclassified fill includes preparing the area on which fill is to be placed, and the depositing, conditioning, and compacting of fill material.

Rocks, broken concrete, or other solid materials which are larger than 100 mm (4 inches) in greatest dimension shall not be placed in fill areas where piles are to be placed or driven.

Clods or hard lumps of earth of 150 mm (6 inches) in greatest dimension shall be broken up before compacting the material in fill, except when the fill material originating from the project contains large rocks, boulders, or hard lumps (such as hardpan or cemented gravel which cannot be broken readily) over 300 mm (12 inches) in greatest dimension, such materials may be incorporated in the fill. The location and depth of its placement in the fill and the method to be used shall be subject to the approval of the Engineer.

Fills shall not be constructed when material is frozen or a blanket of snow prevents proper compaction.

**300-4.2 Preparation of Fill Areas.** Areas over which fills are to be placed shall first be cleared and grubbed in accordance with the provisions of 300-1. The areas shall then be scarified to provide a bond between the existing ground and the material to be deposited thereon.

When fills are designated to be placed over existing surface improvements which are to remain in place, 100 mm (4 inch) drainage holes shall be made through the structure on 1.5 m (5 foot) centers each way or the pavement shall be broken in a grid pattern of 1.5 m (5 feet) each way.

**300-4.3 Other Fill Materials.** Brick rubble, broken asphalt pavement, and broken concrete originating from the project may be disposed of at the Contractor's expense off the Work site, or incorporated in the fill in conformance with 300-4.1. Unless otherwise provided, no such materials may be imported from outside the project limits.

**300-4.4 Benching.** When fill is to be made and compacted against hillsides or existing fill, the slopes of original hillsides and old or new fills shall be horizontally benched to key the fill material to the underlying ground. A minimum of 0.6 m (2 feet) normal to the slope of the original hillside and old or new fill shall be removed and recompacted, as the fill is brought up in layers, to ensure that the new work is constructed on a firm foundation free of loose or disturbed material. For the purpose of this subsection, fill slopes or hillsides shall be defined as steeper than 1 vertical in 4 horizontal. Slopes 1 vertical in 4 horizontal or flatter shall be prepared in conformance with 300-4.2.

Material thus cut shall be recompacted along with new fill material at the Contractor's expense, unless additional excavation is ordered by the Engineer. The additional excavation will be measured and paid for as unclassified excavation.

**300-4.5 Placing Materials for Fills.** Fill material shall be placed in horizontal layers of depths compatible to the material being placed and the type of equipment being used. Each layer shall be evenly spread and moistened or aerated, as necessary. Unless otherwise approved by the Engineer, each layer spread for compaction shall not exceed 200 mm (8 inches) of compacted thickness.

Unless otherwise permitted by the Engineer, each layer of fill material shall cover the length and width of the area to be filled before the next higher layer of material is placed. The top surface of each layer shall be approximately level, but with a crown or crossfall of at least 1 vertical in 50 horizontal, but no more than 1 vertical in 20 horizontal, to provide adequate drainage at all times during the construction period.

When fill material contains by volume over 25 percent of rock larger than 150 mm (6 inches) in greatest dimension, the fill below a plane 1 m (3 feet) from finished grade may be constructed in layers

of a loose thickness before compaction up to the maximum size of rock in the material, but not exceeding 1 m (3 feet) in thickness. The interstices around the rock in each layer shall be filled with earth or other fine material and compacted.

Broken portland cement concrete and bituminous type pavement obtained from the project excavation will be permitted in the fill with the following limitations:

- 1) The maximum dimension of any piece used shall be 150 mm (6 inches).
- 2) Pieces larger than 100 mm (4 inches) shall not be placed within 300 mm (12 inches) of any structure.
- 3) Pieces larger than 75 mm (3 inches) shall not be placed within 300 mm (12 inches) of the subgrade for paving.
- 4) "Nesting" of pieces will not be permitted.

**300-4.6 Application of Water.** At the time of compaction, the moisture content of fill material shall be such that the specified relative compaction will be obtained and the fill will be firm, hard, and unyielding. Fill material which contains excessive moisture shall not be compacted until the material is dry enough to obtain the required relative compaction.

Subject to the approval of the Engineer, the Contractor may use chemical additives in water to be applied to fill material. Where reasonable grounds exist for concern that the use of a chemical additive will be in any way detrimental, the Engineer may prohibit its use.

The furnishing and application of such additives shall be at the Contractor's expense.

**300-4.7 Compaction.** Each layer of earth fill shall be compacted by approved tamping or sheepfoot rollers, pneumatic-tired rollers, or other mechanical means acceptable to the Engineer, to such extent as will produce the specified relative compaction. At locations where it would be impractical because of inaccessibility to use such compacting equipment, fill layers shall be compacted to the specified requirements by hand-directed compaction equipment.

Unless otherwise specified, each layer of earth fill shall be compacted to a relative compaction of at least 90 percent.

When soil types, or a combination of soil types, are encountered which tend to develop densely packed surfaces as a result of spreading or compacting operations, the surface of each layer of fill shall be sufficiently roughened after compaction to ensure bond to the succeeding layer.

**300-4.8 Slopes.** Fill slopes shall be finished in conformance with the lines and grades shown on the Plans. When completed, the average plane of the slopes shall conform to the slopes indicated on the Plans and no point on the completed slopes shall vary from the designated plane by more than 150 mm (6 inches) measured at right angles to the slope.

**300-4.9 Measurement and Payment.** The Contract Unit Price bid for unclassified fill shall include full compensation for the all grading, shaping, compacting or consolidating, or other work that is required under this subsection. The quantities used in determining payment for unclassified fill shall be those of the completed fills within the limits shown on the Plans or as directed by the Engineer.

### **300-5 BORROW EXCAVATION.**

**300-5.1 Local Borrow.** Local borrow shall consist of material excavated and used in the construction of fills, for use as selected material or for other construction purposes. Local borrow shall be obtained by widening cuts or by excavating from other sources outside the planned or authorized cross section within the right-of-way and within the limits of the project. Local borrow shall be material

which is excavated from sources specified or designated by the Engineer. The sources of material to be excavated shall be approved in advance by the Engineer. Local borrow shall be excavated to the lines and grades established by the Engineer.

**300-5.2 Imported Borrow.** Imported borrow shall consist of material required for construction of fills, and unless otherwise designated in the Specifications, the Contractor shall make arrangements for obtaining imported borrow and shall pay all costs involved.

The Contractor shall notify the Engineer sufficiently in advance of opening any borrow site so that adequate time will be allowed for testing the material and establishing cross section elevations and measurements of the ground surface.

**300-5.3 Placing and Compacting.** Borrow shall be placed and compacted as specified in 300-4.

The Contractor shall satisfy itself that there is sufficient space available in fill locations for placing any excavated material before placing imported borrow. Any excess excavation which develops as a result of placing imported borrow in advance of completing excavations shall be disposed of at the Contractor's expense in accordance with the provisions of 300-2.6. A corresponding reduction in the quantity of imported borrow to be paid for will be made, for which the Contractor will have no claim for compensation.

**300-5.4 Measurement and Payment.** Quantities of local borrow will be measured and paid as specified for unclassified excavation in 300-2.8 and 300-2.9.

Quantities of imported borrow will be measured and paid in accordance with the Specifications.

## **300-6 EARTHWORK FOR DEBRIS DAMS AND BASINS.**

**300-6.1 General.** Earthwork for debris dams and basins shall include clearing, stripping, excavation, fill, backfill, grading, and disposal of excess excavated material.

**300-6.2 Clearing and Grubbing.** Unless otherwise specified, the entire area of all rights-of-way shall be cleared of all trees and brush by cutting at the ground surface. All main root clusters shall be entirely removed from areas upon which improvements are to be constructed, and in addition, those areas upon which compacted fills are to be constructed shall be grubbed as follows:

Individual roots of diameters between 13 mm (1/2 inch) and 40 mm (1-1/2) inches shall be removed to a depth of not less than 0.3 m (1 foot) below natural ground. Larger roots shall be removed down to the level at which the root diameter is 40 mm (1-1/2 inches) or less. Regardless of diameter, no roots need to be removed to a depth greater than 1 m (3 feet).

All bulking of soil resulting from the grubbing operations shall be compacted and holes filled and compacted to subgrade for subsequent compacted fills.

**300-6.3 Stripping.** When stripping is indicated on the Plans or in the Specifications, the Contractor shall strip the soil from the designated areas to the depths specified.

The material obtained from stripping operations shall be disposed of away from the site unless otherwise specified.

Soil loosened below the stripping depth specified shall be compacted. Soil removed below stripping depth shall be replaced and compacted to subgrade. All such filling and compacting shall be at the Contractor's expense.

**300-6.4 Basin Excavation.** Unless otherwise specified, material obtained from the basin excavation shall be used for compacted fills. The Engineer will designate the exact limits of basin excavation and the depths thereof in order to obtain a material suitable for use in the compacted fills. Rocks over 150 mm (6

inches) in greatest dimension will not be permitted in compacted fills and shall be disposed of away from the Work site unless otherwise specified.

**300-6.5 Compacted Fills.** Unless otherwise specified, the relative compaction of all fills shall be at least 90 percent.

Compacted fills shall be constructed of materials obtained from the onsite excavation unless otherwise specified.

The work of preparing subgrades, placing fill materials, watering, and compacting shall be performed only in the presence of the Engineer.

On hillsides and at abutments where the existing natural slope is steeper than 1 vertical in 4 horizontal, the existing ground shall be benched as the fill is brought up in layers. The benches shall be approximately horizontal and shall extend below the surface of the cleared and stripped ground a minimum depth of 0.6 m (2 feet) normal to the slope unless otherwise specified. The material cut from the slope shall be incorporated in the fill.

Before placing the materials for the compacted fills, the subgrade therefore shall be moistened, compacted, and scarified in accordance with the requirements hereinafter set forth for subsequent layers of fill. The Engineer may determine the locations at which each load of fill shall be placed in order to obtain the best possible blending of materials. The fill material shall be placed in approximately horizontal, evenly distributed layers not exceeding 200 mm (8 inches) in depth, except that where the Contractor clearly demonstrates that it can attain the required relative density with the type of equipment being used, a greater lift may be authorized. Unless otherwise permitted by the Engineer, each layer of fill material shall cover the full length and width of the entire area to be filled before the next higher layer of material is placed, and each layer shall be sufficiently scarified, after compaction, to provide bond with the succeeding layer. The top surface of each layer shall have sufficient crown to provide adequate drainage for water at all times during the construction period.

Before rolling or tamping, sufficient water shall be evenly applied to each layer of loose material so as to provide proper moisture content for satisfactory compaction to the specified relative compaction. The material shall be disc harrowed, or otherwise similarly worked, as the water is applied. The moisture content at the time of compaction shall be subject to the approval of the Engineer. In case any layer of fill shall prove to be too wet to permit the attainment of the specified relative compaction, the compacting work shall be delayed until the material has dried sufficiently to permit the attainment of said relative compaction.

After each layer has been spread, worked, and properly moistened, it shall be compacted by approved tamping or sheepsfoot rollers, pneumatic-tired rollers, mechanically operated hand tampers, or other mechanical means acceptable to the Engineer, to such extent as will produce the specified relative compaction.

Compacted fill which is to become subgrade for concrete channel or basin facing slabs, spillways, or other hydraulic structures, shall be overfilled sufficiently to permit the trimming thereof to an even and firm subgrade for the concrete to be placed thereon. No direct payment will be made for such overfill. Any costs involved therefore shall be included in the price bid for the compacted fill.

**300-6.6 Payment.** Clearing and grubbing shall be paid for on a lump sum or per hectare (acre) basis as provided in the Specifications.

Stripping, excavation, and compacted fill shall be measured and paid for on a cubic meter (cubic yard) basis as provided for in the Specifications.

### **300-7 EARTHWORK FOR CHANNELS.**

**300-7.1 General.** Earthwork for channels shall consist of clearing, stripping, excavation, fill, backfill, grading, and disposal of excess excavated and removed material.

Channels for the purposes of this section shall mean open rectangular concrete channels and lined or unlined trapezoidal channels.

**300-7.2 Stripping.** When stripping is indicated on the Plans or otherwise specified, the Contractor shall strip the soil from the designated areas to the depths specified.

The material obtained from stripping operations shall be disposed of away from the site unless otherwise specified.

Soil loosened or removed below the stripping depth specified shall be replaced and compacted to not less than 90 percent relative compaction. All such filling and compacting shall be at the Contractor's expense.

**300-7.3 Excavation.** Excavation in an open cut for lined channels may be made so as to place concrete directly against excavated surfaces, provided the faces of the excavation are firm, hard, and unyielding; are such as will stand or can be made to stand without sloughing; and are at all points outside the concrete lines shown on the Plans.

Excavated surfaces becoming subgrade for lined channels, or subdrainage material, shall be excavated to the lines indicated on the drawings. Excavation made below subgrade shall be backfilled and compacted to a relative compaction of not less than 90 percent or, with the approval of the Engineer, with concrete or other materials being placed. However, no payment will be made for such overexcavation or material used for the backfill.

Where it becomes necessary to excavate beyond the normal lines of excavation in order to remove boulders or other interfering objects, the voids remaining after the removal of such boulders or interfering objects shall be backfilled as hereinafter specified, or as otherwise approved by the Engineer.

When the void is below the subgrade for reinforced concrete channel, suitable material approved by the Engineer shall be compacted to a relative compaction of not less than 90 percent or as specified. With the approval of the Engineer, concrete of the same mix as that used in the concrete channel may be used.

The removal of all boulders or other interfering objects and the backfilling of voids caused by such removals shall be at the expense of the Contractor and no direct payment for the cost of such work will be made by the Agency. The cost of such work shall be included in the prices bid for the various items of work.

If, during the progress of excavation, material is encountered which, in the opinion of the Engineer, is unsuitable for subgrade for the structure to be constructed thereon, the Engineer will direct the Contractor to excavate beyond the pay lines shown on the Plans. However, the suitability of subgrade will be determined by the Engineer on the basis of its ability to withstand the load of the proposed channel and not upon the capacity to withstand the loads which may be placed thereon by the Contractor's equipment. Should the Contractor be directed to excavate beyond the pay lines shown on the Plans, said pay lines will be extended to include such excavation. The pay lines for subdrainage material, if used, will be adjusted accordingly.

Materials used or work performed by the Contractor beyond the Agency's requirements for stabilization of the subgrade, so that it will withstand the loads which may be placed upon it by the Contractor's equipment, shall be at the Contractor's expense.

**300-7.4 Fill and Backfill.** Unless otherwise specified, the material obtained from the project excavations will be suitable for use as fill or backfill, provided that all organic material, rubbish, debris, and other objectionable material contained therein is first removed. However, rocks, boulders, broken

portland cement concrete, and bituminous type pavement obtained from the project excavations will be permitted in the backfill or fill with the following limitations:

- 1) The maximum dimension of any piece used shall be 150 mm (6 inches).
- 2) Pieces larger than 100 mm (4 inches) shall not be placed within 300 mm (12 inches) of any structure.
- 3) Pieces larger than 75 mm (3 inches) shall not be placed within 300 mm (12 inches) of the subgrade for paving.
- 4) "Nesting" of pieces will not be permitted.

Unless otherwise specified, the relative compaction of all fill and backfill shall be 90 percent.

**300-7.5 Grading.** Grading of unlined channels, levees, and access roads shall conform to the following tolerances:

A vertical tolerance of zero above and 75 mm (3 inches) below the specified grade will be allowed for:

- 1) The channel bottom.
- 2) The channel sideslopes in both cut and fill.
- 3) The levee and access road sideslopes in cut.

A vertical tolerance of zero below and 75 mm (3 inches) above the specified grade will be allowed on:

- 1) The top surface of levees and access roads in both cut and fill.
- 2) The levee and access road sideslopes in fill.

Regardless of the construction tolerances specified, the excavation and grading shall be performed so that the finished surfaces are in uniform planes with no abrupt breaks in the surface.

The construction tolerances specified herein for grading are solely for purposes of field control.

**300-7.6 Measurement and Payment.** Clearing, stripping, and excavation shall be measured and paid for on a cubic meter (cubic yard) basis or as specified.

Compacted fill shall be measured and paid for as provided in 300-4.9.

All costs involved in backfilling and grading shall be included in the prices bid for the applicable items of earthwork.

## **300-8 GEOTEXTILES FOR DRAINAGE.**

**300-8.1 Trench Drains.** Geotextiles for trench drains shall be placed in accordance with the following provisions:

**300-8.1.1 Placement.** Fabric shall be placed in the trench in accordance with the Plans. The fabric shall be placed loosely and seated firmly into the corners. If heat-bonded fabric is used, the bonded side shall be placed to the inside of the trench and the fuzzy side shall face the outside of the trench, against the native soil. Overlapping, if necessary, shall be a minimum of 300 mm (12 inches). Damaged fabric shall be repaired at Contractor's expense by placing new fabric that meets overlap requirements over the damaged area. Fabric shall be covered as soon as possible after being placed, but not later than 7 calendar days after placement. Fabrics left uncovered for more than 7 calendar days shall be removed and rejected.

Trench sides and bottom shall be excavated to provide a smooth surface, free of obstructions and debris. After placement of granular fill, the two edges of the geotextile protruding at the top of the trench shall be overlapped 300 mm (12 inches) on top of the granular fill, and then soil or other materials required by the Plans shall be compacted in the trench to the required grade.

**300-8.1.2 Measurement and Payment.** Geotextiles shall be measured for payment by the square meter (square yard) of fabric placed, not including any fabric for overlaps or splices.

### **300-9 GEOTEXTILES FOR EROSION CONTROL.**

**300-9.1 Bank and Shore Protection.** Geotextiles for bank and shore protection shall be placed in accordance with the following provisions:

**300-9.1.1 Placement.** Prior to placement of fabric, the Contractor shall construct a subgrade in accordance with the Plans and Specifications. The fabric shall be placed loosely (not in a stretched condition), aligned, and placed in a manner to minimize wrinkling. Adjacent borders and ends of fabric shall be overlapped a minimum of 460 mm (18 inches) or stitched when using nonwoven fabrics with a grab tensile strength of 400 N (90 pounds) or woven fabrics with a grab tensile strength of 890 N (200 pounds) or less. Borders and ends shall be overlapped 900 mm (36 inches) or stitched for nonwoven fabrics with a grab tensile strength greater than 400 N (90 pounds) or woven fabrics with a grab tensile strength greater than 890 N (200 pounds).

If the fabric is overlapped, the upstream or higher panel shall overlap the downstream or lower panel. When stitched, the seam shall have seam breaking strength of not less than 80 percent of the minimum required fabric strength. The size and composition of the stitching material and stitching pattern shall be approved by the Engineer. The stitching yarn shall be of a contrasting color.

Anchoring of the fabric at terminal ends and top and bottom of the slope shall be accomplished through the use of key trenches or aprons as shown on the Plans. If the geotextile is placed in a vertical direction on the slope, there shall be no end joints between rolls. If heat bonded fabric is used, the fuzzy side shall be placed against the soil with the heat bonded side up.

The fabric shall be secured with pins placed on 1.8 m (6 foot) centers at the midpoint of the overlaps unless a key trench is used. Pins at 1.8 m (6 foot) centers shall be placed along the top edge of the slope. Spacing of pins shall be reduced to eliminate tearing of the fabric. Pins shall be 300 mm (12 inches) long or of sufficient length to prevent pin movement.

The outer stone cover shall be thick enough to completely prevent penetration of sunlight, unless a bedding layer of aggregate particles greater in size than the openings in the outer stone cover is installed first.

Fabric shall be covered as soon as possible after being placed, but not later than 7 calendar days after placement. Fabric left uncovered for more than 7 calendar days shall be removed and rejected.

Equipment or vehicles shall not be operated on the fabric. Damaged fabric shall be repaired, at the Contractor's expense, by placing new fabric over the damaged area in a manner that meets the overlap requirements for horizontal placement. Vertically placed fabric shall be replaced in its entirety.

**300-9.1.2 Measurement and Payment.** Measurement and payment shall conform to 300-8.1.2.

### **300-10 GEOTEXTILES FOR SEPARATION.**

**300-10.1 Subgrade Enhancement.** Geotextiles for subgrade enhancement shall be placed in accordance with the following provisions:

**300-10.1.1 Placement.** During grading operations, care shall be taken not to disturb or scarify the subgrade. This may require use of lightweight dozers, etc., for low-strength soils such as saturated, cohesionless, or low cohesion soils.

Once the subgrade along a particular segment of road alignment has been prepared, the geotextile shall be unrolled in line with the placement of the new aggregate. The fabric shall not be dragged across the subgrade, and the entire fabric shall be placed and rolled out as smoothly as possible. If heat bonded fabric is used, the fuzzy side shall be placed against the soil, with the bonded side up.

Parallel rolls or ends of fabric shall be overlapped 600 mm (24 inches) or sewn if required by the Plans or Specifications. When indicated on the Plans or Specifications that soils have a CBR less than 5 or an R-value less than 20, a 900 mm (36 inch) overlap shall be used.

The fabric shall be secured with pins placed on 1.8 m (6 foot) centers at the midpoint of all overlaps and at the edges to maintain them during construction activities. Spacing of pins shall be reduced if necessary to eliminate tearing and movement of fabric.

For roadways, fabric widths shall be selected such that overlaps of parallel rolls occur at lane lines. Overlaps shall not be placed along anticipated main wheel path locations.

Overlaps at the end of rolls shall be in the direction of the aggregate placement with the previous roll on top.

When fabric intersects an existing pavement area, the fabric shall extend to the edge of the old system, and the fabric shall be anchored.

The base aggregate shall be placed on the fabric in such a manner and thickness that wheel rutting of aggregate over the fabric is limited to 13 mm (1/2 inch). Unless otherwise indicated, the minimum thickness shall be 300 mm (12 inches). Lightweight dozers shall be used if necessary. Equipment shall not be allowed directly on the fabric.

Before covering, the conditions of the fabric will be observed by the Engineer to determine that no holes or rips exist in the fabric. All such occurrences shall be repaired by placing a new layer of fabric extending beyond the defect in all directions a distance equal to the minimum overlap required for adjacent rolls.

**300-10.1.2 Measurement and Payment.** Measurement and payment shall conform to the requirements of 300-8.1.2.

### **300-11 STONEMWORK FOR EROSION CONTROL.**

**300-11.1 General.** Stone for erosion control shall be in conformance with 200-1.6 and the following provisions. When shown on the Plans, stonework shall be shall be concreted as specified herein.

**300-11.2 Placing Stone.** Stone for erosion control shall be placed in accordance with the following method:

A footing trench shall be excavated along the toe of the slope, as shown on the Plans. The larger stones shall be placed in the footing trench. Stones shall be placed with their longitudinal axis normal to the embankment face, and arranged so that each stone above the foundation course has a 3-point bearing on the underlying stones. The foundation course is the course placed on the slope in contact with the ground surface.

Bearing on smaller stones which may be used for chinking voids will not be acceptable. Nesting of the smaller stones used for chinking voids will not be permitted. Placing of stones by dumping will not be permitted.

Local surface irregularities of the slope protection shall not vary from the planned slope by more than 0.3 m (1 foot) measured at right angles to the slope.

**300-11.3 Concrete Stone Slope Protection.** Stone for concreted stone slope protection shall be placed in accordance with 300-11.2.

**300-11.3.1 Concrete.** Concrete for concreted stone slope protection shall be 310-C-17P (520-C-2500P) and conform to the requirements of 201-1, except that the slump of the concrete shall be adjusted to provide the penetration shown in Table 300-11.3.1.

**TABLE 300-11.3.1**

<b>Class</b>	<b>225 Kg (500#)</b>	<b>170 Kg (375#)</b>	<b>90 Kg Light</b>	<b>35 Kg Facing</b>
Minimum Penetration in mm (in)	355 (14)	305 (12)	255 (10)	205 (8)

**300-11.3.2 Placing Concrete.** The surfaces of the stone to be concreted shall be cleaned of adhering dirt and clay and then moistened. The concrete shall be placed in a continuous operation for any day's run at one location. Concrete shall be brought to the place of final deposit by buckets or pump. Other placement methods shall be approved by the Engineer prior to use.

In no case shall concrete be permitted to flow on the slope protection a distance greater than 3 m (10 feet).

Immediately after depositing, the concrete shall be spaded and rodded into place with suitable tools until the minimum penetration is that shown in Table 300-11.3.1.

After the concrete has been placed, the stones shall be thoroughly brushed so that their top surfaces are exposed. The outer stones shall project 1/3 to 1/4 their diameter above the concrete surface. After completion of any 3 m (10 foot) strip, no person or load shall be permitted on the surface for a period of at least 24 hours, or longer if so ordered by the Engineer.

Concreted stone slope protection shall be cured as provided in 303-1.10.

**300-11.4 Measurement and Payment.** Stone and stonework for riprap and erosion control will be measured and paid for per tonne (ton) of stone in place.

Concrete and concrete placement will be measured and paid for per cubic meter (cubic yard) in place.

## **SECTION 301 - TREATED SOIL, SUBGRADE PREPARATION, AND PLACEMENT OF BASE MATERIALS**

### **301-1 SUBGRADE PREPARATION.**

**301-1.1 General.** This section shall govern the preparation of natural, filled, or excavated roadbed material prior to the placement of subbase or base material, pavement, curbs and gutters, driveways, sidewalks, or other roadway structures.

**301-1.2 Preparation of Subgrade.** Scarifying and cultivating will be required for dry soils which are impervious to the penetration of water, for soils which contain excessive amounts of moisture which may result in unstable foundations, for soils which are nonuniform in character which may result in nonuniform relative compactions and subsequent differential settlements of finished surfaces, or when pavement is to be placed directly on the roadbed material. Unsuitable material found below the processing depth for subgrade specified herein shall be treated in accordance with 300-2.2, Unsuitable Material.

After rough grading has been completed, when scarifying and cultivating are required, the roadbed shall be loosened to a depth of at least 150 mm (6 inches). The loosened material shall then be worked to a finely divided condition and all rocks larger than 75 mm (3 inches) in diameter shall be removed. The moisture content shall be brought to minus 1 percent of optimum or wetter by the addition of water, by the addition and blending of dry suitable material, or by the drying of existing material. The material shall then be compacted by approved equipment to the specified relative compaction.

Uniform pervious soils, that allow the immediate penetration of water or uniform impervious soils which will allow the penetration of water to a depth of at least 150 mm (6 inches) after the addition of a suitable wetting agent, will not require scarifying and cultivating unless a condition previously set forth in this subsection requires such processing. When scarifying and cultivating are not required, the moisture content of the top 150 mm (6 inches) of the subgrade material shall be brought to optimum by the addition of water at the surface, and the material shall be compacted by approved equipment to the specified relative compaction.

**301-1.3 Relative Compaction.** Except in alleys, when pavement is to be placed directly on subgrade material, the top 150 mm (6 inches) of subgrade material shall be compacted to a relative compaction of 95 percent. When base or subbase material, curb, gutter, alley pavement, driveways, or sidewalks are to be placed on the subgrade material, the top 150 mm (6 inches) of such subgrade material shall be compacted to a relative compaction of 90 percent.

After compaction and trimming, the subgrade shall be firm, hard, and unyielding.

**301-1.4 Subgrade Tolerances.** Subgrade for pavement, sidewalk, curb and gutter, driveways, or other roadway structures shall not vary more than 6 mm (0.02 foot) from the specified grade and cross section. Subgrade for subbase or base material shall not vary more than 12 mm (0.04 foot) from the specified grade and cross section. Variations within the above specified tolerances shall be compensating so that the average grade and cross section specified are met.

**301-1.5 Grading of Areas Not To Be Paved.** Roadway areas where "grade only" is called for on the Plans shall be graded to meet tolerances for base subgrade. The surface shall be constructed to a straight grade from the finish pavement or curb elevations shown on the Plans to the elevation of the existing ground at the extremities of the area to be graded.

**301-1.6 Adjustment of Manhole Frame and Cover Sets to Grade.** Utility manhole and vault frames and covers within an area to be paved or graded will be set by the owners thereof to finished grade. Sewer and storm drain manhole frames within the area to be paved or graded shall be set to finish grade by the Contractor. Manholes in asphalt concrete pavement shall be set to finish grade in accordance with provisions of 302-5.8. In the case of portland cement concrete pavement, manhole frames shall be set to finish grade before paving. Repaving required as a result of reconstructing or adjusting all manhole and vault frames and covers to grade shall be the responsibility of the Contractor and the cost thereof shall be included in the bid item for pavement.

The Contractor shall remove all debris from the interior of manholes and shall clean all foreign material from the top of the frames and covers.

**301-1.7 Payment.** Payment for preparing a subgrade will be considered as included in the item of work for which the subgrade is prepared.

Payment for grading operations in areas designated as "grade only" will be considered as included in the price bid for excavation or fill.

Payment for adjusting manhole frames and covers to grade, where the difference between the lowest point of manhole removal and final elevation of the top of the frame is less than 375 mm (15 inches) or where the adjustment is accomplished by adjustment rings only, will be made at the Contract Unit Price for adjusting each manhole frame.

Payment for adjusting manhole frames and covers to grade, where the difference between the lowest point of manhole removal and final elevation of the top of the frame is 375 mm (15 inches) or more, will be made at the Contract Unit Price per linear meter (foot) for reconstructing each manhole.

If no payment provision for manhole adjustment or reconstruction is made, payment for such work will be as provided in 3-3, Extra Work.

### **301-2 UNTREATED BASE.**

**301-2.1 General.** Untreated base shall be constructed of material conforming to 200-2.

**301-2.2 Spreading.** Imported aggregate bases shall be delivered to the roadbed as uniform mixtures and each layer shall be spread in one operation. Segregation shall be avoided and the base shall be free from pockets of coarse or fine material.

Aggregate bases shall be deposited on the roadbed at a uniform quantity per linear meter (foot), which quantity will provide the required compacted thickness within the tolerances specified herein without resorting to spotting, picking up, or otherwise shifting the aggregate base material. At the time aggregate base is spread, it shall have a moisture content sufficient to obtain the required compaction. Such moisture shall be uniformly distributed throughout the material.

Where the required thickness is 150 mm (6 inches) or less, the base material, except "Pulverized Miscellaneous Base", may be spread and compacted in one layer. Where the required thickness is more than 150 mm (6 inches) the base material, except "Pulverized Miscellaneous Base", shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 150 mm (6 inches). Each layer shall be spread and compacted in a similar manner.

The use of motor-graders will be permitted during depositing, spreading and compacting operations, except when self-propelled spreaders are specified. Pulverized Miscellaneous Base shall be spread and compacted in one or more layers. The maximum compacted layer shall not exceed 250 mm (10 inches).

When the subgrade for aggregate base consists of cohesionless sand and written permission is granted by the Engineer, a portion of the aggregate base may be dumped in piles upon the subgrade and spread from the dumped material in sufficient quantity to stabilize the subgrade. Segregation of aggregates shall be avoided and the material as spread shall be free from pockets of coarse or fine material.

**301-2.3 Compacting.** Rolling shall always be commenced along the edge of the area to be compacted and the roller shall gradually advance toward the center of the area to be compacted.

Rollers shall be operated along lines parallel or concentric with the centerline of the road being constructed, and no material variation therefrom will be permitted. All rollers must be maintained in good mechanical condition.

The relative compaction of each layer of compacted base material shall not be less than 95 percent, except in the areas back of curb (under sidewalks and driveways). Compaction in the excepted areas shall be as specified in 211-1 with each layer of compacted base material having a minimum relative compaction of 90 percent.

The surface of the finished aggregate base at any point shall not vary more than 6 mm (0.02 foot) above or below the grade established by the Engineer.

Base which does not conform to the above requirements shall be reshaped or reworked, watered, and thoroughly recompact to conform to the specified requirements.

**301-2.4 Measurement and Payment.** Quantities of untreated base will be measured as shown in the Bid. The volumetric quantities of base material shall be those compacted in place within the limits of the dimensions shown on the Plans.

The weight of material to be paid for will be determined by deducting (from the weight of material delivered to the Work) the weight of water in the material (at the time of weighing) in excess of 1 percent more than the optimum moisture content. No payment will be made for the weight of water deducted as provided in this subsection.

### **301-3 PORTLAND CEMENT TREATED MIXTURES.**

#### **301-3.1 Soil-cement.**

**301-3.1.1 General.** Soil-cement shall consist of soil, portland cement, and water which are uniformly mixed, compacted, finished, and cured in such a manner that the in-place soil-cement mixture forms a dense, uniform mass conforming to the lines, grades, and cross sections shown on the Plans. Soil-cement mixtures shall also include cement treated base and cement modified soil.

**301-3.1.2 Materials.** Portland cement and water shall conform to the provisions of 201-1.2.1 and 201-1.2.3, respectively, or as otherwise specified. Cement content and moisture content shall be specified.

Soil to be treated may consist of in-place material, select borrow material, a combination of these materials, or select aggregate material proportioned as directed by the Engineer or as specified. The soil shall consist of material not larger than 50 mm (2 inches) in diameter and with not less than 55 percent passing the 4.75 mm (No. 4) sieve. The material shall not be deleterious in its reaction with cement.

**301-3.1.3 Equipment.** Soil-cement shall be constructed utilizing a machine or a combination of machines that will produce results meeting all the requirements herein. Such machines shall be approved by the Engineer prior to use.

**301-3.1.4 Preparation.** Prior to importing materials to be treated, the soil subgrade shall be prepared as provided in 301-1.

Subgrade material that is to be treated in place shall be shaped and rolled to specified cross section prior to the scarification and treatment. No further subgrade preparation will be necessary.

The soil subgrade shall be firm enough to support construction equipment without displacement. Unsuitable soils shall be removed in accordance with 300-2.2.

**301-3.1.5 Cement Application, Mixing, and Spreading.** Mixing of the soil, cement, and water shall be accomplished either by the mixed-in-place or the central-plant-mixed method. No cement or soil-cement mixture shall be spread when the aggregate or subgrade is frozen or when the air temperature is less than 5°C (40°F) in the shade. The finished soil-cement shall be protected against freezing.

After mixing is complete, the soil shall be so pulverized that 100 percent by dry weight passes a 25 mm (1 inch) sieve, and a minimum of 80 percent passes a 4.75 mm (No. 4) sieve, exclusive of gravel or stone retained on these sieves.

**301-3.1.6 Mixing In Place.** The specified quantity of cement shall be spread uniformly on the soil to be treated. Cement that has been spread and then tracked or displaced by traffic or other operations shall be replaced before mixing is started to provide a uniform coverage in all areas.

For the windrow method of mixing, the material shall be shaped and sized uniformly prior to the addition of cement. The tops of soil windrows shall be flattened or slightly trenched to receive the cement. Windrows shall be limited to such size that all material can be passed through the mixing machine in one operation.

Cement shall be spread by an approved cement spreader in such a manner that cement content shall not vary from the specified rate of application by more than 10 percent. Cement may be supplied in sacks and spread by hand when specified or when approved by the Engineer. When hand spreading is used, the sacks shall be spaced at uniform intervals and then emptied, following which the cement shall be spread in a layer of uniform thickness. After the cement has been spread, it shall be uniformly mixed with the soil.

Water shall be applied under pressure by means of controlled distributing equipment which will produce a completed mixture with a uniform moisture content. Leakage of water from equipment will not be permitted. Care shall be exercised to avoid the addition of any excess water.

Mixing shall continue until a uniform mixture of soil, cement, and water has been obtained. If equipment is used that requires more than one pass of the mixer, at least one pass shall be made before any water is added to the material.

**301-3.1.7 Central-Plant Mixing.** Soil-cement mixed in central mixing plants shall use an approved pugmill or continuous flow mixer. Soil, cement, and water shall be stored separately.

The rate of feed of soil, cement, and water shall be within 3 percent of the amount of each material designated by the Engineer or as specified.

Water shall be so proportioned that the Engineer may readily verify the amount of water in a batch or the rate of flow for continuous mixing.

The charge in a batch mixer or the rate of feed to a continuous mixer shall not exceed that which will permit complete mixing of all of the material. Dead areas in a mixer, in which the material does not move or is not sufficiently mixed, will not be permitted.

Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated aggregates of unchanging appearance is produced. Cement content shall not vary more than 5 percent from that specified.

The soil-cement mixture shall be transported from the mixing plant to the site in clean equipment provided with suitable protective devices to prevent material loss and significant moisture change. The total elapsed time between the addition of water to the mixture and the start of compaction shall not exceed 45 minutes.

**301-3.1.8 Placing, Compacting, and Finishing.** Soil-cement shall be uniformly compacted to at least 95 percent of relative compaction.

The mixture shall be placed on the moistened subgrade, or previously completed soil-cement, using mechanical spreading equipment that will produce layers of such width and thickness that it will compact to the required dimensions of the completed soil-cement layers.

The mixture may be spread and compacted in one layer where the required thickness is 200 mm (8 inches) or less. Where the required thickness is more than 200 mm (8 inches), the mixture shall be spread and compacted in two or more layers of approximately equal thickness, provided that the maximum compacted thickness of any one layer does not exceed 200 mm (8 inches).

Compaction shall commence within 30 minutes after the mixture is placed on the grade and shall proceed continuously until completed. Final compaction of the mixture to the specified density shall be completed within 2-1/2 hours after the application of water during the mixing operation.

When two or more layers of soil-cement are to be placed, the surface which will be in contact with succeeding layers shall be kept continuously moist for 7 days or until the placement of the subsequent layer. Any loose material on the surface of the completed layer shall be removed and the surface moistened immediately before placement of the next layer. No standing water will be permitted.

At the start of compaction, the mixture shall be in a uniform, loose condition throughout its full depth.

During finishing operations, the surface of the soil-cement shall be shaped to the required lines, grades, and cross sections and shall be kept moist. The finished surface of the soil-cement shall conform to the requirements of 301-1.4.

**301-3.1.9 Curing.** After placement and compaction of the soil-cement is completed, it shall be protected against drying and from traffic for 7 days.

Curing shall be moist (water fogging), bituminous seal, or other method approved by the Engineer. If moist curing is used, exposed surfaces of the soil-cement shall be kept continuously moist with a fog spray for 7 days. If a bituminous curing is used, it shall consist of liquid asphalt or emulsified asphalt meeting the requirements of Section 203.

The bituminous curing seal shall be applied in sufficient quantity to provide a continuous membrane over the soil at a rate of between 0.45 L/m<sup>2</sup> and 0.90 L/m<sup>2</sup> (0.10 and 0.20 gallon per square yard) of surface with the exact rate determined by the Engineer. It shall be applied as soon as possible after the completion of final rolling. The surface shall be kept moist until the seal is applied. At the time the bituminous material is applied, the soil surface shall be dense, shall be free of all loose and extraneous material, and shall contain sufficient moisture to prevent excessive penetration of the bituminous material.

**301-3.1.10 Construction Joints.** Construction joints shall have vertical faces and shall be made in thoroughly compacted material. Additional mixture shall not be placed against the construction joint until the joint has been approved by the Engineer. The face of the cut joint shall be clean and free of deleterious material and shall be kept moist until the placing of the adjacent soil-cement.

**301-3.1.11 Repair.** If the soil-cement is damaged, it shall be repaired by removing and replacing the entire depth of affected layers in the damaged area. Feathering will not be permitted for repair of low areas.

**301-3.1.12 Measurement and Payment.** Cement treated soils, base, and subbase will be paid for by the square meter (square yard) or cubic meter (cubic yard) in place as shown on the Plans or as directed by the Engineer. The Contract Unit Price shall include full compensation for mixing, spreading, shaping, compacting, trimming, and curing.

### **301-3.2 Plastic Soil-Cement.**

**301-3.2.1 General.** Plastic soil-cement shall consist of soil, portland cement, and water. It shall be proportioned, uniformly mixed to the consistency of plastering mortar, finished and cured in such a manner that the completed plastic soil-cement in place forms a dense uniform mass conforming to the lines and grades shown on the Plans.

**301-3.2.2 Mixing and Finishing.** Mixing of the soil, cement, and water shall be accomplished by a pugmill or rotary drum mixer.

The soil, cement, and water shall be proportioned as specified and uniformly mixed to a consistency similar to that of plastering mortar.

The plastic soil-cement shall be placed on the prepared grade, consolidated, and finished to the lines and grades shown on the Plans.

Finished, plastic soil-cement shall be kept moist and cured as specified in 301-3.1.9.

**301-3.2.3 Measurement and Payment.** Measurement and payment of plastic soil-cement will be in accordance with 301-3.1.12.

### **301-3.3 Cement-Treated Base.**

**301-3.3.1 General.** The cement-treated base shall conform to the requirements of 301-3.1 and 301-3.3.

Cement-treated base shall consist of a combination of specified base material and portland cement, uniformly mixed, moistened, and compacted as described herein, and shaped to conform to the lines, grades, and cross sections shown on the Plans.

**301-3.3.2 Mixed In Place.** Water distributing equipment shall be provided with a metering device for introducing water at the time of mixing.

Should the Contractor elect to perform road-mixing operations off the roadbed at a designated location, the preparation of the material for mixing and the mixing of base material, cement, and water shall conform to the applicable provisions specified herein for preparing and mixing the materials on the roadbed. When the materials are road-mixed off the roadbed, the device for loading the mixed material into the transporting vehicle shall be so constructed and so operated that no untreated material will be picked up. The time required for loading and hauling the material shall be taken into account when determining the amount of material to be mixed at any one time for placement and compaction within the time specified in 301-3.1.8.

**301-3.3.3 Central-Plant Mixing.** Base material, cement, and water shall be mixed in a rotary drum or pugmill mixer with the materials proportioned by batch weights. If a continuous type of mixer is used, the materials shall be proportioned by volume.

If the Contractor elects to use a continuous type mixer, the correct proportions of each aggregate size introduced into the mixer shall be drawn from the storage bins by means of a continuous feeder through adjustable calibrated gates, which gates shall supply the correct amount of aggregate in proportion to the cement and water, and the gates shall be so arranged that the proportion of each aggregate size can be separately adjusted. The mixer shall be equipped with metering devices which will introduce the cement and water into the mixer in the specified proportions. The metering devices and feeder shall be interlocked and so synchronized as to maintain a constant ratio between cement, water, and aggregate. Storage bins shall be equipped with overflow chutes for each compartment. A positive signal system shall be provided to indicate when the level of material in each bin approaches the strikeoff capacity of the feed gate. The plant shall not be permitted to operate unless this signal system is in good working condition. The plant shall be equipped with facilities to weigh samples for calibrating gate openings.

Water may be proportioned by weight or volume. The quantity of water added to the mixture shall be adjusted to produce optimum moisture content. The addition of water shall be made under conditions which will permit an accurate determination of the quantity of water utilized.

**301-3.3.4 Placing, Compacting, and Finishing.** Materials mixed at a location off the roadbed shall be deposited by means of approved spreading equipment. Dumping in piles upon the subgrade will not be permitted.

The surface of the finished cement-treated base at any point shall vary not more than 6 mm (0.02 foot) above or below the grade established by the Engineer.

The mixed materials shall be spread for the full width of the subgrade or base under construction, either by one spreader or by several spreaders operating in echelon across the subgrade, unless traffic conditions require part-width construction. Should only one spreader be used, not more than 45 minutes shall elapse between the time of placing material in adjacent lanes at any location without trimming the longitudinal joint.

Where traffic or other conditions make part-width construction of a base necessary, a windrow of shoulder material or soil shall be placed and compacted to form a choker to restrain the inner edge of the base during compacting operations. The choker shall be constructed to the same elevation as that of the compacted base, and shall be completed in advance of the spreading of the treated material. The toe of the choker shall be not less than 75 mm (3 inches) outside the finished trimming line of the compacted section of base material. The use of side forms, or other methods which will satisfactorily retain the base material during compacting operations, will be permitted in lieu of a choker.

After a part-width section has been completed, the longitudinal joint against which additional material is to be placed shall be trimmed to a vertical edge at the neat line of the section. Choker material and material cut away in trimming shall be used only in the construction of adjacent shoulders or otherwise disposed of along the roadway, unless suitable for incorporation in the Work.

The use of self-propelled graders will be permitted for spreading the mixed material on the roadbed and for trimming.

**301-3.3.5 Curing.** No equipment or traffic shall be permitted on the finished surface during the first 3 days after the application of the curing seal.

In cases where the Contractor has permitted equipment or traffic to operate on a cement-treated base, or subbase, the Contractor shall, before the paving material is placed on the surface, completely remove any other material which has been spread to protect the treated surface and shall apply additional curing seal to any areas where the curing seal has been destroyed. Full compensation for furnishing, spreading, and removing such material and for furnishing and applying the additional curing seal will be considered as included in the price bid for cement-treated base and no additional compensation will be made therefore.

**301-3.3.6 Measurement and Payment of Cement-treated Base.** Measurement and payment of cement-treated base will be in accordance with 301-3.1.12.

#### **301-4 BITUMINOUS-STABILIZED BASE.**

**301-4.1 General.** Bituminous-asphalt-stabilized base shall consist of a mixture of aggregate and emulsified or liquid asphalt spread upon a prepared subgrade in layers.

**301-4.2 Materials.** The aggregates shall consist of soil or mineral aggregates, or blends thereof, which when stabilized and allowed to cure, will meet the requirements specified. If the Contractor intends to import material, it shall notify the Engineer in sufficient time to allow for testing to determine the suitability of the material and quantity of stabilizer required.

**301-4.3 Advance Tests.** When mixing is to be done on the site, a representative sample of the aggregates shall be taken for each 1000 m<sup>2</sup> (10,000 square feet) to be stabilized. When mixing is done in a central mixing plant, samples which are representative of the aggregate to be used shall be taken for tests.

The asphalt and aggregates for the Work shall meet the requirements of the Specifications. The quality of asphalt shall be as specified. In the case of emulsified asphalt, the Engineer will determine the quantity of water to be added.

#### **301-4.4 Mixing.**

**301-4.4.1 General.** The aggregate and asphalt shall be thoroughly mixed in a central pugmill-type mixing plant, or alternatively on the roadbed by traveling mixer or motor grader. The mixture shall be uniform and contain the percentage of asphalt specified by weight or volume of the dry aggregate. If necessary, water shall be added to the aggregate in a quantity sufficient to completely disperse the emulsified asphalt and produce a plastic mixture free from balled fines or balled asphalt.

**301-4.4.2 Central Plant Mixing.** The asphalt binder and aggregate shall be mixed at a central mixing plant by either batch mixing or continuous mixing at the option of the Contractor.

The aggregates shall be blended in such proportions that the combined aggregates will meet the grading limits specified.

Asphalt, at the rate specified, shall be added to the aggregate in the mixer. Necessary additional water shall be added simultaneously with emulsified asphalt. Mixing shall continue until the asphalt is uniformly and thoroughly distributed throughout the mass.

**301-4.4.3 Travel Mixing.** The traveling mixer machine shall be of the pug type or auger type. The traveling mixer shall have provision for introducing the asphalt and water at the time of mixing through a metering device or other approved method. Both the asphalt and the water shall be applied by means of separate controls which will supply a uniform ratio of asphalt and water to the amount of aggregate passing through the mixer, and will produce a complete mixture with a uniform moisture content. Leakage of asphalt or water from equipment will not be permitted and care shall be exercised to avoid the addition of asphalt or water from any source except through the metering device.

Prior to mixing in the traveling mixer, the aggregate shall be placed in such manner that all the material will be passed through the mixer in one mixing operation. If aggregate is brought to the site in separate sizes, each of the sizes in proper amount shall be deposited by means of an approved spreading device equipped with a readily adjustable strike-off device.

The rate of movement of the mixer, the amount of material mixed, and the amount of mixing shall be so regulated that a mix satisfactory to the Engineer will result. The material shall be mixed so that a uniform mixture of unchanging appearance is obtained and all particles of aggregate are coated with asphalt.

**301-4.4.4 Motor-Grader Mixing.** Unless otherwise permitted by the Engineer, the aggregate shall be thoroughly blended with the blade of a motor-grader and uniformly spread over the site preparatory to application of the asphalt. Asphalt shall be spread by an approved pressure distributor in the number of applications directed by the Engineer. After each application, the aggregate shall be mixed. Additional water shall be added as needed by pressure distributor in the amount directed by the Engineer. After the final application, the material shall be bladed into a windrow and the windrow bladed back and forth across the site with a heavy motor-grader having a wheelbase not less than 4.5 m (15 feet) until a satisfactory mixture of uniform and unchanging appearance has been obtained. After having been mixed and deposited in the final windrow, the mixture shall not be allowed to remain in the windrow for more than 24 hours unless otherwise permitted by the Engineer.

**301-4.5 Placing the Mixture.** The mixed base material shall be laid and rolled to the thickness shown on the Plans in layers not to exceed 150 mm (6 inches) in compacted thickness.

If the aggregate and asphalt have been mixed in a central mixing plant, the treated base material shall be transported to the site in trucks and spread. Dumping in piles on the subgrade will not be permitted. If necessary, spreading shall be completed by blading the mixture to proper cross section with motor-grader. An approved spreading, screeding, and tamping machine may be used.

The moisture content of the mixed material prior to compaction shall be as directed by the Engineer.

**301-4.6 Compacting.** Rolling of the mixture shall commence immediately after it has been placed on the subgrade.

Layers of mixture shall be rolled with double-axle, multiple pneumatic-tired rollers. Rollers shall be self-propelled or drawn by tracks or tractors having rubber-tired wheels.

After the specified compaction has been secured in the top layer with the pneumatic-tired rollers, the roadway shall be thoroughly rolled with self-propelled tandem rollers with smooth steel wheels. Such rollers shall weigh between 7.2 and 9.1 tonnes (8 and 10 tons).

Rolling shall commence at the outer edge of the base course and progress toward the center. Each base course layer shall be rolled until it is compacted and true to grade and cross section.

Rolling shall continue until a relative compaction of at least 95 percent has been obtained. The surface of the finished bituminous-stabilized base, at any point, shall not vary more than 12 mm (0.04 foot) above or below the grade established by the Engineer, and such variations shall be compensating.

Areas inaccessible to the roller shall be compacted by power tamping until the base material is compacted to a relative compaction of at least 95 percent.

The surface of each layer shall be clean prior to placing the succeeding layer of material.

**301-4.7 Base Seal.** After the top layer is compacted, cleaned and dried to the percent of moisture required, the surface shall be given a light uniform application of mixing-type emulsified asphalt at the rate of  $0.57 \text{ L/m}^2$  (1/8 of a gallon per square yard). After the seal has dried, the base shall be ready for final pavement surface.

**301-4.8 Payment.** Bituminous-stabilized base or subbase will be paid for by the square meter (square yard) in place as shown on the Plans or as directed by the Engineer. The price per square yard shall include payment for furnishing untreated base material or mineral aggregate required by the Plans or Specifications, mixing, spreading, shaping, compacting, trimming, and sealing the treated material. Separate payment will be made for bituminous materials used for stabilization at the rate specified on the Plans or as directed by the Engineer as provided in 203-2.6 or 203-3.6. Payment for bituminous materials shall include payment for furnishing and spreading. Bituminous materials will not be considered a major bid item for the purpose of adjusting quantities.

### 301-5 LIME-TREATED SOIL.

**301-5.1 General.** Lime treatment shall consist of mixing a soil with a specified percentage of hydrated lime or quicklime and water; spreading, compacting, and curing the mixture to the lines, grades, and dimensions shown on the Plans or as specified herein.

**301-5.2 Lime.** Lime shall be either a commercial dry hydrated lime or quicklime, conforming to ASTM C 51.

When sampled by the Engineer at the point of delivery, the lime shall meet the following quality requirements:

**TABLE 301-5.2 (A)**

Sieve Sizes	Percent Passing	
	Hydrated Lime	Quicklime
4.75 mm (No. 4)	100	100
600 $\mu\text{m}$ (No. 30)	95 - 100	
150 $\mu\text{m}$ (No. 100)		0 - 20
75 $\mu\text{m}$ (200)	75 - 100	
Test Method	ASTM C 110 <sup>1</sup>	ASTM C 136 <sup>2</sup>
Chemical	Percent of Chemical (Min.)	
Ca (OH) <sub>2</sub>	85	119
CaO		90
Test Method	California Test 414 or ASTM C 25	

1. The sample shall be washed for  $15 \pm 1$  mins.

2. Dry sieving only.

The lime shall be protected from moisture exposure until used and shall be sufficiently dry to flow freely. Prior to spreading, a certificate of compliance and a certified copy of the shipping weight shall be submitted to the Engineer with each delivery.

Lime may be mixed with water to form a slurry prior to being added to the soil. Mixing of the lime and water may be accomplished by any method which will produce a uniform consistency. When once established, the proportioning method may not be changed without the approval of the Engineer.

**301-5.3 Water.** All water used must be fresh and potable.

**301-5.4 Preparation.** When material to be treated is to be imported to the project site, the subgrade shall be prepared as provided in 301-1 prior to placing such imported material.

If in-place material is to be treated, it shall be shaped and rolled to the section specified prior to scarifying and treating. No subgrade preparation shall be necessary provided that it is firm and able to support the construction equipment to the satisfaction of the Engineer. Where needed, stabilization of the earth subgrade shall be as directed by the Engineer.

The material to be treated shall contain no rocks larger than 50 mm (2 inches) in diameter. Removing and disposing of rocks larger than 50 mm (2 inches), when in excess of 5 percent of the total material to be treated, will be paid as extra work as provided in 3-3.

**301-5.5 Spreading Lime.** Lime shall be spread by a system, approved by the Engineer, which will uniformly distribute the required amount of lime for the full width of the pass or on the windrow. When lime slurry is used, the distributor truck shall be equipped with a recirculating pump or other device to prevent settling of the lime prior to depositing on grade. The lime spread rate shall not vary more than 10 percent from the designated spread rate. All lime shall be mixed the same day as spread.

If the material to be treated is windrowed, the top of the windrow shall be flattened or trenched to receive the lime. No traffic other than water trucks and the mixing equipment will be allowed to pass over the spread lime until after completion of mixing.

Lime or lime-treated material shall not be spread or mixed while the atmospheric temperature is below 2°C (35°F) or when wind conditions are such that blowing lime can have adverse effect on traffic or adjacent property.

**301-5.6 Mixing.** The mixing shall be accomplished with a traveling mixer, approved by the Engineer, which shall be equipped with a system capable of introducing water at a controlled rate during mixing in order to produce a completed mixture with a uniform moisture content. Mixing operations shall be performed in such a manner as to produce a uniform mixture of the lime, water, and the materials being treated, free of streaks and pockets of lime. Nonuniformity of color reaction, when the treated material is tested with the standard phenolphthalein-alcohol indicator, shall be considered as evidence of inadequate mixing. Water shall be added during the mixing process until the water content of the mixture is approximately 2 percent above the optimum moisture content of the lime-treated soil. Sufficient water shall be added during initial mixing to slake all the quicklime.

The final mixture shall not contain more than 5 percent untreated dirt clods larger than 25 mm (1 inch) in diameter.

At the conclusion of mixing, suitable protective measures shall be taken to minimize evaporation loss and to prevent excessive wetting.

**301-5.7 Spreading and Compacting.** After the mixing operation is complete, a curing period of not less than 16 nor more than 72 hours is required before the lime-treated material is spread and compacted. The completed mixture shall be spread to the plan, grade, and cross section.

The thickness of a compacted layer shall not exceed 200 mm (8 inches). Where the thickness is more than 200 mm (8 inches), the mixture shall be spread and compacted in two or more approximately equal layers. The moisture content shall be maintained to achieve compaction.

Where used directly under pavement, lime-treated soil shall be compacted to not less than 95 percent relative density. This finished surface shall not vary more than 6 mm (0.02 foot) from the specified grade and cross section.

In other cases, the relative density shall be 90 percent minimum. The finished surface shall not vary more than 12 mm (0.04 foot) from the specified grade and cross section.

Initial compaction shall be by means of sheepsfoot or segmented-wheel rollers. Final rolling shall be by means of steel-tired or pneumatic-tired rollers. Areas, inaccessible to rollers, shall be compacted to the required compaction by other means satisfactory to the Engineer.

At the end of each day's work, a vertical-faced construction joint shall be made in thoroughly compacted material normal to the centerline of the roadbed. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.

**301-5.8 Curing.** The surface of the compacted layer shall be kept moist until covered by other base material or application of a curing seal of emulsified asphalt. If a curing seal is used, it should be applied as soon as possible after completion of final rolling, at a rate of between 0.45 L/m<sup>2</sup> and 0.90 L/m<sup>2</sup> (0.10 and 0.20 gallon per square yard), the exact rate to be determined by the Engineer.

No equipment or traffic shall be permitted on lime-treated material for 72 hours after curing seal is applied, unless otherwise permitted by the Engineer.

**301-5.9 Safety Program.** The Contractor shall provide to the Engineer for review a detailed safety program for the protection of the workers and public, covering precautions to be exercised and emergency treatment to be available on the jobsite. The program shall include protective equipment for eye, mouth, nose, and skin protection; and a first-aid kit with an eyeball wash. Said protective equipment shall be available on the jobsite during spreading and mixing operations. This program shall be provided and agreed upon before the lime spreading begins. The Contractor shall actively enforce said program for the protection of its work force and others in the construction area. Adequate care must be taken to avoid quicklime contact during spreading and slaking operations.

**301-5.10 Measurement and Payment.** Lime-treated soil will be paid for by the square meter or cubic meter (square yard or cubic yard) in place as shown on the Plans or as directed by the Engineer. The price per square meter or cubic meter (square yard or cubic yard) shall include payment for breaking-up, mixing, spreading, compacting, trimming, and curing treated soil. Lime will be paid for by the tonne (ton) when spread at the rate prescribed on the Plans or directed by the Engineer. Payment for lime will include furnishing and spreading lime. Lime will not be considered a major bid item for the purpose of adjusting quantities.

## SECTION 302 - ROADWAY SURFACING

### 302-1 OILED ROADWAYS AND SHOULDERS.

**302-1.1 General.** The roadway or shoulder to be oiled shall be prepared in accordance with the Specifications following which it shall be uniformly watered sufficiently to eliminate dust, but not to such extent as to form mud or pools of water. Grade SC-70 liquid asphalt shall then be applied to the dampened surface at a uniform rate of 1.58 L/m<sup>2</sup> (0.35 gallon per square yard) unless otherwise specified.

The oil shall conform to and be applied as required in 203-2.

The application of oil to the roadway or shoulder shall be scheduled to commence after 7:00 a.m. and shall be completed prior to 1:00 p.m., and it is further specified that no oil shall be applied when the air temperature is less than 5°C (40°F).

During all oiling operations, precautions shall be exercised to prevent marring or discoloring adjacent improvements, and adequate protection against such possibility shall be provided.

After the applied oil has dried, or penetrated to such extent that no free oil remains on the surface, and the condition of the oiled area will otherwise permit, the roadway or shoulder shall be opened to traffic.

**302-1.2 Measurement and Payment.** Payment for oiled roadways and shoulders will be made on a square meter (square-yard) basis as shown in the Bid.

### 302-2 CHIP SEAL.

**302-2.1 General.** A chip seal shall consist of an application of emulsified asphalt and screenings to an existing roadway surface. Streets shall be chip sealed to the edge of the existing pavement, excluding inverted shoulders except when shown on the Plans. Manholes, valves, survey monuments, or miscellaneous frames and covers shall not receive a chip seal. If any frame and cover is sealed, it shall be cleaned to the satisfaction of the Engineer.

Chip seals are defined by type, which identifies the size of aggregate and the rate of application of emulsified asphalt and screenings. Unless otherwise specified, a medium type chip seal shall be applied.

**TABLE 302-2.1 (A)**

Chip Seal Types	Size of Screenings	
Fine	6.3 mm X 2.00 mm	(1/4 in X No. 10)
Medium Fine	8.0 mm X 2.36 mm	(5/16 in X No. 8)
Medium	9.5 mm X 3.35 mm	(3/8 in X No. 6)
Coarse	12.5 mm X 4.75 mm	(1/2 in X No. 4)
Double		
1 <sup>st</sup> Application	12.5 mm X 4.75 mm	(1/2 in X No. 4)
2 <sup>nd</sup> Application	6.3 mm X 2.00 mm	(1/4 in X No. 10)

**302-2.2 Surface Preparation.** The Contractor shall remove any raised pavement markers within the area to be sealed, and the pavement surface shall be prepared as required by the Plans or Specifications. Immediately before applying the emulsified asphalt, the surface shall be clean and dry. Cleaning shall be performed by sweeping, flushing, or other means necessary to remove all loose particles of paving, all dirt, and all other extraneous material.

**302-2.3 Application and Spreading.** Chip seals shall only be applied when:

- 1) Atmospheric temperature is above 16°C (60°F) and pavement temperature is above 13°C (55°F).
- 2) The pavement is clean and dry.
- 3) Wind conditions are such that a uniform emulsion coverage can be achieved.
- 4) Rain is not imminent.
- 5) Sufficient screenings shall be on hand before the emulsified asphalt is applied.

Application of emulsified asphalt shall be stopped before the distributor tank is empty to assure designated application rate.

Stockpiling of screenings prior to placing will be permitted; however, any contamination resulting during storage or from reloading operations will be cause for rejection. Stockpiling of screenings within the right-of-way will require the approval of the Engineer.

The emulsified asphalt shall be covered with screenings before setting or “breaking” of the emulsion occurs. Operating the chip spreader at speeds which cause the chips to roll over after striking the bituminous covered surface will not be permitted. The speed of the distributor shall be governed by the speed of the chip spreader.

Screenings shall be spread by means of a self-propelled chip spreader, equipped with a mechanical device which will spread the screenings at a uniform rate over the full width of a traffic lane in one application.

The spreader shall be capable of reducing the aggregate spreading width to accommodate variable widths.

Trucks for hauling screenings shall be tailgate discharge and shall be equipped with a device to lock onto the hitch at the rear of the aggregate spreader. Haul trucks shall also be compatible with the aggregate spreader so that the dump bed will not push down on the spreader when fully raised or have too short an apron resulting in aggregate spillage while dumping into the receiving hopper. Screenings shall be surface damp at the time of application, but excess water on the aggregate surface will not be permitted. Screenings shall be redampened in the vehicles prior to delivery to the spreader when directed by the Engineer.

All joint edges shall be sweep clean of excess screenings prior to the adjacent application of emulsified asphalt material. Precautions shall be taken to avoid "skips" and "overlaps" at joints and to protect the surfaces of adjacent structures from being spattered or marred. Correction of any such defects shall be performed at the Contractor's expense. All transverse joints shall be made by placing building paper over the ends of the previous applications, and the joining application shall start on the building paper. The paper shall be removed and disposed of as required by 7-8.1. The longitudinal joint between adjacent applications of screenings shall coincide with the line between designated traffic lanes.

Application of emulsified asphalt shall be discontinued sufficiently early in the day to permit the termination of traffic control prior to darkness.

**302-2.4 Emulsified Asphalt.** Emulsified asphalt shall be Type CRS-2 per 203-3 and shall be applied by distributing equipment per 203-2.5 and 203-3.

The application rate of emulsified asphalt shall be within the following ranges. The exact rates will be determined by the Engineer.

**TABLE 302-2.4 (A)**

Chip Seal Types	Application Rate	
	L/m <sup>2</sup>	(gal./yd <sup>2</sup> )
Fine	0.68 to 1.36	(0.15 to 0.30)
Medium Fine	0.91 to 1.58	(0.20 to 0.35)
Medium	1.36 to 1.81	(0.30 to 0.40)
Coarse	1.36 to 1.81	(0.30 to 0.40)
Double		
1 <sup>st</sup> Application	0.91 to 1.58	(0.20 to 0.35)
2 <sup>nd</sup> Application	0.91 to 1.36	(0.20 to 0.30)

The distribution of emulsified asphalt shall not vary more than 15 percent transversely, nor more than 10 percent longitudinally from the specified rate of application as determined by California Test 339.

**302-2.5 Screenings.** Screenings shall conform to 200-1.2.1. The spread rate of screenings for the various types of chip seals shall be within the following ranges. The exact rate will be determined by the Engineer.

**TABLE 302-2.5 (A)**

Chip Seal Types	Spread Rate	
	Kg/m <sup>2</sup>	(lbs./yd <sup>2</sup> )
Fine	6.5 to 10.9	(12 to 20)
Medium Fine	8.7 to 13.6	(16 to 25)
Medium	10.9 to 16.3	(20 to 30)
Coarse	12.5 to 19.0	(23 to 35)
Double		
1 <sup>st</sup> Application	12.5 to 16.3	(23 to 30)
2 <sup>nd</sup> Application	6.5 to 10.9	(12 to 20)

**302-2.6 Finishing.** After the screenings have been spread, any piles, ridges, or uneven distribution shall be carefully removed to ensure against permanent ridges, bumps or depressions in the completed surface. Additional screenings shall be spread in whatever quantities may be required to prevent picking up by the rollers or traffic.

Initial rollings shall commence immediately following spread of screenings. The compaction of screenings shall be accomplished by a minimum of three self-propelled, pneumatic-tired rollers meeting the requirements of 302-5.6.1, except that tires shall be inflated to 690 kPa (100 psi) and the operating weight shall be 2300 kg (5,000 pounds) per tire. The rolling equipment shall maintain a distance of not more than 60 m (200 feet) behind the chip spreader on the first pass. The rollers shall operate at a maximum speed of 8 km/hr (5 miles per hour). There shall be at least three complete coverages by the pneumatic-tired rollers (one initial and two secondary) to embed particles firmly into the emulsified asphalt.

After completion of pneumatic-tired rolling and the emulsified asphalt has broken, traffic will be permitted to travel over the chip seal if necessary. Guide vehicles shall be used to limit traffic speeds on the chip seal to 25 km/hr (15 mph) for a period of 2 to 4 hours as determined by the Engineer.

Sweeping shall be a multi-step operation following placement of the screenings. A power broom shall be used to remove loose material without dislodging aggregate set in the asphalt. The initial sweeping shall be a light brooming performed before the roadway may be opened to unguided traffic but no sooner than 3 hours following placement, with a second sweeping completed the day following placement. Additional sweeping shall be performed as necessary during the 5-day period following placement of the chip seal. If because of high temperatures or other causes there is dislodgement of cover aggregate, sweeping shall be discontinued until such time as there will be satisfactory retention of cover aggregate. Final sweeping shall be done and all loose aggregate shall be removed prior to acceptance.

Within 24 hours after placement, the Contractor shall also start removing loose aggregate from parkways, sidewalks, and intersecting streets. Both operations shall continue until all excess or loose aggregate is removed from the roadway surface and abutting right-of-way. The aggregate shall be disposed of by the Contractor at no cost to the Agency.

The sweeping operations shall be accomplished without the use of gutter brooms or steel-tined brooms unless approved by the Engineer.

Blotter material, either fine screenings or concrete sand, may be required immediately after the initial pass of the rollers or after sweeping and opening to traffic so as to prevent bleeding and pickup of the aggregate.

The completed surface shall present a uniform appearance and shall be thoroughly compacted, and free from ruts, humps, depressions, or irregularities due to an uneven distribution of emulsified asphalt or screenings.

**302-2.7 Weighmaster Certificates.** The Contractor shall supply the Engineer with licensed weighmaster's certificates of weight for all materials delivered to the job during the course of each day. Materials so certified as being delivered for use in the Contract shall be used only in the chip seal. The Contractor shall also present weighmaster's certificates for the amount of such materials remaining unused at the completion of the work at no cost to the Agency. Payment will be determined by deducting the amount of unused materials from the total amount of materials delivered, all as shown on the licensed weighmaster's certificates. The certificates shall be presented to the Engineer at the time of delivery.

**302-2.8 Measurement and Payment.** Emulsified asphalt and screenings will be paid for at the Contract Unit Price per square meter (square yard). Such price shall include full compensation for specified surface preparation, removals, sweeping, and sanding if necessary, and for doing all the work involved in constructing the chip seal complete in place.

**302-3 (Not Used.)**

**302-4 EMULSION-AGGREGATE SLURRY.**

**302-4.1 Materials.** Materials for emulsion-aggregate slurry shall conform to 203-5.

**302-4.2 Mixing.**

**302-4.2.1 General.** Mixing shall be performed by a continuous-flow mixer. All aggregate particles shall be uniformly saturated and coated with asphalt.

**302-4.2.2 Continuous-Flow Mixers.** The slurry mixer shall be a multiblade or spiral continuous-flow unit in good working condition capable of accurately delivering a predetermined proportion of aggregate, water, emulsion, additive and asphalt modifier to the mixer and of discharging the thoroughly mixed slurry on a continuous basis. Each mixer shall have a metering device to measure the quantity of water in liters (gallons) used in each load of slurry and a separate metering device or equivalent which meets the approval of the Engineer to measure the quantity of emulsified asphalt used in each load of slurry.

The spreader box shall be equipped with flexible material in contact with the pavement and shall be maintained so as to prevent loss of slurry. It shall be adjustable to ensure a uniform controlled spread and be equipped with a mechanical or hydraulic type horizontal shifting device.

**302-4.3 Application.**

**302-4.3.1 General.** The work shall consist of mixing asphaltic emulsion, aggregate, additive, and water and spreading the mixture on the pavement where shown on the Plans. Type I and Type II slurry shall be applied at the application rate shown in Table 302-4.3.1 (A).

**TABLE 302-4.3.1 (A)**

Slurry Seal	Application Rate		Area Covered	
	Minimum	Maximum	Minimum	Maximum
Type I	4.3 kg/m <sup>2</sup> (8 lbs/yd <sup>2</sup> )	5.4 kg/m <sup>2</sup> (10 lbs/yd <sup>2</sup> )	167 m <sup>2</sup> /ELT (1800 ft <sup>2</sup> /ELT)	209 m <sup>2</sup> /ELT (2250 ft <sup>2</sup> /ELT)
Type II	6.5 kg/m <sup>2</sup> (12 lbs/yd <sup>2</sup> )	8.1 kg/m <sup>2</sup> (15 lbs/yd <sup>2</sup> )	112 m <sup>2</sup> /ELT (1200 ft <sup>2</sup> /ELT)	139 m <sup>2</sup> /ELT (1500 ft <sup>2</sup> /ELT)

An ELT of slurry is made up of 907 kg (2000 pounds) of dry aggregate plus emulsified asphalt, accelerator or retardant, and water. Quantities and application rate shall be approved by the Engineer. When the Engineer determines that the application rate does not conform to the requirements, the Contractor shall take immediate corrective action. When the rate is less than the minimum amount required, the Contractor shall reapply additional slurry seal to the nonconforming area to meet the requirements. When the rates exceed the maximum specified in Table 302-4.3.1 (A), the Engineer should refer to 4-1.1.

The sites for stockpiling and batching materials shall be clean and free from objectionable material. Arrangements for these sites shall be the responsibility of the Contractor.

Hand squeegees and other hand equipment shall be provided to remove spillage and spread slurry in areas inaccessible to the spreader box.

The Contractor shall have two fully operational mixers for use at the project site at all times. These mixers shall be available for inspection by the Agency at least 48 hours prior to commencing work.

**302-4.3.2 Spreading.** Slurry shall not be applied when the atmospheric temperature is less than 10°C (50°F). The maximum speed of the slurry machine shall not exceed 80 meters per minute (270 feet per minute).

The application of slurry shall not commence until after 7:00 a.m. and the slurry shall be sufficiently cured to be open to traffic by 4:00 p.m. The streets to be sealed shall be closed from the time the application begins until the Engineer determines the mixture has achieved sufficient set to be opened to traffic.

Prior to applying slurry, the surface to be sealed shall be cleaned by the Contractor unless otherwise specified. Immediately ahead of the mixer, the pavement shall be prewetted by a pressure water distribution system equipped with a fog-type spray bar which will completely fog the surface of the pavement. The need for application and the rate of application will be determined by the Engineer.

Evidence of solidification of the asphalt, balling or lumping of the aggregates, or the presence of uncoated aggregates will be cause for rejection of the slurry.

Slurry shall be applied in such a manner that no ridges shall remain.

The Contractor shall prevent slurry from being deposited on other than asphalt concrete surfaces and shall remove slurry from surfaces not designated to be sealed at no cost to the Agency. The method of slurry removal shall be approved by the Engineer.

At the direction of the Engineer, the Contractor shall repair and reseal all areas of the streets which have not been sealed properly or completely, at no cost to the Agency.

Where the completed slurry is not uniform in color, the street shall be treated to eliminate the color variation at the Contractor's expense. The method of treatment shall be approved by the Engineer.

**302-4.3.3 Field Sampling.** During the performance of the work, the Agency will take at least two field samples of the mixed slurry per slurry mixer per day. The Wet Track Abrasion test sample shall not be transported until slurry has set as defined by ASTM D 3910. All field samples shall have the following values:

**TABLE 302-4.3.3 (A)**

Tests	Test Method	Requirements	
		Min.	Max.
Wet Track Abrasion Test, Weight loss, gm/m <sup>2</sup> (gm/ft <sup>2</sup> ) Type I Aggregate	ASTM D 3910 <sup>1</sup>	0	540 (50)
Wet Track Abrasion Test, Weight loss, gm/m <sup>2</sup> (gm/ft <sup>2</sup> ) Type II Aggregate	ASTM D 3910 <sup>1</sup>	0	650 (60)
Consistency Test (mm)	ASTM D 3910 <sup>1</sup>	20	40
Extraction Test (Calculated Emulsion Content, %)	ASTM D 2172, California 382 <sup>2</sup>	± 1.0% of mix design	
Water Content, % of Dry Aggregate Weight	See note 3 below	—	25

1. Modified ASTM D 3910 to include 4.75 mm (No. 4) aggregate or greater and to be performed using field samples.

2. Modified CTM 382 to allow 1000 ± 100 gram sample.

3. Weigh a minimum of 500 grams of homogenized mixed slurry into a previously tarred quart can with a friction lid. The lid shall be placed on the can to prevent loss of material during transportation. Place the can with the lid off in an oven and dry to constant mass at 110° ± 5°C (230° ± 9°F). Cool, reweigh and calculate the water content.

Subsection 6.4.4.7 of ASTM D 3910 may be modified to use a microwave oven for drying the specimen after the abrasion cycle and the debris has been washed off.

If the test results fail to meet the specifications, the Contractor shall cease slurry laydown operation with the nonconforming mixer until it demonstrates the ability to comply with the Specifications.

No change in the proportions of the approved mix design will be permitted without the Engineer's approval. If the Contractor changes its source of supply for either the aggregate or the emulsion, the mix design approval and the quality control procedures specified herein shall be repeated. Mixes used shall

not deviate more than  $\pm 1.0$  percent from the approved proportion of emulsion. (Example: If the approved mix is 16 percent emulsion, then the emulsion content must be between 15 and 17 percent). The percentage of emulsion is based on the dry weight of aggregate.

**302-4.4 Public Convenience and Traffic Control.** At least 5 working days prior to commencing work, the Contractor shall submit its spreading schedule to the Agency for approval. This schedule shall allow residents on the streets to be sealed ample "on street" parking within a reasonable distance from their homes. Based upon the spreading schedule, the Contractor shall notify residents and businesses of the work and post temporary "No Parking" signs. Requests for changes in the schedule shall be submitted by the Contractor to the Engineer for approval at least 48 hours prior to the scheduled sealing of the streets affected.

The Contractor shall be responsible for adequate barricading of the work area and controlling of traffic in the vicinity of the project as specified in 7-10, or as directed by the Engineer.

When necessary to provide vehicular or pedestrian crossings over the fresh slurry, the Engineer shall direct the Contractor to spread sufficient sand or rock dust on the affected area to eliminate tracking or damage to the slurry. Sand or rock dust used for this purpose shall be at the Contractor's expense.

**302-4.5 Measurement and Payment.** Slurry will be paid for at the Contract Unit Price per ELT. The payment quantity will be determined by the weight of dry aggregate used in the slurry.

The contract unit price paid per ELT shall include full compensation for furnishing emulsion, accelerator or retardant, and water.

**302-4.6 Payment Reduction for Noncompliance.**

**302-4.6.1 General.** Payment to the Contractor will be reduced for failure to comply with Wet Track Abrasion Testing requirements stated in 302-4.3.3. The percent reduction will be based on the requirements stated in 302-4.6.2. Reduction in payment will be applied to all of the material placed per day by the nonconforming slurry mixer.

**302-4.6.2 Reduction in Payment Based on WTAT.** If the average of the Wet Track Abrasion Tests made for each slurry mixer, per day, fail to conform to the requirements specified in 302-4.3.3, the Contractor agrees that the payments for the slurry shall be reduced as follows:

**TABLE 302-4.6.2 (A)**

WTAT Loss gm/m <sup>2</sup> (gm/ft <sup>2</sup> )	Payment Reduction (Percent) Fine & Type I Aggregate
0 - 540 (0 - 50)	0
540.1 - 650 (50.1 - 60)	5
650.1 - 750 (60.1 - 70)	15
750.1 - 860 (70.1 - 80)	30
860.1 - 1070 (80.1 - 99)	70
1070.1 or greater (99.1 or greater <sup>1</sup> )	100

1. Slurry seal with WTAT loss greater than 1070.1 gm/m<sup>2</sup> (99.1 g/ft<sup>2</sup>) shall be removed to the satisfaction of the Engineer.

**TABLE 302-4.6.2 (B)**

WTAT Loss gm/m <sup>2</sup> (gm/ft <sup>2</sup> )	Payment Reduction (Percent) Type II Aggregate
0 - 650(0 - 60)	0
650.1 - 810 (60.1-75)	15
810.1 - 860 (75.1 - 80)	30
860.1 - 1070 (80.1 - 99)	70
1070.1 or greater (99.1 or greater <sup>1</sup> )	100

1. Slurry seal with WTAT loss greater than 1070.1 gm/m<sup>2</sup> (99.1 g/ft<sup>2</sup>) shall be removed to the satisfaction of the Engineer.

### **302-5 ASPHALT CONCRETE PAVEMENT.**

**302-5.1 General.** Asphalt concrete pavement shall consist of one or more courses of a mixture of paving asphalt and graded aggregate as specified in 203-6, placed upon a prepared roadbed or base, or over existing pavement. The courses shall be of the type of mixture and the dimensions shown on the Plans or Specifications.

Bituminous pavement shall be removed in accordance with 300-1.3.2.

#### **302-5.2 Cold Milling Asphalt Concrete Pavement.**

**302-5.2.1 General.** The Contractor shall cold mill existing asphalt concrete pavement, as dimensioned and as otherwise designated on the Plans. Cold milling shall remove variable depths of asphalt concrete to provide an overlay key at joins and over the width of the cold milled area. Additional widths of cold milling may be required at various locations as determined by the Engineer. The surface of pavement after milling shall be uniformly rough grooved or ridged as directed by the Engineer. The grade shall not deviate from a suitable straight edge by more than 10 mm (3/8 inch) at any point.

The Contractor shall remove existing asphalt concrete overlay from gutters adjacent to any area specified to be cold milled, as directed by the Engineer.

The Contractor's attention is directed to 7-8.2.

##### **302-5.2.2 Equipment.**

The machine used for milling shall meet the following requirements:

The milling machine shall be specially designed and built for milling of bituminous pavements without the addition of heat, with the ability to plane portland cement concrete patches in the bituminous pavement. The cutting drum shall be a minimum of 1500 mm (60 inches) wide and shall be equipped with carbide-tipped cutting teeth placed in a variable lacing pattern to produce the desired finish.

The machine shall be capable of being operated at speeds from 0 to 12 m/min. (0 to 40 feet per minute). It shall be self-propelled and have the capability of spraying water at the cutting drum to minimize dust. The machine shall be capable of removing the material next to the gutter of the pavement being reconditioned and be designed so that the operator can at all times observe the milling operation without leaving the controls. The machine shall be adjustable for slope and depth and shall deep cut in one pass a maximum of 75 mm (3 inches) without producing fumes or smoke.

The Contractor shall provide a smaller machine if required to trim areas inaccessible to the larger machine at manholes, gate valve covers, curb returns, and intersections. The smaller machine shall be equipped with a 300 mm (12 inch) minimum-width cutting drum mounted on a chassis allowing it to be positioned without interrupting traffic or pedestrian flow.

**302-5.2.3 Removal and Disposal of Material.** During the milling operation, the Contractor shall sweep the street with mechanical equipment and remove all loosened material from the Project site until completion of the removal work. The removal crew shall follow within 15 m (50 feet) of the milling machine unless otherwise directed by the Engineer. The Contractor shall take all necessary measures to avoid dispersion of dust. All material removed shall be considered the property of the Contractor and shall be disposed of by the Contractor at its expense.

**302-5.2.4 Traffic Signal Loop Detectors.** Before cold milling pavement within 90 m (300 feet) of a traffic signal, the Contractor shall notify the Agency at least 3 working days prior to commencing work within said area. Upon notification, the Agency will mark the location of all existing loop detectors. The Contractor shall not cold mill within 300 mm (12 inches) of these loop detector conductors.

Damage to the existing loops caused by the Contractor operation will require replacement of the loops in their entirety at the Contractor's expense.

**302-5.2.5 Pavement Transitions.** Structures and vertical joints in the cold-milled area which are transverse to through traffic and greater than 38 mm (1-1/2 inches) in height, shall be ramped with temporary asphalt concrete pavement as specified in 306-1.5.1. Ramps shall be constructed the same day as cold milling and removed the same day as permanent paving. Ramp dimensions and compaction shall be approved by the Engineer.

**302-5.2.6 Measurement and Payment.** Cold milling will be measured by the linear meter (foot) along the edge of the transverse joint lines, adjacent curb, gutter, or cross gutter, or by the square meter (square foot) as shown in the Bid.

Payment for construction, removal, and disposal of temporary asphalt concrete ramps shall be included in the item for cold milling.

**302-5.3 Prime Coat.** When specified, a prime coat consisting of Grade SC-250 liquid asphalt shall be applied at a rate between 0.45 L/m<sup>2</sup> and 1.15 L/m<sup>2</sup> (0.10 and 0.25 gallon per square yard). Grade SC-70 liquid asphalt may be used when approved by the Engineer.

**302-5.4 Tack Coat.** If the asphalt concrete pavement is being constructed directly upon an existing hard-surfaced pavement, a tack coat of either AR 4000/AR 8000 paving asphalt at an approximate rate of 0.25 L/m<sup>2</sup> (0.05 gallon per square yard) or SS-1h emulsified asphalt at an approximate rate of 0.25 L/m<sup>2</sup> to 0.45 L/m<sup>2</sup> (0.05 to 0.10 gallon per square yard) shall be uniformly applied upon the existing pavement preceding the placement of the asphalt concrete. The surface shall be free of water, foreign material, or dust, when the tack coat is applied. To minimize public inconvenience, no greater area shall be treated in any one day than is planned to be covered by asphalt concrete during the same day, unless otherwise authorized by the Engineer.

A similar tack coat shall be applied to the surface of any course, if the surface is such that a satisfactory bond cannot be obtained between it and a succeeding course.

The contact surfaces of all cold pavement joints, curbs, gutters, manholes, and the like shall be painted with either Grade SS-1h emulsified asphalt or AR 4000/AR 8000 paving asphalt immediately before the adjoining asphalt concrete is placed.

**302-5.5 Distribution and Spreading.** The Contractor shall provide and install a header upon the line of termination of asphalt pavement where shown on the Plans or required by the Specifications. Such headers shall remain in place upon completion of the improvements.

Headers shall be 50 mm (2 inch) nominal size lumber, the vertical dimension of which shall be within 13 mm (1/2 inch) of the thickness of the pavement at the header line. The minimum vertical dimension of a header shall be 88 mm (3-1/2 inches). The headers shall have a firm bearing on the header subgrade and the top edges shall be set to conform to the grade of the proposed street surface. Side stakes 50 mm x 75 mm (2 inches by 3 inches) nominal size, 450 mm (18 inches) long, or longer, and spaced not over 1.2 m (4 feet) apart, shall be driven on the outside of the headers to a depth of 25 mm (1 inch) below the top edge and then nailed to the header. The joints between the individual boards being used as headers shall be spliced with a 25 mm (1 inch) thick nominal size board of the same height as the header and not less than 600 mm (24 inches) long.

The temperature of the mixture directly behind the paving machine, before the breakdown roller, shall not be lower than 132°C (270°F) or higher than 160°C (320°F), the lower limit to be approached in warm weather and the higher in cold weather.

Asphalt concrete shall not be placed unless the atmospheric temperature is at least 10°C (50°F) and rising or during unsuitable weather.

The asphalt concrete shall be evenly spread upon the subgrade or base to such a depth that, after rolling, it will be of the specified cross section and grade of the course being constructed.

The depositing, distributing, and spreading of the asphalt concrete shall be accomplished in a single, continuous operation by means of a self-propelled mechanical spreading and finishing machine designed specially for that purpose. The machine shall be equipped with a suitable full-width compacting screed capable of being accurately regulated and adjusted to distribute a layer of the material to a definite predetermined thickness. When paving is of a size or in a location that use of a self-propelled machine is impractical the Engineer may waive the self-propelled requirements.

The asphalt concrete as delivered shall be deposited directly into the hopper of the spreading and finishing machine. With the approval of the Engineer, the Contractor may deposit the asphalt concrete material from bottom-dump trucks into a uniformly sized windrow, then pick up the material and convey it to the spreading machine with loading equipment provided:

- A. The spreading machine shall be of such design that the material will fall into a hopper, having a movable bottom conveyor or screw to feed the screed.
- B. The loader (pickup machine) shall be constructed and operated so that substantially all of the material deposited on the roadbed is picked up and deposited in the spreading machine.
- C. The windrow may be deposited no more than two truck loads ahead of the pickup machine and the temperature of the material in the windrow shall not fall below 132°C (270°F).
- D. Allowable windrow lengths may be increased if approved by the Engineer, but the windrow shall not block intersections prior to the arrival of the paving machine.
- E. A skip loader shall be on site to remove any windrowed material not meeting temperature requirement or which will overload the paving machine hopper.

Asphalt concrete of the Class indicated in the following table shall be laid in courses not exceeding 100 mm (4 inches) in thickness unless directed by the Engineer.

**TABLE 302-5.5 (A)**

Specified Total Thickness of Pavement		Minimum Number of Courses	Class of Mixture
Greater Than mm (inches)	But Not More Than mm (inches)		
0	25 (1)	1	D1 or D2
25(1)	38 (1-1/2)	1	C1, C2, D1 or D2
38(1-1/2)	75 (3)	1	C1, C2, B or A (as directed)
75 (3)	100 (4)	1	B or A (as directed)
100 (4)	125 (5)	2	C1, C2, B or A (as directed)
125 (5)	—	2 or as directed	C1, C2, B or A (as directed)

Spreading, once commenced, must be continued without interruption. No greater amount of the mixture shall be delivered in any one day than can be properly distributed and rolled during that day.

Successive courses may be laid upon previously laid courses as soon as the previous course has cooled sufficiently to show no displacement under equipment or loaded material delivery trucks.

The asphalt concrete surface of an alley shall be warped up to meet paved driveways which are 150 mm (6 inches) or less above grade. Such warping shall not extend more than 450 mm (18 inches) into the alley and shall be accomplished by thickening the pavement.

**302-5.6 Rolling.**

**302-5.6.1 General.** Asphalt concrete shall be thoroughly compacted by rolling. The number of rollers used with each paving operation shall not be less than specified below. Each roller shall have a separate operator.

**TABLE 302-5.6.1 (A)**

Tonnes (Tons) Placed per Hour	Rollers Required <sup>1</sup>	
	Compacted Thickness	
	38 mm (1-1/2 in) or less	More than 38 mm (1-1/2 in)
Less than 90 (100)	1	1
90 to 180 (100 to 200)	2	2
181 to 270 (201 to 300)	3	2
More than 270 (300)	3	3

1. Additional rollers may be necessary to meet the requirements herein.

Self-propelled compacting rollers shall meet the following criteria:

- 1) Each roller manufactured after 1998 shall have a Manufacturer's identification plate that is readily accessible and readable with the following information:
  - a) Name of Manufacturer.
  - b) Model Number.
  - c) Static Newton per millimeter (N/mm) (pounds per lineal inch (PLI)) of each drum.
  - d) Static N/mm (PLI) of ballasted drum.
  - e) N/mm (PLI) of each drum in vibratory mode.

Contractors using rollers manufactured prior to 1999 shall have the manufacturer's specifications, providing the information requested above, available to the Engineer upon request. Any roller not having this information shall not be used and shall be removed from the jobsite.

- 2) Tandem rollers in the static mode used for breakdown or intermediate rolling shall be such that the ballasted or unballasted weight on at least one drum is a minimum 44 N/mm (250 PLI).
- 3) Vibratory rollers used for breakdown or intermediate rolling shall have a compactive effort of not less than 44 N/mm (250 PLI) of centrifugal force at the setting indicated by the manufacturer's ID plate.
- 4) Finish rolling shall be performed by static or vibratory steel rollers in static mode
- 5) Pneumatic-tired rollers used for intermediate rolling shall be the oscillating type having a width of not less than 1.2 m (4 feet) and equipped with pneumatic-tires of equal size and diameter, having treads satisfactory to the Engineer. Wobble-wheel rollers will not be permitted. The tires shall be so spaced that the gap between adjacent tires will be covered by the tread of the following tire. The tires shall be inflated to 620 kPa (90 psi) or such lower pressure as designated by the Engineer, and maintained so that the air pressure will vary not more 35 kPa (5 psi) from the designated pressure. Pneumatic-tired rollers shall be so constructed that the total mass of the roller can be varied to produce an operating mass per tire of not less than 900 kg (2,000 pounds). The total operating mass of the roller shall be varied as directed by the Engineer.

For areas to be paved that are not to be subjected to vehicular traffic and when the asphalt is placed in these areas at a rate less than 90 tonnes (100 tons) per hour the roller shall have a minimum compactive force of 26 N/mm (150 PLI).

Other rollers may be used subject to prior approval by the Engineer.

As soon as the layer of asphalt concrete has been placed the breakdown rolling shall commence. The layer of asphalt shall have an internal temperature greater than 126° C (260°F) and not displace under the roller. Except when compacting lifts greater than 100 mm (4 inches) in compacted thickness, rolling shall be commenced along the lower edge of the area to be rolled and continued until the edge is thoroughly compacted, after which the roller shall be gradually advanced to the crown point, both sides being rolled in like manner. When vibratory rollers are used, they shall be operated at the highest frequency possible without breaking rock. All breakdown and intermediate rolling shall be completed prior to the surface of the mat reaching 82° (180°F). Rolling shall be continued until the pavement layer has become thoroughly compacted throughout and is true to grade and cross section. The finish rolling shall remove all marks from the surface of the mat.

For lifts greater than 100 mm (4 inches) in compacted thickness, rolling shall be commenced in the middle of the mat, after which the roller shall be gradually advanced to both edges. The roller should be advanced to a supported edge first, if applicable. Rolling of an unsupported edge may be delayed provided the required densities are obtained after the completion of the finishing rolling.

All rollers must be maintained in good mechanical condition. Those that cannot be driven along a straight path, operated without jerking, or the amplitude or frequency cannot be adjusted shall not be used and shall be removed from the jobsite. No leakage of petroleum products from any roller shall be allowed to come in contact with pavement being constructed, nor shall any roller be permitted to stand motionless on any portion of the work. The surfaces of all roller wheels shall be treated with sufficient water to prevent the pickup of bituminous materials, but under no circumstances shall the quantity of water used be detrimental to the surface of the pavement being rolled.

**302-5.6.2 Density and Smoothness.** Upon completion, the pavement shall be true to grade and cross section. When a 3 m (10 foot) straightedge is laid on the finished surface parallel to the centerline of the roadway, the surface shall not vary from the edge of the straightedge more than 3 mm (1/8 inch), except at intersections or at changes of grade. Any areas that are not within this tolerance shall be brought to grade immediately following the initial rolling. If the paving material has cooled below the lower limits of the spreading temperatures prescribed in 302-5.5, the surface of the pavement shall be brought to a true grade cross section. The paving material in the area to be repaired shall be removed, by an approved method, to provide a minimum laying depth of 25 mm (1 inch), or 2 times the maximum size aggregate, whichever is greater, of the new pavement at the join line. Repairs shall not be made to pavement surface by feather-edging at the join lines.

The compaction after rolling shall be 95 percent of the density obtained with the California Kneading Compactor per California Test 304.

The field density of compacted asphalt concrete shall be determined by:

1. A properly calibrated nuclear asphalt testing device in the field, or
2. California Test 308 when slabs or cores are taken for laboratory testing. Zinc stearate may be substituted for paraffin.

In case of dispute, method 2 (above) shall be used.

Paved areas not to be subject to vehicular traffic shall be compacted to 90% of California Test 304.

**302-5.7 Joints.** Joints between successive runs shall be vertical and at right angles to the line of the improvement. Care shall be exercised in connection with the construction of all joints to ensure that the surface of the pavement is true to grade and cross section. Lapped joints will not be permitted.

When terminating paving operations for the day, the Contractor shall construct temporary hot-mix ramps at all vertical joints which are greater than 38 mm (1-1/2 inches) in height and transverse to

through traffic. Temporary hot-mix ramp dimensions and compaction shall be approved by the Engineer. Prior to resuming paving operations, the Contractor shall remove temporary hot-mix ramps to provide for a vertical face and a full depth lift joint and apply a tack coat to the faces of the joint in accordance with 302-5.4.

**302-5.8 Manholes (and other structures).** Sewer and storm drain structures extending 50 mm (2 inches) or more above the new subgrade shall be removed by the Contractor to the new subgrade before paving. Other structures shall be lowered by the owners. Structures projecting less than 50 mm (2 inches) above the subgrade may be paved over and later adjusted to grade. All debris and foreign material shall be removed per 301-1.6. The top of reset manholes and other structures shall meet the smoothness requirement as specified in 302-5.6.2.

All structures from which manhole frames and covers have been removed to facilitate paving shall be temporarily covered with a steel plate by the Contractor. When this procedure is impractical, such as for large vaults, special structures, or where portland cement concrete pavement is to be constructed, all remodeling or reconstruction shall be completed to finish permanent surface prior to paving operations. The Contractor shall notify utility owners, at least 2 working days in advance, of the need to commence work required prior to paving operations and again for work required after paving operations. If it is found to be impractical for the utility owner to complete the final remodeling or adjustment of structures within a reasonable time after paving operations, as evaluated by the Engineer, then the Contractor shall be absolved of further responsibility in connection therewith, and the structure shall be adjusted to grade by the utility owner under permit or ordinance procedure established by the Agency for utility cuts in pavement.

After the pavement has been completed, the necessary portions of the subgrade, base, and pavement shall be neatly removed, the structure built up, and the manhole frame set to be backfilled to within 38 mm (1-1/2 inches) of the surface with portland cement concrete conforming to 302-6.1 by the party responsible for adjustment of the frame and cover. The Contractor shall fill the remaining 38 mm (1-1/2 inches) with an asphalt concrete wearing surface mixture to match the project surface course. This material shall be placed and compacted in a workmanlike manner to conform to the appearance of the surrounding pavement.

**302-5.9 Measurement and Payment.** Asphalt concrete pavement will be paid for at the Contract Unit Price per square meter (square foot), or at the Contract Unit Price per tonne (ton) as shown in the Bid. Such price shall constitute full compensation for the preparation of subgrade and applying tack coat if required. Resetting, reconstructing, or adjusting manhole or vault frames and covers to grade will be paid for as provided in 301-1.7.

The asphalt concrete bid item which utilizes the latex modifier shall be identified as Latex Modified Asphalt Concrete or Asphalt Concrete with Latex. The Contract Unit Price paid for Latex Modified Asphalt Concrete or Asphalt Concrete with Latex shall include all costs for furnishing, mixing, and placement.

When payment is to be made on a tonnage basis, the Contractor shall furnish to the Engineer at the time of delivery of the material to the job site a legible copy of a licensed weighmaster's certificate showing gross, tare, and net weights of each truckload of asphalt concrete mixture. When an automatic batching system is used, the licensed weighmaster's certificate may show only the net weight of material in the truck load. Failure of the Contractor to provide a certificate to the Engineer by the end of the day on which the material represented by such certificate is delivered to the job site may, at the discretion of the Engineer, result in the forfeiture of all payment for such material, including any labor and equipment costs included in the price for furnishing and placing the asphalt concrete.

Payment for installing headers, where required, will be made at the Contract Unit Price per linear meter (foot) for headers.

### **302-6 PORTLAND CEMENT CONCRETE PAVEMENT.**

**302-6.1 General.** Unless otherwise specified, portland cement concrete pavement shall be constructed of concrete prepared as prescribed in 201-1.

Concrete pavement shall be removed in accordance with 300-1.3.

#### **302-6.2 Forms and Headers.**

**302-6.2.1 General.** Forms and headers shall be either wood or metal. They shall be set plumb and true to line and grade, with the upper edge thereof set to the grade of the pavement to be constructed; and shall be rigidly installed on a true alignment and so maintained for a distance in advance of placing the pavement to provide for at least a 1-day run of concrete. Headers shall rest firmly on the subgrade or base. They shall be oiled immediately prior to the placing of the concrete and shall remain in place for at least 12 hours after concrete has been placed. Forms and headers must be removed before the work will be accepted.

**302-6.2.2 Wooden Forms.** Wooden forms shall be constructed of 75 mm (3 inch) nominal lumber in pieces not less than 4.9 m (16 feet) long, except where changes in alignment or grade necessitate the use of material of smaller dimensions. The lumber used shall be free from warp and other imperfections which would impair the strength for the use intended; shall have square edges (which may be slightly beveled) and square ends; shall be surfaced on the upper edge; and shall be not more than 13 mm (1/2 inch) less in depth than the specified thickness of the edge of the pavement.

Such forms shall be secured by nailing to side stakes spaced not more than 1.2 m (4 feet) apart and driven into the subgrade vertically to a depth not less than 300 mm (12 inches), and so that the tops will be below the upper edge of the header. The stakes shall be of sufficient length and cross-sectional area to adequately resist lateral displacement of the headers during the paving operations.

Wooden headers shall be spliced by nailing a board to the outside of the headers. The board shall be at least 1.2 m (4 feet) long, 25 mm (1 inch) thick, and at least 150 mm (6 inches) wide (or the depth of the header, whichever is least), and shall be centered on the joint.

**302-6.2.3 Metal Forms.** Metal forms shall be free from warp, have sufficient rigidity to resist springing during the paving operations, and shall be not less in depth than the specified thickness of the edge of the pavement being constructed. They shall be secured by means of metal stakes spaced not more than 1.5 m (5 feet) apart and driven below the top of the forms. They shall be designed so as to be driven through openings in the forms to lock them in position.

#### **302-6.3 Placing Concrete.**

**302-6.3.1 General.** Concrete shall be placed on a subgrade sufficiently dampened to ensure that no moisture will be absorbed from the fresh concrete.

Immediately after being mixed, the concrete shall be deposited on the subgrade to the required depth over the entire width of the section.

At the end of each day's run, or at any time when operations are stopped for a period of more than 40 minutes, a rigid transverse header shall be placed vertically and at a right angle across the improvement at the location designated by the Engineer and the pavement shall be finished to form a square vertical joint against which the work may be resumed. Hand mixing may be used only if necessary to provide sufficient concrete to complete paving to the expedient header.

**302-6.3.2 Slip-Form Construction.** At the option of the Contractor, and with the approval of the Engineer, concrete pavement may be constructed by the use of slip-form paving equipment.

Slip-form paving equipment shall be provided with traveling side forms of sufficient dimensions, shape, and strength to support the concrete laterally for a sufficient length of time during placement to produce pavement of the required cross section, and it shall spread, consolidate, screed, and float-finish the freshly placed concrete to provide a dense and homogeneous pavement.

The concrete shall be distributed uniformly into final position by the slip-form paver and the horizontal deviation in alignment of the edges shall not exceed 32 mm (1-1/4 inches) from the alignment established by the Engineer.

The concrete, for the full paving width, shall be effectively consolidated by internal vibration, with transverse vibrating units, or with a series of longitudinal vibrating units. Internal vibration shall mean vibration by means of vibrating units loaded within the specified thickness of pavement section and at a minimum distance ahead of the screed equal to the pavement thickness.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels, offset to run a sufficient distance from the edge of the pavement to avoid breaking or cracking the pavement edge.

After the concrete has been given a preliminary finish by finishing devices incorporated in the slip-form paving equipment, the surface of the fresh concrete shall be checked by the Contractor with a straightedge to the tolerances and finish required in 302-6.4.

Final finishing for slip-form pavement construction shall be as specified in 302-6.4.4.

### **302-6.4 Finishing.**

**302-6.4.1 General.** The concrete shall be consolidated, and the surface finished true to grade and cross section. Upon completion, the surface shall be free of any unevenness greater than 3 mm (1/8 inch) when checked with a 3 m (10 foot) straightedge placed on the surface of the pavement. The 3 m (10 foot) straightedge shall be furnished by the Contractor and shall be at the Work site prior to the commencing of the placing of the concrete.

**302-6.4.2 Tamping.** The concrete shall be distributed uniformly between the side forms as soon as it is placed, after which the concrete shall be struck off and tamped by means of a mechanical tamper. The tamper shall be operated at right angles to the centerline of the pavement, and tamping continued until the concrete is thoroughly consolidated to the specified cross section and sufficient mortar for finishing purposes has been brought to the surface.

Steel-shod hand tampers or vibrating bars may be substituted in those cases where the use of a mechanical spreader and tamper would be obviously impracticable.

Approved concrete vibrating equipment shall be used in conjunction with the mechanical tamper to consolidate the concrete adjacent to the forms or existing pavement.

### **302-6.4.3 Floating.**

(a) **General.** After tamping, the surface of the concrete shall be floated by either the finishing-machine method or the transverse-float method described below. Bridge decks may be floated by the longitudinal-float method.

(b) **Finishing-Machine Method.** The concrete shall be floated smooth and true to grade with an approved finishing machine.

(c) **Transverse-Float Method.** The concrete shall be floated at least twice with a long-handled float at least 1.5 m (5 feet) wide, following which the surface of the concrete shall be finished smooth and true to grade, with a wooden float 4.9 m (16 feet) long, 50 mm (2 inches) thick, and 150 mm (6 inches) wide. It shall be rigidly ribbed and with adjustable screws between the rib and float board to ensure a true and flat surface on the under side at all times. The float shall be operated from the side of the pavement, and parallel with the centerline.

The edge of the float shall be used to cut down all high areas, and the material so removed shall be floated into the depression until a true surface is obtained. Each successive pass of the float shall half-lap the previous pass.

The float shall be operated as far behind the tamping machine as the workability of the concrete will permit before its initial set.

(d) **Longitudinal-Float Method.** The concrete shall first be floated with a double-handled longitudinal float not less than 4.9 m (16 feet) nor more than 6.1 m (20 feet) in length, having a troweling surface not less than 200 mm (8 inches) nor more than 255 mm (10 inches) wide.

The float shall be operated from bridges over the pavement with its length parallel to the centerline of the improvement, and shall be worked back and forth transversely across the slab, planing off high spots and filling depressions.

This operation shall be continued until the surface is reasonably smooth, after which the bridges may be advanced not to exceed two-thirds the length of the surface so floated, and the operation continued.

**302-6.4.4 Final Finishing.** After being finished by one of the above methods, the outside edges of pavement shall be rounded to a 13 mm (1/2 inch) radius; and transverse contact joints, expansion joints, and joints adjacent to an existing pavement shall be rounded to a 6 mm (1/4 inch) radius.

A strip of wetted burlap shall be provided, of a length not less than the width of the pavement slab. It shall be attached by one edge to a rigid frame supported over the pavement so that the free edge of the burlap will rest or drag on the surface of the concrete. The burlap shall be dragged back and forth longitudinally along the pavement until the surface of the slab is of uniform texture and appearance throughout its entire length.

### **302-6.5 Joints.**

**302-6.5.1 General.** Joints in concrete pavement will be designated as longitudinal and transverse construction joints, transverse expansion joints, and longitudinal and transverse weakened-plane joints.

Unless otherwise specified, transverse joints shall be constructed perpendicularly to the centerline of the pavement, longitudinal joints shall be constructed parallel to the centerline of the pavement, and the faces of all joints shall be perpendicular to the finished surface of the pavement.

Joint filler, when required, shall be as designated on the Plans or in the Specifications.

**302-6.5.2 Construction Joints.** Construction joints are those made by placing fresh concrete against hardened concrete at planned locations. They shall be constructed at the locations and in the manner shown on the Plans.

Longitudinal construction joints shall be constructed by one of the following methods:

- 1) A plain face,
- 2) Use of tie bars,
- 3) Construction of keyways.

The bars or keyways shall be as designated on the Plans or in the Specifications.

**302-6.5.3 Transverse Expansion Joints.** Transverse expansion joints shall be installed at locations shown on the Plans. Expansion joint filler material shall have a minimum thickness of 12 mm (1/2 inch), a maximum thickness of 19 mm (3/4 inch), a depth equal to the thickness of the pavement, and shall be composed of materials as specified or approved by the Engineer. After the concrete has been finished, an edge of 6 mm (1/4 inch) radius shall be used on each side of the expansion joint filler. The expansion joint filler shall be cleaned of all concrete mortar.

**302-6.5.4 Weakened-Plane Joints.** Weakened-plane joints shall be constructed at the locations shown on the Plans and shall be formed by cutting a groove in the pavement with a power-driven saw. The groove for a transverse joint shall be cut to a minimum depth of 38 mm (1-1/2 inches) or one-sixth of the pavement thickness, whichever is greater; the groove for a longitudinal joint shall be cut to a minimum depth of 38 mm (1-1/2 inches) or one-fourth of the pavement thickness, whichever is greater; and the width shall be the minimum width possible with the saw being used, but in no case shall the width exceed 6 mm (1/4 inch). Any portion of the sealing compound which has been disturbed by sawing operations shall be restored by spraying the areas with additional sealing compound.

In the initial lane of concrete, the first transverse weakened-plane joint immediately following a transverse construction joint, and every fourth weakened-plane joint thereafter, shall be sawed within 10 to 24 hours after the concrete has been placed. The time lapse will be subject to the approval of the Engineer. Every second transverse weakened-plane joint shall be sawed within 24 hours after the concrete is placed, and the remaining weakened-plane joints may be sawed at such time as the Contractor may elect; except that in any lane, all weakened-plane joints shall be sawed before concrete is placed in succeeding adjacent lanes and before any traffic whatsoever is permitted to use the pavement.

In succeeding adjacent lanes of concrete pavement transverse weakened-plane joints opposite those which have opened in the initial lane shall be sawed within 10 to 24 hours after the concrete has been placed. The time lapse will be subject to the approval of the Engineer. In all cases, no more than three consecutive, transverse, weakened-plane joints shall be bypassed.

Longitudinal weakened-plane joints may be used at traffic lane lines in multi-lane, monolithic concrete pavement in lieu of longitudinal construction joints. Dowel requirements shall be as shown on the Plans or in the Specifications.

**302-6.6 Curing.** The pavement shall be cured by a concrete curing compound conforming to the requirements of 201-4.1.

Curing shall commence as soon as free water leaves the surface of the concrete, but not later than 3 hours following the deposit of the concrete upon the subgrade.

Spraying equipment shall be of the fully atomizing type, equipped with a tank agitator of an approved type which provides for continual agitation of the compound during application. The use of nonagitating-type, hand-pumped garden sprayers will not be permitted except for small and inaccessible areas as may be permitted by the Engineer.

**302-6.7 Traffic and Use Provisions.** The concrete pavement shall be immediately barricaded upon its installation, and no vehicular traffic will be permitted thereon until the expiration of at least 7 days.

Pavement constructed of concrete which has been treated in accordance with 201-1 to obtain an early increase in strength may be opened to traffic 3 days after it is placed, if directed by the Engineer.

At least 3 days shall elapse from the time the concrete is placed before any mechanical tamper, spreader, or finisher which will be supported by the edge of the new pavement, may be operated in adjacent lanes.

**302-6.8 Measurement and Payment.** Payment for concrete pavement will be made on a cubic meter (cubic-yard) or square meter (square foot) basis as shown on the Bid.

Payment for reconstructing or adjusting manholes to grade will be made as a separate item as provided in 301-1.7. If no such item is provided, payment will be deemed included in the other items of work.

### **302-7 PAVEMENT FABRIC.**

**302-7.1 General.** Pavement fabric shall conform to 213-1.

#### **302-7.2 Placement.**

**302-7.2.1 Pavement Preparation.** The surface of the distressed pavement shall be prepared as required by the Plans or Specifications prior to placement of the tack coat and pavement fabric. The fabric shall then be covered with an overlay of asphalt concrete.

**302-7.2.2 Tack Coat.** The tack coat shall be AR 4000 paving asphalt.

Tack coat shall be applied uniformly prior to placing fabric. The entire surface to be covered shall be free of water, foreign matter, vegetation, or dust before application of the tack coat.

The tack coat shall be sprayed with an asphalt distributor at the rate of  $1.13 \pm 0.09$  L/m<sup>2</sup> (0.25 ± 0.02 gallon per square yard) or as directed by the Engineer. On a new asphalt concrete leveling course, the rate shall be  $0.91 \pm 0.09$  L/m<sup>2</sup> (0.20 ± 0.02 gallon per square yard). Hand spraying shall be kept to a minimum.

The width of the sprayer application shall be no more than 150 mm (6 inches) and no less than 50 mm (2 inches) wider than the fabric width.

The temperature of the tack coat shall not exceed 163°C (325°F) when the fabric is placed.

**302-7.2.3 Placing Fabric.** Pavement fabric shall not be placed in areas where the asphalt concrete overlay is less than 38 mm (1-1/2 inches) thick.

If manual laydown methods are used, the fabric shall be unrolled, stretched, aligned, and placed in increments of approximately 9 m (30 feet).

Adjacent borders of the fabric shall be lapped 50 to 100 mm (2 to 4 inches). The preceding roll shall lap 50 to 100 mm (2 to 4 inches) over the following roll in the direction of paving at ends of rolls or at any break. If the lap exceeds 100 mm (4 inches), a tack coat shall be placed to bond the two layers of fabric together and both tack coat and fabric shall lap by the same amount.

The fabric shall be placed with the treated side up and shall be seated with brooms or pneumatic rolling equipment after placing. Turning of the paving machine and other vehicles shall be gradual and kept to a minimum to avoid damage.

Pavement fabric shall not be placed more than 180 m (600 feet) in advance of paving operations unless allowed by the Engineer. No more fabric shall be placed than can be covered that day.

If the fabric is placed within 15 m (50 feet) of the tack coat spray bar, the first 9 m (30 feet) of each roll shall be placed by hand, if directed by the Engineer, to allow inspection of the tack coat application.

Fabric shall be placed with no wrinkles that lap. The test for lapping shall be made by gathering together the fabric in a wrinkle. The two sides of the wrinkle shall be pressed together from pavement surface to a fold point with equal amounts of fabric on both sides of the fold point down to the pavement surface. If the height of the doubled portion of the extra fabric exceeds 13 mm (1/2 inch), the fabric shall be cleanly cut to remove the wrinkle. The cut shall be made on the side of the wrinkle away from the paving operation. The opposite or longer side shall be lapped over the shorter and the re-laid wrinkle area shall be pressed and smoothed into place against the pavement surface. Any lap in excess of 50 mm

(2 inches) shall be cleanly cut away, and then overlapped in the same manner as for smaller laps. A minimum 13 mm (1/2 inch) overlap shall be provided in all cases when a wrinkle area is re-laid.

Pavement fabric shall not be reduced more than 50 mm (2 inches) on each side after being placed on the tack coat. If the overall width is reduced more than 100 mm (4 inches), then the operation shall be stopped and the temperature of the tack coat immediately prior to placement of the fabric or the type of fabric shall be changed.

Care shall be taken to avoid tracking tack coat onto the pavement fabric or distorting the fabric during seating of the fabric with rolling equipment. If necessary, exposed tack coat shall be covered lightly with sand.

A small quantity of asphalt concrete, to be determined by the Engineer, may be spread over the fabric immediately in advance of placing asphalt concrete surfacing in order to prevent fabric from being picked up by construction equipment.

Public traffic will not be allowed on the bare fabric. However, traffic may be allowed to cross the fabric under traffic control. The Contractor may be required to place a small quantity of asphalt concrete over the fabric to protect it from damage.

Full compensation for advance spreading of asphalt concrete over the fabric shall be considered as included in the Contract Unit Price paid for asphalt concrete and no additional compensation will be allowed therefore.

**302-7.3 Measurement and Payment.** Pavement fabric will be measured and paid for by the square meter (square yard) for the actual pavement area covered.

The Contract Unit Price paid per square meter (square yard) for pavement fabric shall include full compensation for furnishing and placing pavement fabric, including the tack coat.

### **302-8 SEALCOAT FOR MISCELLANEOUS AREAS.**

**302-8.1 Materials.** The materials for sealcoat shall conform to 203-9. Before incorporation in the Work, the Contractor shall submit a 2 Liter (2-quart) sample of undiluted sealcoat at no cost to the Agency per Section 4.

#### **302-8.2 Application.**

**302-8.2.1 General.** The work shall consist of spreading sealcoat material on the pavement where shown on the Plans. The sealcoat material shall be applied in two applications. Unless otherwise specified, the total quantity applied shall be 2.0 L/m<sup>2</sup> (50 gallons per 1,000 square feet).

Sealcoat material shall be diluted as directed by the Engineer using clean, potable water in an amount not to exceed 20 percent of the total volume.

A tack coat, if required by Contract Documents, shall consist of three parts clean, potable water and one part SS-1h emulsion and shall be applied at the rate of 0.25 L/m<sup>2</sup> (0.05 gallon per square yard).

Sealcoat material shall not be placed over new asphalt pavement until the pavement has cured for 30 days or as required by the Engineer.

**302-8.2.2 Spreading.** Sealcoat shall only be applied when the atmospheric temperature is greater than 13°C (55°F) and if rain is not forecast for the period of 24 hours after application.

Prior to applying sealcoat material, all cracked and broken pavement shall be removed and patched in accordance with the Plans and Specifications. Cracks wider than 3 mm (1/8 inch) shall be cleaned, treated with weed killer, and filled with an asphalt-based crack filler specified by the Engineer. The pavement surface shall be clean and free from dirt, oil, and grease deposits.

When ambient temperatures are over 27°C (80°F) or the pavement is excessively aged or porous, the surface shall be sprayed with a mist of water in an amount that will leave the surface damp, but with no visible puddles of water. This procedure is not required if a tack coat per 302-8.2.1 has been applied.

Sealcoat material shall be applied using a truck-mounted tank or wheeled container in continuous parallel lines and spread by means of brooms or rubber-faced squeegees either by hand or machine and in such a manner as to eliminate all ridges, lap marks, and air pockets. Raised pavement markers, valve box covers, and manhole covers shall be protected and kept free of sealcoat material.

Sealcoat material shall be homogeneous prior to spreading, with no visible separation of solids and liquids.

The second coat of sealcoat material shall not be applied until the first coat has dried to the touch.

The Contractor shall exercise care to prevent sealcoat material from being deposited on other than specified surfaces and shall remove sealcoat material from surfaces not designated to be sealed, at no cost to the Agency.

Traffic control shall be per 302-4.4.

**302-8.3 Measurement and Payment.** Sealcoat material shall be paid for at the Contract Unit Price per square meter (square yard) or as shown in the Bid.

### **302-9 Asphalt Rubber Hot Mix (ARHM)**

**302-9.1 General.** ARHM shall conform to 203-6.6, 203-11.5, and 302-5.

**302-9.2 Mixing Binder With Aggregate.** Mixing of the Asphalt Rubber binder with aggregate shall conform to 203-6.7 except that temperature requirements of ARHM shall supercede the requirements in 203-6.7.

**302-9.4 Storage.** Storage of ARHM shall conform to 203-6.8.

**302-9.4 Distribution and Spreading.** Distribution and spreading shall conform to 302-5.5 except that at the time of delivery to the work site, the temperature of the ARHM-GG shall be 149°C (300°F) minimum to 166°C (330°F) maximum. When atmospheric temperatures are above 29°C (85°F), the temperature of the mix delivered to the site may be reduced to 143°C (290°F) if approved by the Engineer. Atmospheric temperature shall be 10°C (50°F) and rising. ARHM-GG shall conform to the specifications for 302-5 except ARHM-GG shall consist of one or more courses of an asphalt-rubber binder and graded aggregate conforming to 203-11.3 placed upon a prepared roadbed or base, or over existing pavement. The courses shall conform to the requirements as shown on the Plans or in the Specifications.

**302-9.5 Rolling.** Rolling shall conform to 302-5.6 except that vibratory rollers using the vibratory mode shall be used for initial breakdown rolling. The initial coverage of breakdown rolling shall commence before the ARHM-GG temperature falls below 143°C (290°F). If the atmospheric temperature is above 29°C (85°F), the initial breakdown rolling temperature may be reduced to 138°C (280°F). Pneumatic rollers shall not be used. If the temperature of the mat during breakdown rolling is reduced, this will not relieve the Contractor of his compaction requirements.

**302-9.6 Rock Dust Blotter.** At the option of the Engineer, when traffic conditions warrant, a rock dust blotter may be required to avoid tracking. Rock dust blotter shall conform to 200-1.2 and be uniformly applied using a mechanical spreader at a rate of 1.1 kg/m<sup>2</sup> (2 lbs./yd<sup>2</sup>) minimum to 2.2 kg/m<sup>2</sup> (4 lbs./yd<sup>2</sup>) maximum. When the ARHM-GG pavement has cooled to below 66°C (150°F), the rock dust blotter may not be required. Rock dust blotter placement and sweeping shall be included in the price bid for other items of work and no additional compensation will be allowed therefore.

### 302-10 Asphalt Rubber Aggregate Membrane.

**302-10.1 Application.** Asphalt rubber shall be placed upon a clean dry surface. The pavement surface temperature shall be a minimum of 13°C (55°F) including shaded areas; the atmospheric temperature shall be a minimum of 16°C (60°F); the wind shall not adversely affect spray distribution; and all necessary equipment shall be in position and ready to commence placement operations prior to starting the work. The contractor shall take temperature readings with a temperature measuring device approved by the Engineer.

Asphalt rubber shall be applied by distributor equipment meeting the requirements of the following:

1. Distributor trucks shall meet the requirements for distributing equipment of 203-2.5 and be equipped with an internal heating device capable of evenly heating the material to a temperature of 218°C (425°F).
2. The distributor shall have a platform on the rear of the vehicle and an observer shall accompany the distributor.
3. The observer shall ride in a position so that all spray bar tips are in full view and readily accessible for unplugging if a plugged tip should occur.
4. Material shall be applied at a rate between 2.5 to 3.0 Liters per square meter (0.55 to 0.65 gallons per square yard) as directed by the Engineer.
5. Material spreading shall not be in excess of that which can be covered with aggregate within 15 minutes maximum.

Distribution and spreading shall conform to 302-5.5 except that at the time of delivery to the work site, the temperature of the asphalt rubber shall be 149°C (300°F) minimum.

The asphalt rubber mixture may be applied to the roadway immediately following mixing and reacting at a temperature between 191°C (375°F) minimum to 218°C (425°F) maximum. However, if the material is not to be used within 6 hours of mixing, the mixture shall be allowed to cool below 149°C (300°F) for 12 hours maximum, or to ambient temperature for longer periods, and shall be uniformly reheated to a temperature between 149°C (300°F) minimum to 218°C (425°F) maximum at time of placement and conform to the viscosity requirements.

When joining edges against areas with cover aggregate, the joint shall be swept clean of excess aggregate prior to the adjacent application of asphalt rubber material. Transverse joints of this type shall be constructed by placing building paper across and over the end of the previous asphalt rubber application. Once the spraying has progressed beyond the paper, the paper shall be removed immediately.

Joints between areas of asphalt rubber without cover aggregate shall be made by overlapping asphalt rubber distributions. The excess material shall be dispersed by spreading with a squeegee or rake over a larger area of freshly applied asphalt rubber. The longitudinal joint between adjacent applications of screenings shall coincide with the line between designated traffic lines. All longitudinal joints shall be overlapped for complete coverage. The overlap shall not exceed 100 mm (4 inches). At longitudinal joints, the edge shall be broomed back and blended so there are no gaps and the elevations are the same, free from ridges and depressions.

The application of asphalt rubber to areas not accessible with the distributor bar on the truck shall be accomplished by using pressurized hand wands or other means approved by the Engineer.

Application of asphalt rubber shall be discontinued sufficiently early in the workday to permit completion of initial sweeping prior to the termination of traffic control.

**302-10.2 Screenings.** Following the application of asphalt rubber, screenings conforming to 203-12.2 shall be placed over all areas receiving asphalt rubber. Screenings shall be applied (within a maximum of 15 minutes) at a temperature between 127°C (260°F) minimum to 163°C (325°F) maximum at a rate of 15 to 22 kilograms per square meter (28 to 40 pounds per square yard) as directed by the Engineer. Stockpiling of screenings after preheating and precoating with paving asphalt will not be permitted.

The contractor shall prevent any vehicle, including construction equipment, from driving on the uncovered asphalt rubber. Screenings shall be placed with a self-propelled aggregate-spreading machine that can be adjusted to accurately spread the specified amounts per square meter (yard). Trucks for hauling screening material shall conform to 302-2.3.

Initial rolling shall commence within 90 seconds following the placement of screenings. Rolling shall be accomplished by three self-propelled, pneumatic-tired rollers meeting the requirements of 302-5.6.1 except that the tires shall be inflated to 690 kPa (100 pounds per square inch). The operating weight of each roller shall be a minimum of 7200 kg (16,000 pounds). If in the opinion of the Engineer, complete coverage may be provided by two rollers in one pass, then two pneumatic-tired rollers are sufficient. The initial rolling equipment shall maintain a distance of not more than 60 m (200 feet) behind the cover-aggregate spreader on the first pass. There shall be at least four complete coverages (single pass in one direction) by the pneumatic-tired rollers before final roller coverage. A steel-drum roller weighing 7.2 Tonnes (8 tons) minimum to 9.1 Tonnes (10 tons) maximum shall complete the final roller coverage.

Sweeping shall be a multi-step operation following final rolling of the aggregate. A power broom shall be used to remove loose material without dislodging aggregate set in the asphalt rubber. The initial sweeping shall be a light brooming on the same day as ARAM placement. The ARAM shall be maintained free of loose screenings for a minimum of 5 working days following placement. During this period, the surface shall be swept as necessary to remove any loose cover material as directed by the Engineer. Final sweeping shall be done and all loose aggregate shall be removed prior to acceptance. The sweeping operations shall be accomplished without the use of gutter brooms or steel-tined brooms.

Immediately upon opening the street to traffic, the Contractor shall start removing loose aggregate from parkways, sidewalks, and intersecting streets. Both operations shall continue until all excess or loose aggregate is removed from the roadway surface and abutting adjacent areas.

At the option of the Engineer, rock dust blotter material shall be applied immediately after the initial pass of the rollers or after sweeping, but prior to opening to traffic, to prevent bleeding and pickup of the asphalt rubber material. Rock dust blotter conforming to 200-1.2 shall be uniformly applied using a mechanical spreader at a rate of 1.1 kg/m<sup>2</sup> (2 lbs./yd<sup>2</sup>) minimum to 2.2 kg/m<sup>2</sup> (4 lbs./yd<sup>2</sup>) maximum. The Contractor shall include in the bid price for ARAM the full cost of applying rock dust blotter to all areas of ARAM, as directed by the Engineer. If the ARAM is to be used as a finished surface, a flush coat shall be used.

The Contractor shall protect all existing manhole, valve, survey monument, and other miscellaneous frames and covers. The Contractor shall cooperate with the owners of any frames and covers and shall cover and completely protect them with heavy roofing paper or other suitable material. Petroleum-based release agents shall not be used for this purpose.

**302-10.3 Flush Coat.** If required a flush coat shall be applied. This work shall consist of an application of fog seal coat and rock dust blotter material to the surface of ARAM. The Contractor shall include in the bid price for ARAM the full cost of applying a flush coat (if required) to all areas of ARAM, as directed by the Engineer.

Flush coat shall be applied to the ARAM immediately after removal of excess screenings following initial brooming of the ARAM and prior to opening the lane to uncontrolled public traffic, as directed by the Engineer.

Asphaltic emulsion (fog seal coat) shall be applied to the surface of the ARAM and shall be grade CSS1 or CSS1H, per 203-3, unless otherwise ordered by the Engineer.

The application rate of the fog seal coat (asphaltic emulsion and an equal amount of water) shall be such that the diluted asphaltic emulsion will be spread at a rate of 0.27 L/m<sup>2</sup> (0.06 gal./yd<sup>2</sup>) minimum to 0.54 L/m<sup>2</sup> (0.12 gal./yd<sup>2</sup>) maximum. The exact rate of application will be determined by the Engineer.

During fog seal coat operations the surface upon which an ARAM is being applied shall be closed to public traffic. Care shall be taken to avoid tracking fog seal coat material onto existing pavement surfaces beyond the limits of construction.

**302-10.4 Public Convenience and Traffic Control.** The Contractor shall prohibit traffic on the street until the initial sweeping is complete. Prior to opening the streets to traffic, "Loose Gravel," C6 signs, and appropriate speed-reduction signs conforming to local, State, and Federal regulations shall be posted and maintained by the Contractor. These signs shall remain in place until there is no further dislodging of the cover aggregate.

**302-10.5 Measurement and Payment.** ARAM including asphalt rubber and cover aggregate will be paid for at the contract unit price per square meter (square yard). Unless otherwise specified, such price shall include full compensation for pavement preparation, furnishing and placing materials required, including rock dust blotter, and for all labor, equipment, sweeping, tools, and incidentals needed to complete the work in place.

## SECTION 303 - CONCRETE AND MASONRY CONSTRUCTION

### 303-1 CONCRETE STRUCTURES.

#### 303-1 CROSS REFERENCES

Portland Cement Concrete.....	201-1
Steel Reinforcement for Concrete.....	201-2
Expansion Joint Filler and Joint Sealants.....	201-3
Concrete Curing Compound.....	201-4
Cement Mortar.....	201-5
Lumber and Plywood.....	204-1

**303-1.1 General.** Concrete bridges, culverts, catch basins, retaining walls, abutments, pier footings, foundations, and similar structures shall be constructed in conformity with the Plans and Specifications. Concrete for use in work constructed under this section shall conform to the requirements of 201-1.

Safe and suitable ladders shall be provided to permit access to all portions of the work.

The compressive strength of the concrete referred to in this section will be based on the results of concrete test cylinders made and tested by the Engineer in accordance with the requirements of 1. Test cylinders shall be cured in accordance with ASTM C 31, unless otherwise approved by the Engineer.

When plastic-lined concrete structures are required by the Plans, the plastic liner materials shall comply with 210-2 and the installation of the liner shall be in accordance with 311-1.

**303-1.2 Subgrade for Concrete Structures.** Earth subgrade upon which concrete is placed shall be firm and free from standing water. Groundwater shall be kept below subgrade until the concrete has set. When the subgrade is in dry earth, it shall be thoroughly dampened with water to ensure that no moisture will be absorbed from the fresh concrete.

When the design details for the project provide for the construction of filter or drain material consisting of gravel (or combination of gravel and sand), which material will be subgrade for concrete, the placing of steel reinforcement and placement of concrete shall follow the installation of the filter or drain material as closely as practical. The filter or drain material shall be kept dewatered to the extent necessary to prevent any portion of concrete materials being deposited in water. No payment will be made for dewatering other than as may be included in the prices bid for various items of work or when an item for dewatering is provided.

When the concrete is to be deposited on rock, the rock shall be fully uncovered, cleaned, and its surface shall be removed to a depth sufficient to expose sound rock. Bedrock shall be roughly leveled off or cut to approximately horizontal and vertical steps. Seams in the rock shall be grouted under pressure or otherwise treated as the Engineer may direct. Grouting seams in rock or otherwise treating them will be paid for as provided in the Specifications.

**303-1.3 Forms.** Forms shall be of suitable material and of a type, size, shape, quality, and strength to ensure construction as designed. The forms shall be true to line and grade, mortar-tight, and sufficiently rigid to resist deflection during placing of the concrete. The responsibility for their adequacy shall rest with the Contractor. All dirt, chips, sawdust, nails, and other foreign matter shall be completely removed from forms before any concrete is deposited therein. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes that would deface the finished surfaces. Forms previously used shall be thoroughly cleaned of all dirt, mortar, and foreign matter before being reused. Before concrete is placed in forms, all inside surfaces of the forms shall be thoroughly treated with an approved releasing agent which will leave no objectionable film on the surface of the forms that can be absorbed by the concrete. Care shall be exercised that no releasing agent is deposited on previously placed concrete.

Forms for all surfaces that will not be completely enclosed or hidden below the permanent surface of the ground shall be made of surfaced lumber, or material which will provide a surface at least equal to surfaced lumber or plywood. Any lumber or material which becomes badly checked or warped, prior to placing concrete, shall not be used.

Forms for all exposed surfaces of bridges, viaducts, overcrossings, and similar structures shall be constructed of plywood or an approved equal. Plywood for forms shall be of the grade "Exterior B-B (concrete form)", conforming to the latest Product Standard for Soft Plywood, Construction and Industrial, of the National Institute of Standards and Technology. Plywood shall be furnished and placed in no less than 1.2 m (48 inch) widths and in uniform lengths of not less than 2.4 m (96 inches) except where the dimension of the member formed is less than the specified panel dimension. Plywood shall be placed with the grain of the outer plies in the direction of the span. Where plywood is attached directly to the studs or joists, the panels shall be not less than 15 mm (5/8 inch) thick, and the studs or joists shall be spaced not more than 305 mm (12 inches), center to center. Plywood less than 15 mm (5/8 inch) thick, otherwise conforming to the requirements specified herein, may be used with a continuous backing of 19 mm (3/4 inch) sheeting. All form panels shall be placed in a neat, symmetrical pattern with the horizontal joints level and continuous. All joints shall be filled with an approved quick-setting compound and finished flush with the interior of the form.

Wooden forms for copings and curbs shall have a thickness of not less than 38 mm (1-1/2 inches) and a width of not less than the full depth of coping or curb.

Unless otherwise shown on the Plans, all sharp edges shall be chamfered with 19 mm x 19 mm (3/4 inch by 3/4 inch) triangular fillets. Forms for curved surfaces shall be so constructed and placed that the finished surface will not deviate from the arc of the curve.

Forms shall be so constructed that portions, where finishing is required, may be removed without disturbing portions of forms to remain in place.

Joists and stringers supporting slabs and overhangs shall be considered as falsework and designed in accordance with 303-1.6.

Forms for girders and slabs shall be cambered as may be required by the Engineer.

Forms shall, as far as practicable, be so constructed that the form marks will conform to the general lines of the structure. Concrete bridge railings shall be constructed to present a smooth uniform appearance in their final position, conforming to the lines shown on the Plans. The height of the concrete railings shall be adjusted as directed by the Engineer to compensate for the camber and deadload deflection of the superstructure.

Form clamps or bolts, approved by the Engineer, shall be used to fasten forms. The use of twisted-wire loop ties to hold forms in position will not be permitted, nor shall wooden spreaders be used unless authorized by the Engineer. Clamps or bolts shall be of sufficient strength and number to prevent spreading of the forms. They shall be of such type that they can be entirely removed or cut back 25 mm (1 inch) inside the finished surface of the concrete. All forms for outside surfaces shall be constructed with stiff wales at right angles to the studs, and all form clamps or bolts shall extend through and fasten such wales.

Forms for cast-in-place concrete drain conduits or sewer structures will not be required for concrete to be placed directly against the sides of the excavation or sheeting, provided the following conditions are met:

- 1) If concrete is placed directly against the faces of the excavation, the faces must be firm, compact, able to stand without sloughing, and must be outside the concrete lines shown on the Plans at all points. The entire faces of excavation, against which concrete is to be placed without the use of outside forms, shall be gunited to sufficient thickness to prevent raveling of the exposed earth faces during the placing of reinforcing steel, forms, and concrete.
- 2) If concrete is placed against sheeting, such sheeting shall be closely fitted and all points shall be outside the concrete lines shown on the Plans. Those surfaces against which the concrete is to be placed shall be faced with building paper. Except as otherwise specified herein, all sheeting shall be removed, but not until at least 7 days after placing concrete, or until the concrete has attained strength in compression of 14 MPa (2,000 psi).

Care shall be used in removing sheeting so as to avoid damaging the concrete. Voids left by the removal of sheeting, piles or similar sheeting components shall be backfilled with material having a sand equivalent of not less than 30 and consolidated by jetting as directed by the Engineer. When field conditions or the type of sheeting or methods of construction used by the Contractor are such as to make the removal of sheeting impracticable, that portion of the sheeting against which concrete has been placed may be left in place.

- 3) The reinforcing steel shall be set accurately and held firmly in place.
- 4) The Contractor shall assume all risks of damage to the Work or to existing improvements that may be attributable to this method of construction.

- 5) Should this method of construction prove unsatisfactory, the Contractor shall discontinue this method and construct the conduit by using outside forms.
- 6) No direct payment will be made for building paper, sheeting, gunite, for concrete placed outside of concrete lines shown on the Plans, or for cement used in such gunite and concrete. The cost thereof shall be included in the prices bid for the various items of work.

### **303-1.4 Removal of Forms.**

**303-1.4.1 General.** The periods of time for form removal set forth herein are permissive only and subject to the Contractor assuming all risks that may be involved. The time periods are minimum with no allowance therein for external loads. At times of low temperature, or other adverse conditions, the Engineer may require the forms to be kept in place for longer periods of time.

The time periods are predicted on the use of concrete to which no admixtures have been added for the purpose of obtaining a high early strength, and upon the use of the same type of cement throughout the structure. The Engineer may permit the use of admixtures, additional cement, or different types of cement in accordance with 201-1.2.4. If such permission is granted, the minimum time periods for stripping forms will be established by the Engineer in accordance with the materials, methods to be used, and the stresses to which the structure may be subjected.

When the Contractor elects to use Type IP (MS) cement in accordance with 201-1.2.1 minimum form removal times may be longer than indicated in the following subsections.

**303-1.4.2 Bridges.** The periods of time set forth herein are based on the use of Type II cement.

Forms and falsework supporting concrete beams, arch ribs, slabs, or other members subject to direct bending stress shall not be removed in less than 21 days after the concrete has been placed, unless concrete test cylinders show a strength of not less than 21 MPa (3,000 psi) in compression, when cured under conditions similar to those affecting the structure.

Forms and falsework supporting the bottom slab of the superstructure of box girder structures shall remain in place 14 days after placing of the deck of the superstructure. Forms for the webs of box girders shall be removed before the deck slab is placed. Forms for the upper deck slab which are to remain in place shall be supported by bolts through the girder webs or some equally satisfactory method that will prevent the transfer of any load to the lower deck slab. Forms supporting the concrete deck slab of box girders may be left in place. All interior forms in box girders, except those permitted to remain in place, shall be removed completely and the inside of the box girder cleaned of all loose material.

Side forms for beams, girders, columns, railings, or other members in which the forms do not resist dead load bending, may be removed within a period of 2 to 5 days, as authorized by the Engineer, provided that satisfactory arrangements are made to cure and protect the concrete thus exposed.

Side forms for arch rings, columns, and piers shall be removed before the members of the structure which they support are cast so that the quality of the previously placed concrete may be inspected. Such forms shall be so constructed that they may be removed without disturbing other forms which support direct load or resist bending stress.

**303-1.4.3 Miscellaneous Structures.** The periods of time set forth herein are based on the use of Type II cement.

Forms for concrete members (except bridges) subject to bending stresses, where the member relies upon forms for vertical support, may be removed 7 days after concrete is placed.

Curb forms shall not be removed until the concrete has set sufficiently to hold its shape but shall be removed in time to permit proper finishing.

Stairway forms shall be removed and the finish of the steps completed on the day the concrete is placed. Metal stairway treads, if required by the drawings, shall be installed immediately after the steps have been poured.

#### 303-1.4.4 Standard Structures.

(a) **General.** Except as otherwise stipulated, the periods of time set forth herein for removal of forms are based on the use of Types II, III, IV, or V portland cement.

##### (b) Standard Catch Basins.

- 1) Outside forms and inside wall forms which do not support the top slab forms - 16 hours.
- 2) Top slab forms - 48 hours if Type II or V cement is used; 24 hours if Type III cement is used.

##### (c) Standard Transition Structures.

- 1) Outside forms and inside wall forms which do not support the top slab form - 16 hours.
- 2) Top slab forms - as specified for box section slab forms.

#### 303-1.4.5 Channels and Conduits.

(a) **General.** Except as otherwise specified, the periods of time set forth herein are based on the use of Types II, III, IV, or V portland cement.

(b) **Forms Removal.** Forms for open channels and forms and shoring for box sections and arch sections of sewers and storm drains may be removed as follows:

- 1) Forms for open channel walls - 16 hours.
- 2) Outside forms of box sections and inside wall forms of box sections which do not support the slab forms - 16 hours.
- 3) Arch sections in open cut - 12 hours.
- 4) Slab forms for box sections -
  - a) Type II cement - 48 hours or 20 hours per meter (6 hours per foot) of span between supports, whichever is greater.
  - b) Type III cement - 24 hours or 10 hours per meter (24 hours or 3 hours per foot) of span between supports, whichever is greater.
  - c) Type V cement - 56 hours or 23 hours per meter (56 hours or 7 hours per foot) of span between supports, whichever is greater.

**303-1.5 Removal of Forms for Box Sections.** In lieu of form removal as specified in 303-1.4, the forms may be stripped by the following method:

If the walls and top slab of the box structure are placed monolithically, the forms may be removed when the concrete has attained the compressive strength as computed from the following formula:

$$C_{SI} = 0.45 S + 7 \text{ For Metric Units}$$

$$C_{US} = 20 S + 1000 \text{ For U.S. Std. Measure}$$

Where S = Span length in meters (feet from center to center of supports (maximum span 6 m (20 feet) unless otherwise approved by the Engineer).

Where  $C_{SI}$  ( $C_{US}$ ) = Required compressive strength in MPa (pounds per square inch) of the concrete as determined in accordance with the requirements below:

If the top slab is not placed monolithically with side walls and if the wall forms do not support the top slab forms, the forms for the walls may be removed when the concrete has attained a compressive strength of 7 MPa (1,000 psi). The forms for the top slab may be removed when the concrete has attained a compressive strength equal to that computed by the above formula; provided that the concrete in the walls has attained a compressive strength at least equal to that determined for the top slab at the time it is proposed to remove the top slab forms.

The strengths set forth herein at which the Contractor may remove forms in the walls and top slab of box sections are permissive only, and subject to the Contractor assuming all risks that may be involved in such removals. No allowance for external loads is included in the specified strength. At times of low temperature, or other adverse conditions, the Engineer may require the forms to be kept in place until greater concrete strength have been attained.

### **303-1.6 Falsework.**

**303-1.6.1 General.** The Contractor shall, in accordance with 2-5.3, submit detailed plans of the falsework proposed to be used. Such plans shall be in sufficient detail to indicate the general layout, sizes of members, anticipated stresses, grade of materials to be used in the falsework, and typical soil conditions.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be imposed if the entire superstructure were placed at one time.

All falsework, staging, walkways, forms, ladders, cofferdams, and similar accessories shall equal or exceed the minimum requirements of the State Division of Industrial Safety. Compliance with such requirements shall not relieve the Contractor from full responsibility for the adequacy of safety measures.

Sufficient inspection walkways and access thereto shall be provided under the deck to permit inspection of all forms. The walkways shall be not more than 2.4 m (8 feet) below the forms to be inspected.

Falsework shall be placed upon a solid footing safe against undermining and protected from softening. When the falsework is supported on timber piles, the piles shall be driven to a bearing value as determined by the formula specified in 305-1.5, equal to the total calculated pile loading. The maximum calculated pile loading shall not exceed 180 kN (20 tons).

Construction of falsework which is to be supported on a concrete invert may be started 48 hours after the concrete is placed, provided no heavy equipment or concentrated loads are placed on the concrete invert. When heavy equipment must be placed on the concrete invert to erect falsework, the concrete shall be 7 days old or shall have attained a compressive strength of 14 MPa (2,000 psi) before falsework erection is started. Unless otherwise directed by the Engineer, concentrated falsework loads shall be so spread over the supporting concrete slab as to reduce the soil pressure under it not over 96 kN/m<sup>2</sup> (2,000 pounds per square foot), assuming 45-degree lines of distribution through the slab.

Falsework and forms shall be so constructed as to produce in the finish structure the lines and grades indicated on the Plans. Suitable jacks or wedges shall be used in connection with the falsework to set the forms to the grade or the form work before or during the placing of concrete. Single wedges for this purpose will not be permitted, it being required that all such wedges be in pairs to ensure uniform bearing. Dead load deflection in stringers and joists will be compensated for by varying the depths of the joists or by using varying depth nailing strips.

Arch centering shall be removed uniformly and gradually, beginning at the crown and working toward the haunches to permit the arch to take its load slowly and evenly. Centering for adjacent arch spans shall be struck simultaneously.

Falsework under any continuous unit or rigid frame shall be struck simultaneously; the supporting wedges being released gradually and uniformly, starting at the center and working both ways toward the supports.

**303-1.6.2 Falsework Design.** Falsework shall be designed to carry all loads and pressures applied to it. The construction loads to be applied are as follows:

- 1) Tunnel centering - 100 percent of the concrete load where concrete is placed by pneumatic process.
- 2) All other structures - a live load of 1.5 kN/m<sup>2</sup> (30 pounds per square foot) of horizontal area.
- 3) Transverse and longitudinal bracing - a horizontal force equal to 2 percent of the vertical load.

The unit stresses shown below shall be the maximum allowable for falsework design for used material. The Contractor may elect to furnish new grade-marked material. In such event, the falsework plans submitted shall indicate the grade. The unit stresses allowed shall be those recommended in the latest issue of "Standard Grading Rules for West Coast Lumber" (published by the West Coast Lumber Inspection Bureau), increased 25 percent for short time loading.

**MAXIMUM UNIT STRESSES FOR FALSEWORK**

Axial tension and bending.....	9.7 MPa (1,400 psi)
Compression perpendicular to grain.....	2.4 MPa (350 psi)
End grain bearing .....	9.0 MPa (1,300 Psi)
Shear parallel to grain.....	0.9 MPa (125 psi)

Timber Columns:

Metric Units.....	$S_{SI} = 9.0$	$(1 - L/60d)$
U.S. Standard Measure.....	$S_{US} = 1300$	$(1 - L/60d)$

Where:

- $S_{SI}$  ( $S_{US}$ ) = Maximum allowable stress in MPa (psi).
- d = Least side dimension of column in mm (in).
- L = Unbraced length of column in mm (in).
- L/d shall not exceed 50 for bracing.
- L/d shall not exceed 30 for main members.

Falsework may be bolted or spiked at the option of the Contractor, but the use of bolts and spikes shall not be combined in the same connection. The allowable spacings and connection values of bolts and spikes shall be in accordance with the National Design Specifications for Stress-Grade Lumber and its Fastenings as recommended by National Lumber Manufacturers Association, except that an additional allowance of 25 percent for temporary use shall be added to the connection values for bolts and spikes.

Ends of columns bearing on wedges shall be tied in both directions by girts.

**303-1.7 Placing Reinforcement.**

**303-1.7.1 General.** Before placing reinforcing steel, the Contractor shall submit a reinforcing steel placing plan in accordance with 2-5.3.

Reinforcing bars shall be placed in accordance with the size and spacing shown on the Plans. Reinforcing bars shall be firmly and securely held in position in accordance with the "Manual of Standard Practice" of the Concrete Reinforcing Steel Institute, using concrete or metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing

under full load. Metal chairs which extend to the surface of the concrete (except where shown on the Plans) and wooden supports, shall not be used. Tack welding on reinforcing bars will not be permitted.

Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted. Before placing in the form, all reinforcing steel shall be cleaned thoroughly of mortar, oil, dirt, loose mill scale, loose or thick rust, and coatings of any character that would destroy or reduce the bond. No concrete shall be deposited until the placing of the reinforcing steel has been inspected and approved.

Bar spacing is center to center of bars. Bar cover is clear distance between surface of bar and face of concrete and shall be 50 mm (2 inches) unless otherwise noted on the Plans. Reinforcement shall terminate 50 mm (2 inches) from concrete surfaces and expansion joints, unless otherwise noted on the Plans.

Reinforcement used in post-tensioned concrete shall be adjusted or relocated during the installation of prestressing ducts or tendons, as required to provide planned clearances to the prestressing tendons, anchorages, jacks, and equipment, as approved by the Engineer.

**303-1.7.2 Splicing.** Splices of bars shall be made only where shown on the Plans or as approved by the Engineer. Where bars are spliced, they shall be lapped at least 30 diameters, unless otherwise shown on the Plans.

Splicing shall be accomplished by placing the bars in contact with each other and wiring them together.

Welding of reinforcing steel will not be permitted unless specifically authorized by the Engineer.

**303-1.7.3 Bending Reinforcement.** Bends and hooks in bars shall be made in the manner prescribed in the "Manual of Standard Practice" of the Concrete Reinforcing Steel Institute.

Bars shall not be bent or straightened in a manner which will injure the material. Bars with kinks or unspecified bends shall not be used.

**303-1.7.4 Welded Wire Fabric.** Welded wire fabric shall be spliced not less than two meshes. It shall be lifted carefully into its specified position after the concrete is placed but still plastic.

### **303-1.8 Placing Concrete.**

**303-1.8.1 General.** Concrete shall be conveyed, deposited, and consolidated by any method which will preclude the segregation or loss of ingredients. Equipment used in conveying and depositing concrete shall not have any aluminum or other material component in direct extended contact with the concrete which results in deleterious or injurious effects to the concrete.

All surfaces against which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete. All ponded and excess water shall be removed to leave surfaces moist but not flooded.

Chutes used in conveying concrete shall be sloped to permit concrete of the consistency required to flow without segregation. Where necessary to prevent segregation, chutes shall be provided with baffle boards or a reversed section at the outlet.

Where a sequence for placing concrete is shown on the Plans, no deviation will be permitted unless approved in writing by the Engineer.

**303-1.8.2 Grouting.** Where concrete is to be deposited against hardened concrete at horizontal construction joints, placing operations shall begin by conveying a grout mixture through the placing system and equipment and depositing the mixture on the joint. Unless otherwise approved by the Engineer, the grout mixture shall have a combined aggregate E grading in accordance with 201-1.3.2,

and meet all other requirements consistent with the approved mix design. Consolidation techniques shall be utilized to ensure proper bond at the joint.

**303-1.8.3 Depositing.** To avoid segregation, concrete shall be deposited as near to its final position as is practicable. The use of vibrators for extensive shifting of the mass of concrete will not be permitted. Concrete that has partially hardened, has been retempered, or is contaminated by foreign materials shall not be deposited in the structure.

Concrete shall be placed in horizontal layers insofar as practical. Placing shall start at the low point and proceed up grade unless otherwise permitted by the Engineer. Concrete shall be placed in a continuous operation between construction joints and shall be terminated with square ends and level tops unless otherwise shown on the Plans.

Concrete shall not be permitted to free fall more than 1.8 m (6 ft) without the use of tremies or other suitable conveyance. Tremies shall be at least 150 mm (6 inches) in diameter, or the equivalent cross-sectional area for rectangular sections. Concrete shall not be placed in horizontal members or sections until the concrete in the supporting vertical members or sections has been consolidated and a 2-hour period has elapsed to permit shrinkage to occur.

**303-1.8.4 Consolidating.** Concrete shall be thoroughly consolidated in a manner that will encase the reinforcement and inserts, fill the forms, and produce a surface of uniform texture free of rock pockets and excessive voids.

Structural concrete, except slope paving such as spillway aprons and channel lining, and concrete placed under water, shall be consolidated by means of high frequency internal vibrators of a type, size, and number approved by the Engineer. The location, manner, and duration of the application of the vibrators shall be such as to secure maximum consolidation of the concrete without separation of the mortar and coarse aggregate, and without causing water or cement paste to flush to the surface. Internal vibrators shall not be held against the forms or reinforcing steel.

The number of vibrators employed shall be sufficient to consolidate the concrete within 15 minutes after it has been deposited in the forms. At least two vibrators in good operating condition shall be available at the site of the structure in which more than 19 m<sup>3</sup> (25 cubic yards) of concrete is to be placed.

Approved external vibrators for consolidating concrete will be permitted when the concrete is not accessible to internal vibration. Forms and falsework shall be designed and constructed to resist displacement or damage from external vibration.

**303-1.8.5 Walkways.** Walkways and platforms shall be provided for personnel and equipment at a level convenient for the concrete placement and to permit the performance of all operations necessary for the completion of such work including finishing.

Where bridge decks are to be constructed to final roadway grade, walkways shall be provided outside the deck area along each side and for the full length of the structure. These walkways shall be of sufficient width and so constructed as to provide for the support of the bridges from which the longitudinal floats specified are to be operated.

**303-1.8.6 Joints.** The work shall be so prosecuted that construction joints will occur at designated places shown on the Plans unless otherwise authorized by the Engineer. The Contractor shall construct, in one continuous concrete placing operation, all work comprised between such joints. Joints shall be kept moist until adjacent concrete is placed.

All construction joints having a keyed, stepped, or roughened surface shall be cleaned by sandblasting prior placement of the adjacent concrete, unless otherwise directed by the Engineer. Any quality of sand may be used which will accomplish the desired results.

The sandblasting operations shall be continued until all unsatisfactory concrete, laitance, coatings, stains, debris, and other foreign materials are removed. The surface of the concrete shall be washed thoroughly to remove all loose material. The method used in disposing of wastewater employed in washing the concrete surfaces shall be such that the wastewater will not stain, discolor, or affect exposed surfaces of the structures, and will be subject to the approval of the Engineer.

Expansion and contraction joints in concrete structures shall be formed where shown on the Plans. No reinforcement shall be extended through the joints, except where specifically noted or detailed on the Plans.

Asphalt paint used in joints shall be as specified in 203-8. Premolded asphalt filler shall be as specified in 201-3.

No direct payment will be made for furnishing and placing asphalt paint, premolded asphalt filler, or other types of joint separators. The cost therefore shall be included in the price bid for the item of work of which they are a part.

### **303-1.8.7 Application of Joint Sealants.**

(a) **General.** All joints sealants shall conform to the general requirements 201-3 and the special requirements shown below. Prior to sealing joints containing waterstops, the expansion joint filler, hardboard, concrete spillage, and all foreign material shall be removed from the deck joint down to a depth of the waterstops. All such material shall be removed from the entire depth of joints in curbs, sidewalks, railings, and the overhanging portion of deck slabs. Immediately before applying the joint sealant, the joint shall be thoroughly cleaned by abrasive blasting or other approved means to remove all mortar, laitance, scale, dirt, dust, oil, curing compounds, and other foreign material. The joints shall be blown out with high pressure compressed air to remove all residue.

If a sealant is shown in the sidewalk, saw-cutting of grooves at concrete railing locations shall be completed prior to constructing the railings. Joint seal material shall be protected during the construction of the railing.

At the time of applying the joint sealant, the joint shall be surface dry, and acceptable to the Engineer. No sealant shall be placed during unsuitable weather, when the atmospheric temperature is below 10°C (50°F), or when weather conditions indicate that the temperature may fall below 0°C (32°F) within 24 hours.

The joint shall be filled from the bottom to the top without formation of voids. The top of the finished joint seal shall be between 6 mm (1/4 inch) and 10 mm (3/8 inch) below the finished surface.

All adjoining surfaces shall be carefully protected during the joint sealing operations, and any stains, marks or damage thereto, as a result of the Contractor's operations, shall be corrected in a manner satisfactory to the Engineer.

(b) **Type "A" Seal.** The top edges of the seal shall remain in continuous contact with the sides of the groove over the entire range of joint movement and such contact shall not break when thumb pressure is applied vertically to the seal at the centerline of the seal. The seal shall satisfactorily resist the intrusion of foreign material and water.

Grooves for joint seals shall be cut to a uniform width and depth and to the alignment shown on the Plans or as ordered by the Engineer. Both sides of the groove shall have saw-cut surfaces for their full depth and shall expose sound concrete.

The concrete saw for cutting the grooves shall be fitted with diamond blades having a core (disk) thickness not less than 5 mm (3/16 inch). Double blades, cutting both sides of the groove

simultaneously, shall be used for the initial cut. The completed groove measured at the top shall be within 3 mm (1/8 inch) of the width shown on the Plans. The groove width measured at the bottom shall not vary from the top width by more than 1.5 mm (1/16 inch) for each 50 mm (2 inches) of depth.

Immediately following cutting, the lip of the groove shall be beveled by grinding, as shown on the Plans, and the groove shall be thoroughly washed with water under pressure and blown out with high pressure air jets to remove all residue and foreign materials.

At least 48 hours prior to installing the seal, the Contractor shall repair all spalls, fractures, breaks, or voids in the concrete surfaces of the joint groove by methods approved by the Engineer.

If any of the requirements of this subsection are not satisfied, the Contractor at its expense shall remove the seal, repair or reconstruct the groove, and replace the seal or install new seal material.

(c) **Type "B" Seal.** All of the requirements of 303-1.8.7 (b) shall apply to the application of Type "B" seals. In addition, the following requirements shall apply:

Sawcutting of grooves shall not be started until seal material has been tested, approved, and delivered to the Work site.

The elastomeric joint seal shall be installed with mechanical equipment specifically designed for this purpose.

The equipment shall not elongate the seal longitudinally nor cause structural damage to the seal or the concrete. The equipment shall place the seal to the depth shown on the Plans.

The equipment shall not twist, distort, or cause other malformations in the completed seal. Equipment that does not provide a properly installed seal shall not be used.

A combination lubricant and adhesive shall be applied to the dry sides of the seal and to all vertical surfaces which will be in contact with the seal immediately prior to installation. The rate of application shall be as recommended by the manufacturer of the seal. The contact surfaces of the seal shall be cleaned with normal butyl acetate, using clean rags or mops, just prior to applying the lubricant-adhesive.

If the completed joint seal is out of position or out of shape, if it does not maintain uniform folding, if the top edges pull away from the sides of the groove, or if the seal does not satisfactorily resist the intrusion of foreign material and water, the Contractor at its expense shall remove the seal, repair or reconstruct the groove, and replace the seal.

(d) **Type "C" Seal.** At no time shall the emulsion be subjected to a temperature below 4°C (40°F). Prior to application, the joint sealant may be warmed if necessary to permit proper filling of the joints. The heating shall be carefully controlled to avoid overheating of any part of the container or mixture and under no circumstance shall the emulsion be heated to a temperature greater than 54°C (130°F).

Immediately before applying the sealant, the emulsion shall be mixed with the proper amount of pastesetting agent. The components shall be mixed, preferably with a powder mixer, for 5 minutes to produce a homogeneous material.

(e) **Type "E" Seal.** The rubber rod shall be compressed into the clean joint to a position such that the top is 32 mm (1-1/4 inches) below the level of the finished surface.

The sealing material components shall be maintained at temperatures of not less than 16°C (60°F). To ensure adequate mixing and application, they may be preheated to a maximum of 32°C (90°F), by means other than the application of direct flame.

The materials shall be power mixed for at least 8 minutes to produce a homogeneous material. When the amount of component "A" is less than 25 percent by weight of component "B", extreme care must be used to be certain that all of component "A" is incorporated in the mix.

Joint sealant in place shall comply with the following test: within 24 hours of application, a 1-cent coin shall be pressed edgewise one-half of its diameter into the joint sealer. Within 1 minute after release, the coin shall be ejected by the joint sealant, leaving the sealing compound free of abrasions or indentations deeper than 1.5 mm (1/16 in).

Joint sealant, which does not cure to a homogeneous, rubber-like compound, bond to the joint faces, or comply with any other requirements of this section, shall be removed. The joint shall be recleaned and new joint sealant placed by the Contractor at its expense.

**303-1.8.8 Placing Concrete Under Adverse Weather Conditions.** Concrete for structures shall not be placed on frozen ground nor shall it be mixed or placed while the atmospheric temperature is below 2°C (35°F), unless adequate means are employed to heat the aggregates and water, and satisfactory provisions have been made for protecting the work.

Concrete shall not be placed on frozen ground, nor shall concrete be mixed or placed when the atmospheric temperature is below 2°C (35°F), or when conditions indicate that the temperature may fall to 2°C (35°F) within 24 hours, except with the written permission of the Engineer and only after such precautionary measures for the protection of the concrete have been taken as approved by the Engineer.

Concrete shall be effectively protected from freezing or frost for a period of 5 days after placing.

Concrete for structures shall not be mixed or placed while the atmospheric temperature is above 46°C (115°F) unless adequate means are employed to cool the aggregate and water and satisfactory provisions have been made for protecting the work. In any case, the temperature of the concrete as placed shall not exceed 32°C (90°F).

Concrete placement shall be stopped when rainfall is sufficient to cause damage to the work.

**303-1.8.9 Concrete Deposited Under Water.** When conditions render it impossible or inadvisable to dewater excavations before placing concrete, the Contractor shall deposit underwater, by means of a tremie or underwater bottom-dump bucket, a layer of concrete of sufficient thickness to thoroughly seal the cofferdam. To prevent segregation, the concrete shall be carefully placed in a compact mass and shall not be disturbed after being deposited. Water shall be maintained in a still condition at the point of deposit.

A tremie shall consist of a watertight tube having a diameter of not less than 250 mm (10 inches) with a hopper at the top. The tube shall be equipped with a device that will close the discharge end and prevent water from entering the tube while it is being charged with concrete. The tremie shall be supported to permit free movement of the discharge end over the entire top surface of the work and to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of the work to prevent water entering the tube and shall be entirely sealed at all times, except when the concrete is being placed. The tremie tube shall be kept full of concrete. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow shall be continuous until the work is completed and the resulting concrete seal shall be monolithic and homogeneous.

The underwater bucket shall have an open top and the bottom doors shall open freely and outwardly when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash and shall not be dumped until it rests on the surface upon which the concrete is to be deposited. After discharge, the bucket shall be raised slowly until well above the concrete.

### 303-1.9 Surface Finishes.

**303-1.9.1 General.** The classes of surface finish described herein shall be applied to various parts of concrete structures as specified. Exposed box sections and bridge decks shall be finished in conformance with 302-6.4, except that final finish shall be accomplished with a drag broom in lieu of burlap drags.

The invert of cast-in-place sewers and sewer structures shall be given a steel-trowel finish. The invert in circular conduit is defined as the unlined portion of lined conduit or the bottom 60 degrees of circumference of the inside of unlined conduit. Unless otherwise specified, the invert of cast-in-place storm drains shall be given a wood-float finish.

**303-1.9.2 Ordinary Surface Finish.** Immediately after the forms have been removed, all exterior form bolts shall be removed to a depth of at least 25 mm (1 inch) inside the surface of the concrete and the resulting holes or depressions cleaned and filled with mortar, except on the interior surfaces of box girders, the bolts may be removed flush with the surface of the concrete. Mortar shall be Class "C". White cement shall be added to the mortar in an amount sufficient to tint the mortar a shade lighter than the concrete to be repaired. Mortar shall be mixed approximately 45 minutes in advance of use. Care shall be exercised to obtain a good bond with the concrete. After the mortar has thoroughly hardened, the surface shall be rubbed with a carborundum stone in order to obtain the same color in the mortar as in the surrounding concrete. All fins caused by form joints, and other projections shall be removed and all pockets cleaned and filled. Mortar for filling pockets shall be treated as specified for bolt holes.

Ordinary surface finish shall be applied to all concrete surfaces either as a final finish or preparatory to a higher-class finish. On surfaces which are to be buried underground or surfaces which are completely enclosed (such as the cells of box girders), the removal of fins and form marks and the rubbing of a mortared surface to a uniform color will not be required. Ordinary surface finish, unless otherwise specified, shall be considered as a final finish on the following surfaces:

- 1) The undersurfaces of slab spans, box girders, filled-spandrel arch spans, and floor slabs between T-girders of superstructures except for grade separation structures.
- 2) The exposed surfaces of channel walls and the inside vertical surface of T-girders of superstructures except for grade separation structures.
- 3) Surfaces which are to be buried underground, covered with fill, or for surfaces of culverts above finish grade which are not visible from the traveled way.
- 4) Top surfaces which are to be buried underground shall be struck off and given a float finish.

**303-1.9.3 Class 1 Surface Finish.** Class 1 surface finish shall be applied to the following surfaces, unless otherwise specified:

- 1) All surfaces of superstructures for grade separation structures.
- 2) All surfaces of bridge piers, columns, and abutments; culvert headwalls; and retaining walls above finished ground and to at least 0.3 m (1 foot) below finished ground.
- 3) The outside vertical surfaces and bottom surface of outside girders, and the outside vertical surfaces and the undersurfaces of cantilever sidewalks, safety curbs, and floor slabs overhanging outside girders.
- 4) All surfaces of open spandrel arch rings, spandrel columns, and abutment towers.
- 5) Surfaces inside of culvert barrels having a height of 1.2 m (4 feet) or more for a distance inside the barrel at least equal to the height of the culvert.
- 6) All interior surfaces of pumping plant motor and control rooms and the engine-generator room.

After completion of the ordinary surface finish, the entire surface specified shall be sanded with a power sander or other approved abrasive means as required to obtain a uniform color and texture.

The use of power carborundum stones or discs will be required to remove unsightly bulges or irregularities. The Class 1 surface finish shall not be applied until after the surfaces have been exposed to the elements for a period of 30 days, or until a uniform appearance of the surface can be secured.

The specifications for a Class 1 finish require a smooth, even surface of uniform appearance with unsightly bulges removed and depressions due to form marks and other imperfections repaired. The degree of care in building forms and the character of materials used in formwork are a contributing factor in the amount of such sanding and grinding required, and the Engineer shall determine the extent of such work required to meet the standard of this class of finish.

**303-1.9.4 Class 2 Surface Finish.** Class 2 surface finish shall be applied to the following surfaces unless otherwise specified:

All surfaces of concrete railings, including barrier railings, rail posts, rail endposts, and rail bases.

When Class 2 surface finish is specified, the ordinary surface finish and Class 1 surface finish shall be completed in succession. The process specified under Class 2 surface finish shall then be deferred until all other work which would in any way affect or mar the final finish is complete. The Contractor shall then apply a brush coat or surface film of Class "A" mortar.

**303-1.10 Curing.** All concrete shall be cured after the completion of the specified finishing operations and as soon as the condition of the concrete will permit without damaging the concrete. All exposed surfaces shall be cured either by continuous application of water; or by being covered with plastic sheeting, soil, sand, or burlap; or by application of a curing compound. Curing materials shall conform to 201-4.

Concrete that is water cured shall be kept continuously wet for at least 10 days after being placed; preferably being covered with at least two layers of not lighter than  $305 \text{ g/m}^2$  (10-ounce per linear yard, 40 inches wide) burlap. Handrail, base rail, railing posts, tops of walls, and similar parts of the structure, if water cured, shall be covered with burlap as prescribed above, immediately following the finishing treatment specified therefore, and such covering shall not be removed in less than 10 days.

Roadway areas, floors, slabs, curbs, walks, and the like, that are water cured may be ponded or covered with sand to a depth of at least 50 mm (2 inches) in lieu of the burlap as prescribed above, as soon as the condition of the concrete will permit, and such covering shall remain wet and in place for at least 10 days, unless otherwise directed by the Engineer or prescribed by the Specifications.

When the surface is covered with plastic sheeting, it shall remain covered for at least 10 consecutive days. The plastic sheeting shall be laid either with edges butted together and sealed with a 50 mm (2 inch) wide sealing tape or with edges lapped not less than 75 mm (3 inches) and fastened with waterproof adhesive.

When a membrane curing compound is used, it shall be applied in a manner and quantity to entirely cover and seal all exposed surfaces of the concrete with a uniform film. The membrane shall not be applied to any surface until finishing operations have been completed. Such surfaces shall be kept damp until the membrane is applied. All surfaces on which a bond is required, such as construction joints, shear planes, reinforcing steel, and the like, shall be adequately covered and protected before starting the application of the curing compound to prevent any of the compound from being deposited thereon; and any such surface with which the compound may have come in contact shall immediately be cleaned. Care shall be exercised to prevent damage to the membrane seal during the curing period. Should the

seal be damaged before the expiration of 10 days after the placing of the concrete, additional impervious membrane shall be immediately applied over the damaged area.

The top surface of highway bridge decks shall be cured by a combination of both the curing compound method and the water method, except that the curing compound shall be Type 2. The curing compound shall be applied continuously and progressively during the deck finishing operations immediately after the finishing operations are completed on each individual portion of the deck. The water cure shall be applied as soon as the curing compound has formed a continuous membrane, but not later than 4 hours after completion of deck finishing or, for portions of the decks on which finishing is completed after normal working hours, the water cure shall be applied as directed by the Engineer.

Should any forms be removed sooner than 10 days after the placing of the concrete, the exposed surface shall either be immediately coated with curing compound or kept continuously wet by the use of burlap or other suitable means until such concrete has cured for at least 10 days.

When tops of walls are cured by the curing compound method, the side forms, except for metal forms, shall be kept continuously wet for the 10 days following the placing of the concrete.

If there is any likelihood of the fresh concrete checking or cracking prior to the commencement of the curing operations (due to weather conditions, materials used, or for any other reason), it shall be kept damp, but not wet, by means of an indirect fine spray of water until it is not likely that checking or cracking will occur, or until the curing operations are started in the area affected.

**303-1.11 Payment.** Payment for concrete structures will be made in conformance with the terms of the Contract and will be based on unit prices or lump sums as set forth in the Bid.

Where concrete is scheduled for payment on the basis of cubic meters (cubic yards), the calculation of the quantity of concrete for payment will be made only to the neat lines of the structures as shown on the Plans and on the basis of the concrete having the specified dimensions. However, all concrete shall be placed to line and grade within such tolerances, as determined by the Engineer, are reasonable and acceptable for the type of work involved. The quantity of such concrete will be calculated considering the mortar used to cover construction joints as being concrete and no deductions will be made for rounded or beveled edges, space occupied by reinforcing steel, or metal inserts or openings  $0.5 \text{ m}^2$  (5 square feet) or less in area. The cost of cement used in mortar for covering construction joints, patching, or other uses in the structure being constructed, in excess of that required for the design mix of the adjacent concrete, shall be included in the item of work of which said mortar is a part.

The quantity of reinforcing steel, when scheduled as a separate item, will be calculated for payment on the basis of the number of each type bar actually placed in accordance with the Plans and approved changes. The weight will be calculated using the actual lengths of bars placed and the unit weights per linear meter (foot) specified in ASTM A 615/615M, A 616/616M, and A 617/617M.

Steel for laps indicated on the Plans, or required by the Engineer, will be paid for at the Contract Unit Price. No payment will be made for reinforcing steel in laps (whether specified or optional) which are not used, and payment will not be made for additional steel in laps which are requested by the Contractor for its convenience, or for steel used in chairs or other devices for supporting the required reinforcement.

Payment for longitudinal steel reinforcement will be made on the basis that the longest standard mill lengths will be placed; and not more than one lap will be paid for between two consecutive construction joints, unless otherwise authorized by the Engineer. The standard mill length for bar sizes No. 13M (No. 4) and larger is shall be 18 m (60 ft).

When optional longitudinal construction joints are indicated on the Plans or specified, the Contractor will be permitted to lap the transverse reinforcing steel at said joints and the reinforcing steel used in such laps will be paid for at the Contract Unit Price.

### 303-2 AIR-PLACED CONCRETE.

#### 303-2 CROSS REFERENCES

Rock Products.....	200-1
Curing .....	303-1.10

#### 303-2.1 Requirements.

**303-2.1.1 General.** Air-placed concrete construction shall be in accordance with this subsection and the applicable provisions of 303-1.

Only personnel skilled in the techniques of air placement of concrete shall be utilized for air-placed concrete construction.

Unless otherwise specified, air-placed concrete shall be applied by one of the following methods.

**303-2.1.2 Method A (Gunite).** A proportional combination of portland cement and aggregate pneumatically transported in a dry state through a pipe or hose to a nozzle where water is added immediately prior to discharge.

**303-2.1.3 Method B (Shotcrete).** A proportioned combination of portland cement, aggregate, and water mixed by mechanical methods, pumped in a plastic state through a pipe or hose to the nozzle where, by the addition of air, the mixture is forcibly propelled to the work.

**303-2.2 Equipment.** For Method A, the minimum air pressure shall be 310 kPa (45 psi) on the gun tank when 30 m (100 feet) or less of hose is used and the pressure shall be increased 35 kPa (5 psi) for each additional 15 m (50 feet) of hose. The pressure shall also be increased 35 kPa (5 psi) for each 8 m (25 feet) that the nozzle is located above the elevation of the gun tank. The maximum nozzle diameter shall be 42 mm (1-5/8 inches) unless otherwise permitted by the Engineer. Water pressure at the nozzle shall be at least 100 kPa (15 psi) above the air pressure at the nozzle.

For Method B, the pump system utilized to convey premixed concrete shall deliver a uniform and uninterrupted flow of material, without segregation or loss of the ingredients. The main run from the pump to the work shall be at least 75 mm (3 inch) diameter steel pipe or flexible hose reduced to 50 mm (2 inch) diameter at the point of expulsion. Aluminum pipe will not be permitted. The air compressor shall have the capacity to deliver at least 2.8 m<sup>3</sup> (100 cubic feet) per minute for each operating nozzle.

#### 303-2.3 Materials, Proportioning, and Mixing.

**303-2.3.1 Method A.** Aggregate and portland cement shall comply with 200-1.5.4 and 201-1.2.1, respectively. Unless otherwise specified, the proportions by volume shall be 1 part cement to 4-1/2 parts sand. The sand shall contain not less than 3 percent nor more than 6 percent moisture by weight. The cement and sand shall be mixed thoroughly in a power mixer for at least 1-1/2 minutes. The dry-mixed material shall be used promptly after mixing and any material that has been mixed for more than 45 minutes shall be rejected and removed from the Work site.

**303-2.3.2 Method B.** The concrete class shall comply with 201-1.1.2.

**303-2.4 Tests.** The Contractor shall make the work accessible to facilitate the preparation of test specimens.

The strength of air-placed concrete shall be determined from cores cut from the completed work, cores cut from test panels, compression test cylinders or a combination of these methods as directed by the Engineer.

Compression test cylinders shall be prepared by the Contractor in the presence of the Engineer in 150 mm (6 inch) diameter x 300 mm (12 inch) long containers of 19 mm x 19 mm (3/4 inch-square) hardware cloth, utilizing the same mix, air pressure, water pressure and nozzle tip as for the material placed in the structure. Cylinders shall be cured in accordance with ASTM C 31 and tested in accordance with ASTM C 39.

Test panels prepared for core tests shall be constructed by the Contractor, of material that is representative of that used in the structure. The size of the test panel shall be as directed by the Engineer. 100 mm (4 inch) minimum-diameter core specimens shall be obtained from the completed work or test panels and tested in accordance with ASTM C 42 at the Contractor's expense. Core holes in the completed work shall be repaired with Class C mortar per 207-3.3.1 (b) and 201-5.1.

A compressive strength test of air-placed concrete shall consist of three specimens. If the test specimens are 150 mm x 300 mm (6 inch by 12 inch) cylinders, one shall be tested at 7 days. If the test specimens are cores, one shall be tested at 14 days. The remaining two specimens shall be tested at 28 days. At least one set of test specimens shall be obtained for each day's work from each nozzleperson employed.

The minimum strength of test specimens shall be:

- 7-day (cylinders)..... 14 MPa (2,000 psi)
- 14-day (cores)..... 16 MPa (2,300 psi)
- 28-day..... 23 MPa (3,250 psi)

When a test specimen shows deficient strength, two cores taken from adjacent areas at the Contractor's expense may be required for each deficient specimen. Should either core prove deficient, the work shall be subject to rejection.

**303-2.5 Preparation of Surfaces.** Earth subgrade for air-placed concrete shall be neatly trimmed to line and grade and shall be free of all loose material. The subgrade shall be compacted as required by the Plans or Specifications.

Overexcavation shall be backfilled with earth compacted to 90 percent relative density, or air-placed concrete at the Contractor's expense.

Masonry, rock, asphalt, and concrete surfaces to be covered by air-placed concrete shall be free of loose material. Dust, dirt, grease, organic material, or other deleterious substances shall be removed and the surface washed with water.

**303-2.6 Placement.** All surfaces shall be dampened before application and material shall not be applied to a surface on which free water exists.

The velocity of the material as it leaves the nozzle shall be maintained uniformly at a rate satisfactory for the job conditions. Material that rebounds and does not fall clear of the work, or which collects on the surfaces, shall be removed. Rebound shall not be used in any portion of the work.

The nozzle shall be held at such distance and position that the stream of flowing material will impinge approximately at right angles to the surface being covered. Any portion of the in-place material which sags, is soft, contains sand pockets, or shows other evidence of being defective, shall be removed and replaced with new material. Reinforcement damaged or destroyed by such repairs shall be replaced by properly lapped additional steel.

Mortar blocks, metal chairs, clips, or spacers with wire ties, or other acceptable means shall be used to secure the reinforcement firmly in the position shown on the Plans.

Where material is placed on overhead surfaces, the amount of water in the mix shall be controlled to permit placement of layers of material approximately 19 mm (3/4 inch) thick without sag or slough.

**303-2.7 Forms and Ground Wires.** The forms shall be built in accordance with the applicable provisions of 303-1. All forms shall be constructed so as to permit the escape of air and rebound.

Ground wires shall be installed in such a manner that they accurately outline the finished surface as indicated on the Plans. They shall be located at intervals sufficient to ensure proper thickness throughout. Wires shall be stretched tight and shall not be removed prior to application of the finish coat.

Headers will be required where the Plans indicate a formed edge or joint.

**303-2.8 Joints.** Construction joints shall be sloped off at an angle of approximately 45 degrees to the surface to which air-placed material is being applied. Before applying air-placed material in the adjacent sections, the sloped portion shall be thoroughly cleaned and wetted by means of air and water blasting.

Control joints shall be formed at the locations designated on the Plans.

**303-2.9 Finish.** Upon reaching the thickness and shape outlined by forms and ground wires, the surface shall be rodded off to true line and grade. Low spots or depressions shall be brought up to proper grade by placing additional air-placed material. Ground wires shall then be removed and, unless otherwise specified, the surface shall then be broom-finished to secure a uniform surface texture. Rodding and working with a wood float shall be held to a minimum.

Rebound or accumulated loose sand shall be removed and disposed of by the Contractor.

When a nozzle finish is specified on the Plans, the surface upon which the finish is to be applied shall be at the proper grade and prepared by sand and water blasting to remove all laitance prior to application of the concrete.

**303-2.10 Curing.** Air-placed concrete (guniting or shotcrete) shall be cured in accordance with the provisions of 303-1.10.

The Contractor shall, at all times, protect the finished work from being scarred or damaged.

**303-2.11 Measurement and Payment.** Quantities of air-placed concrete will be computed from measurements of actual areas in the plane of the work and the dimensions shown on the Plans. No compensation will be allowed for material placed in excess of the dimensions shown on the Plans.

The Contract Unit Price for air-placed concrete shall include full compensation for preparing the foundation, setting all formwork and grounds, furnishing and placing reinforcement, placing the concrete, finishing surfaces, curing, and structure backfill as shown on the Plans or in the Specifications.

### **303-3 PRESTRESSED CONCRETE CONSTRUCTION.**

#### **303-3 CROSS REFERENCES**

Portland Cement Concrete .....	201-1
Concrete Structures .....	303-1
Pile Driving .....	305-1

**303-3.1 General.** This work shall consist of furnishing and placing pretensioned or post-tensioned prestressed concrete members, and shall include the manufacture, transportation, and storage of girders, slabs, piling, and other structural of prestressed concrete, and placing of all prestressed concrete members, except piling which shall be placed as provided in 305-1.

The members shall be furnished complete including all concrete, prestressing steel, reinforcing steel, and incidental materials.

Prestressing shall be performed by either pretensioning or post-tensioning methods. The method of prestressing to be used shall be optional with the Contractor, within the limitations of these specifications.

Prior to casting any members, the Contractor shall, in accordance with 2-5.3, submit complete drawings and details of the method, materials, concrete mix, and equipment to be used in the prestressing operations. Any additions or rearrangement of reinforcing steel from that shown on the Plans shall be specially noted. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, anchoring stresses, type of enclosures, and all other data pertaining to the prestressing operations, including the arrangement of the prestressing steel in the members, pressure grouting materials, and equipment. The shop drawings shall also include details of the holdups and holddowns if the pretensioned method is used. Friction losses at these locations shall be included in the calculations submitted to the Engineer in accordance with 2-5.3. For any rearrangement of stress pattern, the stress calculations, signed by a Civil or Structural Engineer registered by the State of California, shall be submitted for approval by the Engineer.

**303-3.2 Concrete.** Concrete construction shall conform to the applicable provisions in 303-1.

The design of the precast prestressed concrete members is based on the use of concrete having an ultimate compressive strength at 28 days of not less than the values shown on the Plans.

The Contractor shall be responsible for furnishing concrete for prestressed members which contains not less than 330 kg (560 pounds) nor more than 445 kg (750 pounds) of cement per cubic meter (cubic yard) of concrete, which is workable, and which conforms to the strength requirements specified. Variation from the above cement content shall have prior approval of the Engineer.

The compressive strength of the concrete will be determined from concrete test cylinders cured under conditions similar to those affecting the member.

The use of admixtures shall be as specified in 201-1.2.4.

Concrete shall not be placed in the forms until the Engineer has inspected the placing of the reinforcement, enclosures, anchorages, and prestressing steel.

The concrete shall be vibrated internally or externally, or both, as required to consolidate the concrete. The vibrating shall be done with care and in such a manner that displacement of reinforcement, enclosures, and prestressing steel will be avoided.

Holes for anchor bars and for diaphragm dowels which pass through the member, openings for connection rods, recesses for grout, and holes for railing bolts shall be provided in the members in accordance with the details shown on the Plans. Where diaphragm dowels do not pass through the member, the dowels may be anchored in the member by embedment in the concrete or by means of an approved threaded insert.

Forms for interior cells or holes in the members shall be constructed of a material that will resist breakage or deformation during the placing of concrete and will not materially increase the weight of the member.

Lifting anchors shall be installed as detailed on shop drawings. In members to be placed in bridge decks, all portions of the anchor above the concrete shall be removed after the members are placed.

Side forms for prestressed members may be removed after a period of 24 hours, provided arrangements satisfactory to the Engineer are made for curing and protecting the concrete. If side forms are left in place until transfer strength has been attained, no further curing will be required.

The steam curing method or other methods approved by the Engineer may be used for curing precast prestressed concrete members in lieu of water curing. Steam curing, if elected by the Contractor, shall conform to the following provisions:

- 1) After placement of the concrete, members shall be held for a 4-hour-minimum presteaming period. If the ambient air temperature is below 10°C (50°F), steam shall be applied during the presteaming period to hold the air surrounding the members at a temperature between 10°C and 32°C (50°F and 90°F).
- 2) All exposed surfaces of the members shall be kept wet continuously during the holding and curing period.
- 3) The steam shall be saturated, low pressure and shall be distributed uniformly over all exposed surfaces of the member and shall not impinge on the exposed concrete surfaces.
- 4) The steam hood shall be equipped with temperature recording devices that will furnish an accurate, continuous, permanent record of the temperatures under the hood during the curing period. The position of the temperature devices shall be approved by the Engineer.
- 5) During application of the steam the temperature gradient within the enclosure shall not exceed 22°C (40°F) per hour. The curing temperature shall not exceed 66°C (150°F) and shall be maintained at a constant level for a sufficient time necessary to develop the required compressive strength.
- 6) The members shall be protected from sudden temperature and moisture loss after completion of steam curing. In discontinuing the steam application, the ambient air temperature shall decrease at a rate not to exceed 22°C (40°F) per hour until a temperature has been reached 11°C (20°F) above the temperature of the air to which the concrete will be exposed.
- 7) After steam curing is complete, a copy of the steam charts shall be submitted to the Engineer.

**303-3.3 Prestressing Steel.** Prestressing steel shall be high-tensile wire conforming to ASTM A 421, high-tensile wire strand conforming to ASTM A 416, or uncoated high-strength steel bars conforming to ASTM A 722, including all supplementary requirements.

Bars of different ultimate strength shall not be used interchangeably in the same member, unless otherwise permitted by the Engineer.

In handling and shipping bars, care shall be taken to avoid bending, injury from deflection, scraping, or overstressing of the bars. All damaged bars will be rejected.

When bars are to be extended by the use of couplers, the assembled units shall have tensile strength of not less than the specified minimum ultimate tensile strength. Failure of any one sample to meet this requirement will be cause for rejection of the heat of bars and lot of couplers. The location of couplers in the member shall be subject to approval by the Engineer.

All wires, strands, and bars shall be:

- 1) Protected from corrosion during shipping by a factory treatment or process.
- 2) Protected against abrasion during shipment and handling.
- 3) Installed in members to be post-tensioned after steam curing, when steam curing is used, unless otherwise approved by the Engineer.
- 4) Grouted in the enclosures of post-tensioned members within 48 hours after the wire or strand has been tensioned, and within 10 calendar days after removal of the prestressing steel from shipping containers, unless adequate provisions are made to inhibit corrosion. In all cases, grouting shall be completed within 96 hours after the wire or strand has been tensioned.

Wires shall be straightened, if necessary, to produce equal stress in all wires of wire groups or parallel-lay cables that are to be stressed simultaneously, or when necessary to ensure proper positioning in the enclosures.

When wires are button-headed, the buttons shall be cold-formed symmetrically about the axes of the wires, and shall develop the full strength of the wire. No cold-forming process shall be used that results in indentations in the wire.

When the button-headed wire assembly is tested as a unit in tension in accordance with California Test 641, at least 90 percent of the failures at or above the minimum guaranteed ultimate strength of the wire shall occur in the wire and not in the buttons.

Until finally encased in concrete or grouted in the member, all prestressing steel shall be protected against corrosion and damage, and shall be free of all dirt, scale, oil, grease, and other deleterious substances. Evidence of mishandling or inadequate protection such as physical damage or development of visible rust or other results of corrosion shall be cause for rejection.

No welds or grounds for welding equipment shall be made on any prestressing steel. If arc welding is utilized on other parts of a prestressed structure, the ground shall be attached directly to the part being welded. All grounding and welding operations performed after the prestressing steel has been installed shall be approved by the Engineer.

**303-3.4 Anchorages and Distribution.** All post-tensioned prestressing steel shall be secured at the ends by means of approved permanent anchoring devices. The anchors shall be of such design that they will not kink, neck down, or otherwise damage the prestressing steel.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete.

All anchorage devices for post-tensioning shall hold the prestressing steel at a load producing stress of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel, when tested in accordance with California Test 641.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts on the anchor devices will be at least 50 mm (2 inches) inside of the end surface of the members, unless a greater embedment is shown on the Plans. Following post-tensioning, the recesses shall be filled with Class "A" mortar and finished flush.

When headed wires are used, the outside edge of any hole for prestressing wire through a stressing washer, or through an unthreaded bearing ring or plate, shall not be less than 6 mm (1/4 inch) from the root of the thread of the washer or from the edge of the ring or plate.

Distribution plates or assemblies shall conform to the following requirements:

- 1) The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 21 MPa (3,000 psi), and a suitable grillage of reinforcing steel shall be used in the stressed area.
- 2) Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 100 percent of the ultimate load is applied.

Materials and workmanship shall conform to Section 304.

Should the Contractor elect to furnish anchoring devices of a type which are sufficiently large and which are used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates, or assemblies may be omitted.

**303-3.5 Duct Enclosures.** Duct enclosures for prestressing steel shall be rigid, mortar-tight, accurately placed at Plan locations, and free of angle changes, crimping, or flattening.

Ducts shall be rigid, galvanized, ferrous metal tubes with either welded or interlocked seams having sufficient strength to maintain correct alignment during placing of concrete. Galvanizing of the welded seam will not be required. Joints between sections shall be positive metallic connections sealed with waterproof tape. Transition couplings connecting ducts to anchoring devices need not be galvanized.

All duct openings or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing. After installation in the forms, the ends of ducts shall be covered to prevent the entry of water or debris. The Contractor shall demonstrate by positive means to the satisfaction of the Engineer that the ducts are free of water and debris prior to the installation of the prestressing steel. The inside diameter of ducts shall be at least 10 mm (3/8 inch) greater than the outside diameter of the tendon.

Ducts shall be securely fastened in place to prevent movement during the placement of concrete. Vents shall be 12 mm (1/2 inch) minimum-diameter standard pipe connected at the high points in the duct profile to ducts with metallic structural fasteners sealed with waterproof tape. Ends of vents shall be removed 50 mm (2 inches) below the roadway surface after grouting has been completed.

**303-3.6 Prestressing.** All prestressing steel shall be tensioned by means of hydraulic jacks. Each jack shall be equipped with an accurate pressure gage with a dial at least 150 mm (6 inches) in diameter, and each jack and its gage shall be accompanied by a recent certified calibration chart acceptable to the Engineer, showing the relationship between gage readings and total load applied by the ram. At the option of the Contractor, with the approval of the Engineer, a reverse calibrated load-cell may be used. Except where the compressive strength of concrete at time of initial prestress is specified on the Plans, tension shall not be applied or transferred to any member until the concrete in the member has attained 80 percent of the design compressive strength shown on the Plans.

Subject to prior approval by the Engineer, a portion of the total prestressing force may be applied to a member when the strength of the concrete in the member is less than the value shown on the Plans and the member may then be moved. Approval by the Engineer of such partial prestressing and moving shall in no way relieve the Contractor of full responsibility for successfully constructing the members.

The cutting and release of prestressing steel in pretensioned members shall be performed in such an order that the eccentricity of prestress will be a minimum. The prestressing steel shall be cut off flush with the end of the member and the exposed ends of the prestressing steel shall be heavily coated with roofing asphalt or an approved epoxy.

Post-tensioning will not be permitted until it is demonstrated that the prestressing steel is free and unbonded in the enclosure. In addition, prior to placing forms for the closing of box girder cells, the Contractor shall demonstrate that adjacent ducts are unobstructed.

The tensioning process, as applied to post-tensioned members, shall be so conducted that tension being applied and the elongation of the prestressing steel may be measured and recorded at all times. The record of gage pressures and elongations shall be submitted to the Engineer for approval.

Prestressing steel in post-tensioned members shall be tensioned by simultaneous jacking at both ends of the assembly, except that simple span members may be tensioned by jacking from one end only. Where jacking from one end is permitted, half of the prestressing steel in the member shall be stressed from one end and the other half from the opposite end.

Determination of the jacking stresses shall be supported by calculations, or both calculations and field tests when specified, prepared by the Contractor. The Contractor shall, prior to making field tests, submit to the Engineer for approval, its calculations and details of its proposed gages and load devices for determining the jacking load at each end of the test prestressing unit. The stress at the center will be calculated from the average of the end test loads. Jacking stresses within 2 percent of the specified values will be considered satisfactory.

The following friction coefficients shall be used in calculating friction losses. K represents the wobble of the ducts, and U represents the curvature in draped cables:

TABLE 303-3.6 (A)

Type of Steel	Type of Duct	K	U
Bright metal wire or strand	Galvanized-rigid	0.0002	0.25
Bright metal bars	Galvanized-rigid	0.0002	0.15

The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 75 percent of the ultimate tensile strength of the prestressing steel. The prestressing steel shall be anchored at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the Plans, but in no case shall the initial stress exceed 70 percent of the ultimate tensile strength of the prestressing steel. The value to be used for ultimate tensile strength of prestressing steel shall be the specified minimum ultimate tensile strength, unless satisfactory evidence is furnished that the actual ultimate tensile strength exceeds the specified minimum ultimate tensile strength. Such evidence shall be furnished to the Engineer at the time the Contractor submits details as specified.

The loss in stress in post-tensioned prestressing steel due to creep and shrinkage of concrete, creep of steel, and sequence of stressing shall be assumed to be 172 MPa (25,000 psi).

The loss in stress in pretensioned prestressing steel due to creep and shrinkage of concrete, creep of steel, and elastic compression of concrete shall be assumed to be 241 MPa (35,000 psi).

Longitudinal prestressing steel in pretensioned members shall not be cut or released until tests on concrete cylinders indicate that the concrete in the member has attained a compressive strength of not less than the value shown on the Plans or the following values, whichever is greater:

TABLE 303-3.6 (B)

Diameter of Strand mm (in)	Compressive Strength MPa (psi)
9.53 (3/8)	24 (3,500)
11.11 (7/16)	28 (4,000)
12.70 (1/2)	28 (4,000)

The working force in the prestressing steel shall be not less than the value shown on the Plans. Unless otherwise specified or shown on the Plans, the average working stress in the prestressing steel shall not exceed 60 percent of the ultimate tensile strength of the prestressing steel.

Working force and working stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, creep of steel, losses in post-tensioned prestressing steel due to sequence of stressing, friction and takeup of anchorages, and all other losses inherent in the method or system of prestressing, have taken place.

The minimum clear spacing of prestressing steel at the end of pretensioned beams shall be three times the diameter of the steel or one and one-half times the maximum size of the concrete aggregate, whichever is greater. In post-tensioned beams, the minimum clear distance between ducts at the ends of the beam shall be 38 mm (1-1/2 inches) or one and one-half times the maximum size of the concrete aggregate, whichever is the greater.

**303-3.7 Bonding and Grouting.** Post-tensioned prestressing steel shall be bonded to the concrete by completely filling the entire void space between the duct and the tendon with grout placed under pressure.

Grout shall consist of Type II portland cement, water, and a nonshrinking or expansive admixture in compliance with the requirements of 201-1.

The grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed grout. The water content shall be not more than 42 L per 100 kg (5 gallons per 100 pounds) of cement and shall first be added to the mixer followed by cement and admixture. Retempering of grout will not be permitted. Grout shall be continuously agitated until it is pumped.

The pumpability of the grout shall be determined by the Engineer in accordance with the U.S. Army Corps of Engineers Test Method CRD-C 79. The efflux time of a grout sample immediately after mixing shall be not less than 11 seconds at zero-quiescent time. Efflux time is the amount of time that a sample of grout requires to run out of the flow cone after the plug is pulled. Quiescent time is the amount of time that a sample of grout remains undisturbed in the flow cone.

Grouting equipment shall be capable of grouting at a pressure of at least 700 kPa (100 psi) and shall be furnished with a pressure gage having a full-scale reading of not more than 2100 kPa (300 psi).

Standby flushing equipment capable of developing a pumping pressure of 1700 kPa (250 psi) and of sufficient capacity to flush out any partially grouted ducts shall be provided.

All ducts shall be clean and free of deleterious materials that would impair bond of the grout or interfere with grouting procedures. Immediately prior to the grouting, each duct shall be thoroughly flushed with water containing 12 grams (0.1 pounds) of hydrated lime or quicklime per Liter (gallon) and then blown out with oil-free air, or cleaned by another method approved by the Engineer.

All grout shall pass through a screen with 1.8 mm (0.07 inch) maximum clear openings prior to being introduced into the grout pump.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Vents and ejecting pipes shall be fitted with valves, caps or other devices capable of withstanding the pumping pressures. Valves and caps shall not be removed or opened until the grout has set. Leakage of grout through anchorage assemblies shall be prevented by mechanical capping or other positive devices capable of withstanding the grouting pressure.

Grout shall be pumped through the duct and continuously wasted at the outlet until 15 seconds after all visible slugs of water or air are ejected. The outlet pipe shall then be closed and the pumping pressure held momentarily. The valve at the inlet shall then be closed while maintaining this pressure.

After post-tensioned prestressing steel has been pressure grouted, the members shall not be moved or otherwise disturbed until at least 24 hours have elapsed.

The anchorage assemblies shall not be encased in concrete until the duct grouting has been completed and the concrete surfaces against which the encasement is to be placed have been cleaned by abrasive blasting to expose the aggregate.

**303-3.8 Samples for Testing.** Sampling and testing shall conform to the specifications of ASTM A 416, ASTM A 421, and as specified in this subsection.

Samples from each size, lot, and heat of prestressing steel wires and bars, from each manufactured reel of prestressing steel strand, and from each lot of anchorage assemblies and bar couplers to be used, shall be furnished for testing. With each sample of prestressing steel wires, bars, and strands furnished for testing, there shall be submitted a certification stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

All materials for testing shall be furnished by the Contractor at its expense. The Contractor shall anticipate and furnish far enough in advance of the need in the work to allow reasonable time for testing and shall have no claim for additional compensation in the event its work is delayed awaiting approval.

All wire or bars, of each size from each mill lot, and all strands from each manufactured reel to be shipped to the site, shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the jobsite. Each lot of anchorage assemblies and bar couplers to be installed at the site shall be likewise identified. All unidentified prestressing steel, anchorage assemblies, or bar couplers received at the site will be rejected.

Samples of material and tendons, selected by the Engineer from the prestressing steel at the plant or jobsite well in advance of anticipated use, shall be furnished by the Contractor as follows:

- 1) For wire or strand, two 2.0 m (7 foot) long samples shall be furnished for each heat or reel; for bars, two 2.0 m (6 foot) long samples shall be furnished for each heat.
- 2) If the prestressing tendon is to be prefabricated, one completely fabricated prestressing tendon 1.5 m (5 feet) in length for each size of tendon shall be furnished, including anchorage assemblies. If the prestressing tendon is to be assembled at the jobsite, sufficient wire or strand and end fittings to make up one complete prestressing tendon 1.5 m (5 feet) in length for each size of tendon shall be furnished, including anchorage assemblies.
- 3) If the prestressing tendon is a bar, one 2.0 m (6 foot) length complete with two end anchorages shall be furnished, and, in addition, if couplers are to be used with the bars, two 1.0 m (3 foot) lengths of bar equipped with one coupler and fabricated to fit the coupler shall be furnished.

For prefabricated tendons, the Contractor shall give the Engineer at least 10 days notice before commencing the installation of end-fittings or the heading of wires. The Engineer will inspect all end-fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for all testing required.

No prefabricated tendon shall be shipped to the site without first having been released by the Engineer, and each tendon shall be tagged before shipment for identification purposes at the site. All unidentified tendons received at the site will be rejected.

Jobsite or site as referred to herein shall be considered to mean the location where the members are to be manufactured, whether at the Work site or a casting yard elsewhere.

The release of any material by the Engineer shall not preclude subsequent rejection of the material if it is damaged in transit or later found to be defective.

**303-3.9 Handling.** Extreme care shall be exercised in handling, storing, moving, or erecting precast prestressed concrete members to avoid twisting, racking, or other distortion that would result in cracking or damage to the members. Every precast prestressed member shall be handled, transported, and erected in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its position.

After erection, the prestressed girders shall be adequately supported and braced until after the concrete of the diaphragms or of other girder bracing members has hardened.

Precast prestressed concrete piling shall be placed in accordance with the provisions for concrete piling as specified in 305-1.

**303-3.10 Measurement and Payment.** Precast prestressed concrete members, except piling, will be paid for at the Contract Unit Price in the Bid for furnishing and erecting precast prestressed concrete members of the various types and lengths.

Precast prestressed concrete piling will be measured and paid for as provided in 305-1.8.

Full compensation for furnishing and placing transverse connections, anchor rods, expansion joints material, and for grouting spaces and recesses between the members shall be considered as included in the contract unit price paid for furnishing and erecting the member and no additional compensation will be allowed therefore.

### **303-4 MASONRY CONSTRUCTION.**

#### **303-4.1 Concrete Block Masonry<sup>1</sup>.**

1. Portions reprinted through courtesy of Concrete Masonry Association of California.

**303-4.1.1 General.** All materials for concrete block masonry shall conform to the requirements of 202-2.

**303-4.1.2 Construction.** All work shall be performed in a workmanlike manner and in full compliance with the applicable building ordinances.

All masonry walls shall be laid true, level, and plumb in accordance with the Plans.

Masonry units shall be cured, dry, and surfaces shall be clean when laid in the walls.

During construction, all partially laid walls as well as units in storage shall be protected from moisture. All concrete block units and any partially laid walls which become wet during the construction shall be permitted to dry for at least 1 week or longer, if required by weather conditions, before recommencing work.

Proper masonry units shall be used to provide for all windows, doors, bond beams, lintels, pilasters, etc., with a minimum of unit cutting. Where masonry unit cutting is necessary, all cuts shall be neat and regular and edges exposed in the finished work shall be cut with a power-driven abrasive saw.

Where no bond pattern is shown, the wall shall be laid up in straight uniform courses with regular running bond and alternate header joints in vertical alignment.

Intersecting masonry walls and partitions shall be bonded by the use of 6 mm (1/4 inch) minimum-diameter steel ties at 600 mm (24 inches) on centers (maximum).

Where stack bond is indicated on the Plans, approved metal ties shall be provided horizontally at 600 mm (24 inches) on centers (maximum).

Mortar joints shall be straight, clean, and uniform in thickness. Unless otherwise specified or detailed on the Plans, horizontal and vertical joints shall be approximately 10 mm (3/8 inch) thick with full mortar coverage on the face shells and on the webs surrounding cells to be filled. Units shall be laid with "push joints". No slushing or grouting of a joint will be permitted, nor shall a joint be made by working in mortar after the units have been laid.

Exposed walls shall have joints tooled with a round bar (or V-shaped bar) to produce a dense, slightly concave surface well-bonded to the block at the edges. Tooling shall be done when the mortar is partially set but still sufficiently plastic to bond. All tooling shall be done with a tool which compacts the mortar, pressing the excess mortar out of the joint rather than dragging it out.

If it is necessary to move a block so as to open a joint, the block shall be removed from the wall, cleaned, and set in fresh mortar.

**303-4.1.3 Placing Reinforcing Steel.** Reinforcing steel shall be placed as indicated on the Plans. Splices shall be lapped a minimum of 40 diameters, except that dowels other than column dowels need be lapped only 30 diameters. Column dowels shall lap 50 diameters.

Outside horizontal steel shall lap around corners 40 diameters and be carried through columns unless otherwise shown on the Plans. Inside horizontal steel shall extend as far as possible and bend into corner core. A dowel shall be provided in the foundation for each vertical bar.

Where horizontal courses are to be filled, metal stops shall be used. Use of paper stops will not be permitted. All horizontal reinforcing steel shall be laid in a course of bond beam blocks filled with grout.

Vertical cores containing steel shall be filled solid with grout, and thoroughly rodded.

Where knockout blocks are used, steel shall be erected and wired in place before three courses have been laid. Vertical cores at steel locations shall be filled as construction progresses.

Where knockout blocks are not used, vertical cores at steel locations shall be filled in lifts of not more than 1.2 m (4 feet). The maximum height of pour shall be 2.4 m (8 feet). Cores shall be cleaned of debris and mortar and shall have reinforcing steel held straight and in place. If ordered by the Engineer, inspection and cleanout holes shall be provided at the bottom of each core to be filled.

Reinforcing steel shall be inspected prior to placing grout.

**303-4.1.4 Protection and Curing.** During construction operations, all adjoining work shall be protected from mortar droppings. Concrete block masonry shall be protected from the sun and rain. When approved in advance by the Engineer, completed masonry construction may be protected with a curing compound. Except in hot weather when it may be fog sprayed sufficiently to dampen the surface, finished concrete block masonry shall not be wetted.

**303-4.1.5 Measurement and Payment.** Payment for concrete block masonry will be made as shown in the Bid.

Unless otherwise specified, concrete block masonry walls will be measured parallel to the finished grade, deducting the widths of full-height openings.

### **303-4.2 Brick Masonry.**

**303-4.2.1 Materials.** Unless otherwise specified, brick masonry shall be constructed of Grade MW brick and cement mortar as described in 202-1.

**303-4.2.2 Bricklaying.** Brick shall be clean, wetted immediately before laying, and shall be laid on a full mortar bed with "push joints". In no event will slushing or grouting of a joint be permitted, nor shall a joint be made by working in mortar after the brick has been laid. Joints between courses of bricks shall be of a uniform thickness of 10 mm (3/8 inch) as nearly as possible. Joints on surfaces which are not to be plastered, or on any surface that will be exposed upon completion of the work, shall be neatly struck and pointed. In all cases, the work shall be well-bonded, and if new work is to be joined to the existing or unfinished work, the contact surfaces of the latter shall first be properly cleaned and moistened.

Brickwork shall not be constructed upon a concrete foundation until at least 24 hours after such foundation has been placed. No brick shall be laid in water nor shall water be permitted to stand or run on any brickwork until the mortar has thoroughly set, except as provided in 303-4.2.3.

**303-4.2.3 Protection and Curing.** During construction operations, all adjoining work shall be protected from mortar droppings. Brickwork shall be protected from the sun and rain.

Except in hot weather when it may be fog sprayed sufficient to dampen the surface, finished brick masonry shall not be wetted.

**303-4.2.4 Measurement and Payment.** Payment for brick masonry will be made as shown in the Bid.

Unless otherwise specified, brick masonry walls will be measured parallel to the finished grade, deducting the width of full-height openings.

### **303-5 CONCRETE CURBS, WALKS, GUTTERS, CROSS GUTTERS, ALLEY INTERSECTIONS, ACCESS RAMPS, AND DRIVEWAYS.**

#### **303-5 CROSS REFERENCES**

Portland Cement Concrete .....	201-1
Expansion Joint Filler and Joint Sealants .....	201-3
Concrete Curing Compound .....	201-4
Cement Mortar .....	201-5
Lumber and Plywood .....	204-1
Subgrade Preparation .....	301-1
Portland Cement Concrete Pavement .....	302-6

#### **303-5.1 Requirements.**

**303-5.1.1 General.** Concrete curbs, walks, gutters, cross gutters, alley intersections, access ramps, and driveways shall be constructed of portland cement concrete of the class and other requirements prescribed in 201-1. The finish coat to be applied to curbs shall consist of Class "B" mortar prepared as prescribed in 201-5.1. Subgrade preparation shall conform to the requirements of 301-1.

Unless otherwise specified on the Plans, and except as otherwise prescribed in 303-5.1.3 under the heading "Driveway Entrances", the minimum thickness of walks shall be 75 mm (3 inches). The thickness of gutters, cross gutters, alley intersections, access ramps, and driveway aprons shall be as shown on the Plans.

**303-5.1.2 Drainage Outlets Through Curb.** Where existing building drains occur along the line of work, the new curb shall be suitably sleeved to provide for such drains. Similar sleeves shall be installed to serve low areas on adjacent property where drainage has been affected by the work.

The location and size of the sleeves and construction of connecting sidewalk drains shall be in accordance with 306-7.

**303-5.1.3 Driveway Entrances.** Driveway entrances shall be provided in new curb at all existing driveways along the line of the work, at locations shown on the Plans, and at such other locations as may be designated by the Engineer.

The fully depressed curb opening at driveway entrances shall be 25 mm (1 inch) above gutter flowline at the curb face. The top of the fully depressed portion of the curb shall be finished to a transverse slope toward the gutter of 19 mm (3/4 inch).

Where walk is to be constructed across driveways to commercial establishments, the thickness thereof shall be 150 mm (6 inches) unless otherwise specified or indicated on the Plans. At residential driveways, the thickness of the walk will be 100 mm (4 inches) unless otherwise specified.

### **303-5.2 Forms.**

**303-5.2.1 Standard Forms.** Form material shall be free from warp, with smooth and straight upper edges, and if used for the face of curb, shall be surfaced on the side against which the concrete is to be placed. Wooden forms for straight work shall have a net thickness of at least 38 mm (1-1/2 inches). Metal forms for such a work shall be of a gage that will provide equivalent rigidity and strength. Curb face forms used on monolithic curb and gutter construction shall be of a single plank width when the curb face is 250 mm (10 inches) or less, except for those used on curb returns. All forms used on curb returns shall be not less than 19 mm (3/4 inch) in thickness, cut in the length and radius as shown on the Plans, and held rigidly in place by the use of metal stakes and clamps. The curb face form shall be cut to conform exactly with the curb face batter as well as being cut to the required length and radius. Forms shall be of sufficient rigidity and strength, and shall be supported to adequately resist springing or deflection from placing and tamping the concrete.

Form material shall be clean at the time it is used and shall be given a coating of light oil, or other equally suitable material, immediately prior to the placing of the concrete.

All forms except back planks of curb shall be set with the upper edges flush with the specified grade of the finished surface of the improvement to be constructed, and all forms shall be not less than a depth equivalent to the full specified thickness of the concrete to be placed.

Back forms shall be held securely in place by means of stakes driven in pairs at intervals not to exceed 1.2 m (4 feet), one at the front form and one at the back. Clamps, spreaders, and braces shall be used to such extent as may be necessary to ensure proper form rigidity. Forms for walk, gutter, and similar work shall be firmly secured by means of stakes driven flush with the upper edge of the form at intervals not to exceed 1.5 m (5 feet). Form stakes shall be of sufficient size and be driven so as to adequately resist lateral displacement.

Commercial form clamps for the curb and gutter may be used provided they fulfill the requirements specified herein.

**303-5.2.2 Slip-Forms.** At the option of the Contractor and with the approval of the Engineer, slip-form equipment may be used for the construction of concrete curb and gutter.

Slip-form equipment shall be provided with traveling side and top forms of suitable dimensions, shapes, and strength to support the concrete for a sufficient length of time during placement to produce curb and gutter of the required cross section. The equipment shall spread, consolidate, and screed the freshly placed concrete to provide a dense and homogeneous product.

The slip-form equipment shall have automatic sensor controls which operate from an offset control line. The line and grade of the slip-form equipment shall be automatically controlled.

**303-5.3 Placing Concrete.** Concrete shall be placed on a subgrade sufficiently dampened to ensure that no moisture will be absorbed from the fresh concrete.

Concrete shall be placed in curb, gutter, and curb and gutter forms in horizontal layers not exceeding 150 mm (6 inches) in thickness, each layer being spaded along the forms and thoroughly tamped. Concrete may be placed in layers of more than 150 mm (6 inches) in thickness only when authorized by the Engineer and the spading and tamping is sufficient to consolidate the concrete for its entire depth.

After the concrete for walk has been placed, a strikeoff shall be used to bring the surface to the proper elevation when compacted. It shall be spaded along the form faces and tamped to assure a dense and compact mass, and to force the larger aggregate down while bringing to the surface not less than 10 mm (3/8 inch) of the free mortar for finishing purposes.

Concrete shall be placed in cross gutters in horizontal layers of not more than 100 mm (4 inches) in thickness, each layer being spaded along the form faces and thoroughly tamped into a dense and compact mass. If internal vibrators are used, the full specified thickness may be placed in one operation.

After the concrete has been placed and tamped, the upper surface shall be struck off to the specified grade.

### **303-5.4 Joints.**

**303-5.4.1 General.** Joints in concrete curb, gutter, and walk shall be designated as expansion joints and weakened plane joints.

**303-5.4.2 Expansion Joints.** Expansion joints shall be constructed in curb, walk, and gutter as shown on the Plans or as specified herein. Such joints shall be filled with premolded joint filler conforming with the requirements prescribed in 201-3.2. No such joints shall be constructed in cross gutters, alley intersections, access ramps, or driveways except as may be approved by the Engineer.

Six (6) mm (1/4 inch) joints shall be constructed in curb and gutter at the end of all returns except where cross gutter transitions extend beyond the curb return, in which case they shall be placed at the ends of the cross gutter transition. No joints shall be constructed in returns. Where monolithic curb and gutter is constructed adjacent to concrete pavement, no expansion joints will be required except at the EC and BC of curb returns.

Expansion joint filler 6 mm (1/4 inch) thick shall be placed in walk at the EC and BC of all walk returns and around all utility poles which may project into the concrete along the line of the work. 6 mm (1/4 inch) joints shall be constructed in walk returns between the walk and the back of curb returns when required by the Engineer. At the EC and BC and around utility poles, the joint filler-strips shall extend the full depth of the concrete being placed. Joint filler-strips between walk and curb shall be the depth of the walk plus 25 mm (1 inch) with the top set flush with the specified grade of the top of curb.

All expansion joint filler strips shall be installed vertically, and shall extend to the full depth and width of the work in which they are installed, and be constructed perpendicular to straight curb or radially to the line of the curb constructed on a curve. Expansion joint filler materials shall completely fill these joints to within 6 mm (1/4 inch) of any surface of the concrete. Excess filler material shall be trimmed off to the specified dimension in a neat and workmanlike manner. During the placing and tamping of the concrete, the filler strips shall be held rigidly and securely in proper position.

### **303-5.4.3 Weakened Plane Joints.**

(a) **General.** Weakened plane joints shall be straight and constructed in accordance with Subsections (b) or (c) below, unless otherwise shown on the Plans.

In walks, joints shall be transverse to the line of work and at regular intervals not exceeding 3 m (10 feet). At curves and walk returns, the joint shall be radial.

In gutter, including gutter integral with curb, joints shall be at regular intervals not exceeding 6 m (20 feet). Where integral curb and gutter is adjacent to concrete pavement, the joint shall be aligned with the pavement joints where practical.

(b) **Control Joint.** After preliminary troweling, the concrete shall be parted to a depth of 50 mm (2 inches) with a straightedge to create a division in the coarse aggregate. The concrete shall then be refloated to fill the parted joint with mortar. Headers shall be marked to locate the

weakened plane for final joint finishing, which shall be accomplished with a jointer tool having a depth of 13 mm (1/2 inch) and a radius of 3 mm (1/8 inch). The finished joint opening shall not be wider than 3 mm (1/8 inch).

(c) **Plastic Control Joint.** The joint material shall be a T-shaped plastic strip at least 25 mm (1 inch) deep, having suitable anchorage to prevent vertical movement, and having a removable stiffener with a width of at least 19 mm (3/4 inch). After preliminary troweling, the concrete shall be parted to a depth of 50 mm (2 inches) with a straightedge. The plastic strip shall be inserted in the impression so that the upper surface of the removable stiffener is flush with the concrete. After floating the concrete to fill all adjacent voids, the removable stiffener shall be stripped. During final troweling, the edges shall be finished to a radius of 3 mm (1/8 inch), using a slit jointer tool.

### 303-5.5 Finishing.

**303-5.5.1 General.** Finishing shall be completed as specified herein for the type work being performed.

**303-5.5.2 Curb.** The front forms may be stripped as soon as the concrete has set sufficiently. Class "B" mortar, as prescribed in 201-5.1 and thinned to the consistency of grout, shall be immediately applied to the top and face of the curb. If monolithic curb and gutter is being constructed, this mortar shall be applied to the full exposed curb face; otherwise, it shall extend 50 mm (2 inches) below the gutter surface.

The face and top of the curb shall then be carefully troweled to a smooth and even finish; the top being finished to a transverse slope of 6 mm (1/4 inch) toward the gutter, with both edges rounded to a radius of 13 mm (1/2 inch). The troweled surface shall be finished with a fine-hair broom applied parallel with the line of the work. The edge of the concrete at all expansion joints shall be rounded to a 6 mm (1/4 inch) radius. The surface of the work shall be finished as prescribed; after which the name of the Contractor, together with the year in which the improvement is constructed, shall be stamped therein to a depth of 6 mm (1/4 inch) in letters not less than 19 mm (3/4 inch) high, at the BC and EC of curb returns.

Joints shall conform to 303-5.4.

**303-5.5.3 Walk.** The forms shall be set to place the finished surface in a plane sloping up from the top of curb 2 percent when measured at right angles to the curb.

Following placing, the concrete shall be screeded to the required grade, tamped to consolidate the concrete and to bring a thin layer of mortar to the surface, and floated to a smooth, flat, uniform surface. The concrete shall then be edged at all headers, given a preliminary troweling and provided with weakened plane joints.

Walk shall be steel troweled to a smooth and even finish. All formed edges shall be rounded to a radius of 13 mm (1/2 inch). Edges at expansion joints shall be rounded to a radius of 3 mm (1/8 inch). Preliminary troweling may be done with a longhandled trowel or "Fresno", but the finish troweling, shall be done with a hand trowel. After final troweling, walk on grades of less than 6 percent shall be given a fine-hair-broom finish applied transversely to the centerline. On grades exceeding 6 percent, walk shall be finished by hand with a wood float. Walk shall be remarked as necessary after final finish, to assure neat uniform edges, joints, and score lines.

Scoring lines, where required, shall have a minimum depth of 6 mm (1/4 inch) and a radius of 3 mm (1/8 inch). When longitudinal scoring lines are required, they shall be parallel to, or concentric with, the lines of the work. Walk 6 m (20 feet) or more in width shall have a longitudinal center scoring line. In walk returns, one scoring line shall be made radially midway between the BCR and ECR. When directed by the Engineer, longitudinal and transverse scoring lines shall match the adjacent walk. The Contractor shall have sufficient metal bars, straightedges, and joint tools on the project.

Headers shall remain in place for at least 16 hours after completion of the walk but must be removed before the Work is accepted.

**303-5.5.4 Gutter.** After the concrete has been thoroughly tamped to force the larger aggregate into the concrete and bring to the top sufficient free mortar for finishing, the surface shall be worked to a true and even grade by means of a float, troweled with a longhandled trowel or "Fresno", and wood-float finished. The flowline of the gutter shall be troweled smooth for a width of approximately 100 mm (4 inches) for integral curb and gutter and 100 mm (4 inches) on either side of the flowline on cross gutters and longitudinal gutters. The outer edges of the gutter shall be rounded to a radius of 13 mm (1/2 inch).

Side forms shall remain in place for at least 24 hours after completion of the gutter, but must be removed before the work will be accepted.

Joints shall conform to 303-5.4.

**303-5.5.5 Alley Intersections, Access Ramps, and Driveways.** Alley intersections, access ramps, and driveways shall be constructed as specified for concrete pavement in 302-6, except final finishing for alley intersections, access ramps, and the sloping portion of driveways shall be done by hand with a wood float and the remaining portion of the driveway finished as specified for walks in accordance with 303-5.5.3.

**303-5.6 Curing.** Immediately after finishing operations are completed, curing compound conforming to 201-4.1 shall be applied.

The curing compound shall be applied in a manner to entirely cover all exposed surfaces of the concrete with a continuous membrane.

No power equipment used for the preparation of subgrade will be permitted adjacent to concrete curb, gutter, or alley intersections until the fourth day following placement of the concrete. The placement of bituminous pavement adjacent to concrete curb, gutter, or alley intersections will not be permitted until the seventh day following the placement of concrete nor will concrete paving operations be permitted until the seventh day where placing or finishing equipment will ride on the previously placed concrete. If admixtures, additional cement or Type III cement is used to obtain high early strength concrete in accordance with 201-1, grading operations will be permitted on the second day following the placement of the concrete and paving operations on the third day.

**303-5.7 Repairs and Replacements.** Any new work found to be defective or damaged prior to its acceptance shall be repaired or replaced as approved by the Engineer.

**303-5.8 Backfilling and Cleanup.** Backfilling to the finished surface of the newly constructed improvement must be completed before acceptance of the Work.

Upon completion of the work the surface of the concrete shall be thoroughly cleaned and the site left in a neat and orderly condition.

**303-5.9 Measurement and Payment.** Payment for concrete curbs, walks, gutters, cross gutters, alley intersections, access ramps, and driveways will be made as shown in the Bid.

### **303-6 STAMPED CONCRETE.**

**303-6.1 General.** Stamped concrete shall be imprinted with special tools to provide the pattern specified. Colored stamped concrete shall also conform to 303-7.

The Contractor shall install a sample for each pattern included in the Work. The sample shall be a minimum of 1 m<sup>2</sup> (10 ft<sup>2</sup>) which shall be subject to inspection and approval by the Engineer. All other areas to be installed shall match the texture of the approved area.

All coloring and curing compounds used in the Work shall be from the same manufacturer.

**303-6.2 Concrete Placement.** Placing of concrete shall conform to 302-6 and 303-5. The minimum slab thickness shall be 100 mm (4 inches). The maximum size aggregate in the top 50 mm (2 inches) shall be 9.5 mm (3/8 inch).

**303-6.3 Pattern.** The pattern of stamped concrete shall be implanted, indented, imprinted, or stamped into the surface by means of forms, molds, or other approved devices. The impressions shall be approximately 10 mm (3/8 in) in width, not to exceed 13 mm (1/2 in) in depth and be ungrouted unless otherwise specified. Expansion joints and control joints shall be located so as not to disrupt the pattern.

Joints shall conform to 303-5.4.

**303-6.4 Curing.** Curing shall conform to 303-1.10. Curing compound used in the Work shall be of a single type and manufacturer.

**303-7 Colored Concrete.**

**303-7.1 General.** Colored concrete shall be produced by Method A or B as specified below. The Contractor shall provide a sample in the Work for each color specified of a size satisfactory to the Engineer. The sample shall be inspected and approved by the Engineer before proceeding with the Work.

**303-7.2 Method A (Dry Shake).** Color hardener shall be applied evenly to the plastic surface by a dry shake method using approved manufacturer’s printed instructions, otherwise, it shall be applied in two applications, wood floated after each, and troweled only after the final floating.

**303-7.3 Method B (Integral Color).**

**(a) Color Conditioning Admixture.** Color conditioning admixture shall be added to the concrete in accordance with approved manufacturer’s printed instructions. No calcium chloride shall be added to the concrete. Other non-chloride admixtures may be added subject to approval of the Engineer.

**(b) Pure Mineral Pigments.** Pure mineral pigments shall be added to the concrete in accordance with approved manufacturer’s printed instructions. Other admixtures specified or approved by the Engineer shall be added to the concrete in accordance with 201-1.2.4, except that no calcium chloride, or other admixture containing chloride ions shall be used.

**303-7.4 Curing.** Colored concrete shall be cured with a liquid curing compound in matching color and complying with the requirements of ASTM C 309. The curing compound shall be applied in accordance with approved manufacturer’s printed instructions. Curing with clear, white-pigmented or fugitive-dye curing compounds, or with plastic or other waterproof membranes will not be allowed. When approved by the Engineer, colored concrete may be cured by a continuous indirect fine spray of water for a minimum of 10 days.

**SECTION 304 - METAL FABRICATION AND CONSTRUCTION**

**304-1 STRUCTURAL STEEL.**

**304-1 CROSS REFERENCES**

Shop Drawings.....	2-5.3
Structural Steel, Rivets, Bolts, Pins, and Anchor Bolts ...	206-1
Paint.....	210-1
Galvanizing .....	210-3

### 304-1.1 General.

**304-1.1.1 Shop Drawings.** The Contractor shall, in accordance with 2-5.3, submit shop drawings which show details, dimensions, sizes of material, and all information and data necessary for the fabrication of the metal work, including full details of the match markings. Drawings required to be submitted by the Contractor shall conform to the applicable provisions of 304-1.4.

When required by the Plans and Specifications, the Contractor shall furnish to the Engineer, before acceptance of the Work, detailed drawings of the structure to be built. Inasmuch as the drawings will be retained by the Agency as permanent records, they must be in the form of printable transparencies of quality satisfactory to the Engineer.

**304-1.1.2 Falsework Plans.** The Contractor shall, in accordance with the provisions of 2-5.3 and 303-1.6, submit detailed plans of falsework to be used. Approval of such plans will be based upon compliance with the design criteria set forth for falsework for concrete structures in 303-1.6.2. Approval of falsework plans will not relieve the Contractor of responsibility for the results obtained by use of such plans. The Contractor shall be fully responsible for providing falsework capable of supporting all loads which are applied.

**304-1.2 Methods and Equipment.** When requested before starting erection of any structural members, the Contractor shall inform the Engineer fully as to the methods it proposes to follow and the amount and character of equipment proposed for use in such work. The use of such methods and equipment shall be subject to the approval of the Engineer, but this approval shall not be considered as relieving the Contractor of the responsibility for the safety of its methods or equipment, or for carrying out the work in full accordance with the Plans and Specifications.

**304-1.3 Inspection.** An inspector or other authorized representative of the Engineer will examine the metals and metal items to be fabricated before they are worked in the shop and may exercise constant surveillance over the Work during its progress, with full power to reject all materials or workmanship not conforming to the Plans and Specifications.

The Contractor shall give the Engineer 5 days minimum advance notice before commencement of the fabricating operations to permit ample time for the inspection of the materials.

The Engineer shall be furnished complete copies of all mill reports prior to commencing fabrication. The Contractor shall furnish ample means and assistance for sampling all materials. Arrangements shall be made for the Engineer to have free access at all times to any portion of the workshops where work is being done under these specifications.

No fabricating, machining, cutting, welding, assembling, or painting shall be done except with the knowledge of the Engineer. Any work done otherwise will be subject to rejection.

The acceptance of any material or finished member by the Engineer shall not preclude subsequent rejection if it is later found to be defective. Rejected material and workmanship shall be promptly repaired or replaced by the Contractor.

Samples of materials, except castings, shall be cut from stock designated by the Engineer or will be selected from items furnished. Gray iron, steel, and bronze castings shall be cast with test coupons.

**304-1.4 Steel Structures.** Fabrication and erection of structures shall conform to "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings" of the American Institute of Steel Construction (AISC), except for any conflicts with the applicable building code which may exist, and except that the following sections are considered as excluded from the AISC Specifications:

- 1) Section 1.1 Plans and Drawings
- 2) Section 1.4 Material
- 3) Section 1.24 Shop Painting
- 4) Section 1.26 Inspection

The subject matter excluded from the foregoing AISC Specifications shall be superseded by the applicable provisions of these specifications.

In addition to complying with AISC Specifications, when work involving the use of the high strength bolts is included in the project, the design and construction of such work shall conform to ASTM A 325.

The design, fabrication and erection of structural steel and all similar work incidental or appurtenant to steel construction for highway bridges shall be performed and accomplished in accordance with the latest Standard Specifications for Highway Bridges adopted by the American Association of State Highway and Transportation Officials.

The Plans or Specifications will designate the members to be painted or galvanized.

### **304-1.5 Workmanship.**

**304-1.5.1 General.** Workmanship and finish shall be equal to the best general practice in modern steel fabricating shops.

Before being laid out or worked, rolled material shall be straight. If straightening is necessary, it shall be done by methods approved by the Engineer. Kinks and bends in the material will be cause for rejection. Heat shrinking of low alloy structural steels will not be permitted.

If straightening is necessary in the field, only methods approved by the Engineer shall be used.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately. Undercut gusset plates will not be accepted. All sharp corners and edges, and edges that are marred, cut, or roughened in handling or erection, shall be slightly rounded by grinding or other suitable means.

### **304-1.5.2 Holes for Bolts or Rivets.**

**General.** Holes shall be either punched full size, punched and reamed, or drilled. The finished hole shall be 1.5 mm (1/16 inch) larger than the nominal diameter of the rivet.

Holes punched full size shall have all burrs and sharp edges removed. The diameter of the die shall not exceed that of the punch by more than 2.4 mm (3/32 inch).

(a) **Shop Rivets.** Holes for shop rivets shall be subpunched, or subdrilled at the fabricator's option, 6 mm (1/4 inch) less in diameter than that of the finished holes, and shall be reamed to size with the parts assembled, with the following exceptions:

- 1) Holes in material thicker than 22 mm (7/8 inch) shall not be punched; however, at the fabricator's option, they may be subdrilled to the diameter specified for subpunching or may be drilled full size with the parts assembled, provided that the parts are adequately bolted or clamped together.
- 2) Holes in rolled beams and plate girders, including stiffeners and active fillers at bearing points, may be subpunched 3.2 mm (1/8 inch) less in diameter than that of the finished holes; and reamed to size (after assembly) in material not thicker than the nominal diameter of the rivet less 3.2 mm (1/8 inch).

- 3) Holes in material not more than 22 mm (7/8 inch) thick, for rivets which do not transfer stress caused by external vertical loading, may be punched full size or, at the fabricator's option, may be subpunched 3.2 mm (1/8 inch) less in diameter than the finished holes and reamed to size after assembly. This applies to holes for stitch rivets, lateral, longitudinal, or sway bracing and their connecting material, lacing, stay plates, diaphragms which do not transfer shear or stress, inactive fillers, and stiffeners not at bearing points. However, holes through assembled material shall not pass through both reamed plies and plies punched full size unless the reamed holes have been subpunched for the fabricator's convenience, or the assembled material is not over five plies thick, of which the main material consists of not more than three plies.

(b) **Field Rivets.** Holes for field rivets shall be subpunched or subdrilled at the fabricator's option, 6 mm (1/4 inch) less in diameter than that of the finished holes, and shall be reamed to size through steel templates with hardened steel bushings, with the following exceptions:

- 1) Field splices in plate girders and in the chords of trusses shall be reamed with the members assembled. Other field connections may be reamed with the members assembled, at the fabricator's option. Chord splices in truss members shall, in all cases, be reamed or drilled with at least three abutting sections assembled and with milled ends of compression chords in full bearing.
- 2) Assemblies, such as floor systems to girders, complete trusses, rolled beam spans connected by diaphragms, and portals to trusses shall be reamed with the members assembled if so indicated on the Plans, and otherwise at the fabricator's option.
- 3) Field connections of lateral, longitudinal, or sway bracing shall conform to the requirements of holes for shop rivets.
- 4) Holes in material thicker than 22 mm (7/8 inch) shall not be punched, but shall be subdrilled to the diameter specified for subpunching, or drilled full size with parts assembled.

The accuracy of the punching shall be such that for any group of holes when assembled, 75 percent shall admit a rod equal to the diameter of the cold rivet at right angles to the plane of the connection. Otherwise the holes shall be reamed. When the extent of the reaming is such that the holes cannot be properly filled or accurately adjusted after reaming, the faulty member shall be discarded and replaced.

Mispunched members shall not be corrected by welding without the approval of the Engineer.

**304-1.5.3 Reamed Work.** Reaming shall be done after the pieces forming a member are assembled and so firmly bolted together that the surfaces are in close contact. Burrs and sharp edges of each reamed hole under both rivet heads shall be removed with a countersinking tool making 1.5 mm (1/16 inch) fillets. The pieces shall be taken apart before riveting, if necessary, and any shavings removed. If it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked that they may be reassembled in the same position. Reamed parts shall not be interchanged.

**304-1.5.4 Drilled Holes.** Drilled holes shall be 1.5 mm (1/16 inch) larger than the nominal diameter of the rivet. Burrs and sharp edges of each drilled hole under both rivet heads shall be removed with a countersinking tool making a 1.5 mm (1/16 inch) fillet. Burrs on the outside surfaces shall be removed. If members are drilled while assembled, the parts shall be held securely together while the drilling is being done.

Drilled holes shall be drilled to finish size while all of the thicknesses of metal are assembled, or subdrilled and reamed as required for punched and reamed holes.

Holes shall be clean-cut, without torn or ragged edges. Holes that must be enlarged to admit rivets shall be reamed. Drilling shall be done accurately.

### 304-1.5.5 Assembling Steel.

(a) **General.** Steel parts shall be assembled in the shop or in the field in accordance with 304-1.5.5 (b) and 304-1.5.5 (c).

(b) **Shop Work.** At the time of assembling and riveting, bolting, or welding, steel surfaces in contact for shop or field connection shall be thoroughly cleaned of rust, loose mill scale, dirt, grease, or other material foreign to the steel. No paint shall be applied to contact surfaces prior to riveting, bolting or welding.

Riveted or bolted trusses, continuous plate girder and I-beam spans, skew portals, skew connections, rigid frames, bents, and towers shall be completely assembled in the shop and accurately adjusted to line and camber. Holes for field connections shall be drilled or reamed while assembled. Holes for other connections, except those in lateral, longitudinal, and sway bracing shall be drilled or reamed in the shop with the connecting parts assembled; or drilled or reamed to a metal template with hardened bushing, without assembling.

Long-span truss work shall be assembled in lengths of not less than three abutting panels, the members adjusted for line and camber, and holes for field connections drilled or reamed while assembled.

Field riveted or bolted joints for girders shall be completely assembled, the members adjusted for line and camber, and holes for field connections drilled or reamed while assembled.

Field butt joints for welded girders shall be completely assembled with the members adjusted for line and camber and prepared to fit for welding.

All machinery shall be completely assembled. All bearing shall be fitted to the specified clearances and alignment. Gear reductions and all line gears shall have gear center distances set and the gears properly matchmarked.

(c) **Field Work.** The parts shall be accurately assembled as shown on the Plans and all matchmarks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members will not be permitted. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully riveted or bolted and all other truss connections pinned and bolted. Rivets or bolts in splices of butt joints of compression members and rivets or bolts in railings shall not be driven or torqued until the span has been erected in place, temporarily bolted, and the member is supporting its own weight. Splices and field connections shall have half of the holes filled with bolts and cylindrical erection pins (in approximately equal numbers) before riveting or bolting.

Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the rivets, and cylindrical erection pins shall be 0.8 mm (1/32 inch) larger.

The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.

If any holes must be enlarged to admit the rivets, they shall be reamed.

Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be matchmarked, and a diagram showing such marks shall be furnished to the Engineer.

### 304-1.5.6 Riveting.

(a) **Shop Work.** Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale, and other adhering matter. When driven, they shall completely fill the holes. The heads shall be of approved shape, full size, neatly formed, concentric with the shank, free from fins, and in full contact with the surface of the member.

Loose, burned, or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal. Caulking or recupping will not be permitted.

Rivets shall be driven by direct-acting riveters where practicable. If rivets are driven with a pneumatic hammer, a pneumatic buckler shall be used if practicable.

(b) **Field Work.** Pneumatic hammers shall be used for field riveting. Connections shall be accurately and securely fitted up before the rivets are driven.

Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. They shall not be overheated or burned.

Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Cup-faced dollies, fitting the head closely to ensure good bearing, shall be used. Sufficient air compressor capacity shall be maintained to keep the air pressure at 100 psi at the hammers.

Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured. The removal of loose or defective rivets by flame cutting will not be permitted, except upon written permission of the Engineer.

**304-1.5.7 Bolted Connections.** Bolts shall be unfinished bolts, turned bolts, or high strength steel bolts, as shown on the Plans or in the Specifications.

Unfinished or turned bolts shall have hexagonal heads and nuts and shall be of such length that they will extend entirely through the nut but not more than 6 mm (1/4 inch) beyond. Bolts in tension shall have two nuts.

Unfinished bolts in shear shall have not more than one thread within the grip. The diameter of the unfinished bolt shall not be more than 0.8 mm (1/32 inch) smaller than the diameter of the hole.

The threads of turned bolts shall be entirely outside the grip. The holes for turned bolts shall be reamed and the bolts shall be finished to provide a driving fit. Approved nut locks or flat washers 6 mm (1/4 inch) thick shall be furnished, as specified.

Bolted connections using high strength steel bolts shall conform to ASTM A 325.

Holes for bolted connections using high strength steel bolts shall conform to the requirements specified in 304-1.5.2, except as follows: Holes that are required to be subdrilled and reamed may be subdrilled 3.2 mm (1/8 inch) less in diameter than that of the finished hole, provided that the offset of any hole in any ply measured from the outer ply after the hole is finished does not exceed 0.8 mm (1/32 inch) and that no more than 20 percent of the holes shall provide as much offset as 0.8 mm (1/32 inch).

### 304-1.6 Joint and Connections.

**304-1.6.1 Edge Planing.** Sheared edges of plates more than 16 mm (5/8 inch) in thickness and carrying calculated stress shall be planed to a depth of 6 mm (1/4 inch).

**304-1.6.2 Facing of Bearing Surfaces.** Surfaces of bearing and base plates and other metal bearing surfaces that are to come in contact with each other, with ground concrete surfaces, or with asbestos sheet packing shall be finish-machined flat to within 1 mm (1/32 in) tolerance in 300 mm (12 inches) and to within 1.5 mm (1/16 inch) tolerance overall. Surfaces of bearing and base plates and other metal bearing surfaces that are to come in contact with preformed fabric pads, elastomeric and elastic bearing pads, or portland cement grout shall be finish-machined flat to within 3 mm (1/8 inch) tolerance in 300 mm (12 inches) and to within 5 mm (3/16 inch) tolerance overall.

Steel slabs, where not in contact with other metal bearing surfaces, may be heat-straightened in lieu of machining, provided the above tolerances are met.

**304-1.6.3 Abutting Joints.** When shown on the Plans, abutting joints shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 6 mm (1/4 inch).

**304-1.6.4 End Connection Angles.** Floor beams, stringers, and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angle shall not be less than that shown on the detail drawings.

**304-1.6.5 Web Plates.** In girders having no cover plates and which are not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall be not more than 3 mm (1/8 inch) below at any point.

**304-1.6.6 Fit of Stiffeners.** End stiffener angles of girders and stiffener angles intended as supports for concentrated load shall be milled or ground to secure an even bearing against the flange angles. All fillers under stiffener angles shall fit sufficiently tight to exclude water after being painted.

**304-1.6.7 Pin and Bolted Connections.** Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. In field assembling, the pin nuts on pin connections and the bolts on bolted connections shall be screwed up tight and the threads, except when high strength bolts are used, burred at the face of the nuts with a pointed tool.

**304-1.6.8 Pins and Rollers.** Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. The final surface shall be produced by a finishing cut.

Pins and rollers more than 175 mm (7 inches) in diameter shall be forged and annealed.

In pins larger than 230 mm (9 inches) in diameter, the forging shall be permitted to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling, and a hole not less than 50 mm (2 inches) in diameter shall be bored full length along the axis of the pin before being annealed.

Pin holes in structural members shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than 0.8 mm (1/32 inch). Holes in built-up members shall be bored after riveting, bolting, or welding is completed.

The diameter of the pin hole shall not exceed that of the pin by more than 0.5 mm (1/50 inch) for pins 125 mm (5 inches) or less in diameter, or 0.8 mm (1/32 inch) for larger pins.

**304-1.6.9 Screw Threads.** Screw threads shall make close fits in the nuts and shall be Unified Standard Series conforming to ANSI B1.1-1960.

**304-1.7 Bearings and Anchorage.** Anchor bolts shall be either headed bolts, installed with or without pipe sleeves, or swage bolts installed in drilled holes, as detailed on the Plans. The anchor bolts shall be carefully installed to permit true positioning of the bearing assemblies.

When anchor bolts are installed in pipe sleeves, the pipes shall be completely filled with grout at the time the grout pads are constructed or at the time the bearing assemblies or masonry plates are placed. Swage bolts installed in holes shall be either sulphured in or grouted in as shown on the Plans.

All bearing assemblies shall be set level and to the elevations shown on the Plans. Adjustments in the horizontal positions of bearing assemblies shall be made for temperature as directed by the Engineer.

In conformance with the details shown on the Plans, masonry plates and the bearing plates of bearing assemblies shall be set on ground concrete surfaces, on preformed fabric pads, or on grout pads.

Grout to be placed below masonry plates or bearing plates of the bearing assemblies and in anchor bolt sleeves shall consist of Class "E" mortar. Concrete areas to be in contact with the grout shall be cleaned of all loose or foreign matter that would in any way prevent bond between the mortar and the concrete surfaces and shall be kept thoroughly saturated with water for a period of not less than 24 hours immediately prior to placing the grout. The grout shall contain only sufficient moisture to permit packing and shaping. The grout shall completely fill the anchor bolt sleeves and shall be tightly packed under the masonry or bearing plates to provide full bearing. After placing, all exposed surfaces of the grout pads shall be kept covered with a heavy thickness of burlap saturated with water for a period of 3 days. All improperly cured or otherwise defective grout shall be removed and replaced at the Contractor's expense.

Immediately before setting bearing assemblies or masonry plates directly on ground concrete surfaces, the Contractor shall thoroughly clean the surfaces of the concrete and the metal to be in contact and shall apply a coating of non-sag polysulfide or polyurethane caulking conforming to Federal Specification TT-S-230, Type II, to contact areas to provide full bedding of the metal in the caulking.

Preformed fabric pads shall be furnished and installed at the locations and in accordance with the details shown on the Plans.

The preformed fabric pads shall be composed of multiple layers of 270 g/m<sup>2</sup> (8 ounces per square yard) cotton duck impregnated and bound with high-quality natural rubber or of equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be sufficient to produce the specified thickness, after compression and vulcanizing. The finish pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 70 MPa (10,000 psi) without extrusion or detrimental reduction in thickness.

**304-1.8 Expansion and Rotation Assemblies.** Before leaving the shop or foundry, the rockers or roller nests shall be completely assembled with the bearing plates for checking and approval by the Engineer.

**304-1.9 Welding.** All welding shall conform to the requirements of the *Structural Welding Code AWS D1.1*, and these specifications.

Inspection of welding made to control the quality of welds and workmanship will be performed in accordance with the requirements of the AWS. All welding may be subject to radiographic or other nondestructive testing. Such nondestructive testing will be performed without charge to the Contractor except that if a weld is shown to be defective, all costs involved in reinspection shall be borne by the Contractor.

Weld metal shall be sound throughout, except that very small gas pockets and small inclusions of oxide or slag may be permitted if well dispersed and if none exceeds 1.5 mm (1/16 inch) in greatest dimension, and provided further that the sum of the greatest dimension of all such defects in any 25 mm by 25 mm (1 square inch) weld area does not exceed 10 mm (3/8 inch).

All welding shall be performed in such a manner that the Brinnell hardness of the weld metal and heat-affected zone is within the following limits:

#### Minimum Brinnell Hardness

$$\text{In SI Units} = \frac{\text{Minimum specified tensile strength of parent metal (MPa)}}{3.5}$$

$$\text{In US Std. Units} = \frac{\text{Minimum specified tensile strength of parent metal (psi)}}{500}$$

#### Maximum Brinnell Hardness

$$\text{In SI Units} = \frac{\text{Maximum specified or tested tensile strength of parent metal (MPa)} + 50}{3.5}$$

$$\text{In US Std. Units} = \frac{\text{Maximum specified or tested tensile strength of parent metal (psi)} + 50}{500}$$

All welding of structural steel (ASTM A 36, A 242, and A 441) shall be performed by either the submerged or gas-shielded arc process, or with low hydrogen electrodes. Low hydrogen electrodes for welding low alloy steel shall conform to the requirements of the Military Specifications for Electrodes (mineral covered, low hydrogen) for Welding Medium and High Tensile Steels, MIL-E-18038 (Ships). All welding of low alloy structural steel shall be qualified by procedure tests before fabrication is commenced.

Low hydrogen electrodes shall be stored for holding in an approved low hydrogen oven at a temperature of from 150°C to 205°C (300°F to 400°F) to control the moisture in the coating on the electrode.

Low hydrogen electrodes not packaged in a moisture-proof container shall be restored by rebaking for 2 hours or more at a temperature of from 232°C to 260°C (450°F to 500°F) in an approved oven.

Low hydrogen electrodes which have been removed from their moisture-proof containers shall be stored in an approved oven at a temperature of from 150°C to 205°C (300°F to 400°F) after rebaking.

Areas contiguous to welding operations shall be preheated to a minimum temperature of 150°C (300°F) when necessary to prevent distortion of weld cracking. Preheating to a temperature in excess of 205°C (400°F) will not be required.

Unless otherwise shown on the Plans or specified, bearing assemblies that are to be machined after welding shall be stress-relieved by heat treatment before machining, in accordance with the "Structural Welding Code" AWS D1.1.

Portions of members in bearing assemblies or in direct bearing shall be straightened, planed, or otherwise corrected after fabrication as necessary to provide full bearing on bearing assemblies or bearing areas on level bearing plates.

Where the end of a stiffener plate is shown "tight fit" on the Plans, the end of the plate shall be so fitted that it bears on the beam flange with at least point bearing. Local clearances between the end of the plate and the flange shall not exceed 1.5 mm (1/16 inch).

Unless otherwise shown on the Plans or specified, erection bolts required for welded splices or welded connections may be left in place and the ends of all such erection bolts which project beyond the nut shall be burned off flush with the face of the nut. Where the bolt does not project, the end of the bolt and nut shall be tack welded to prevent loosening of the nut. Burning off projecting bolt ends and tack welding shall be performed prior to painting.

Welders, welding operators, and tackers shall be prequalified in accordance with the specifications of AWS D1.1 and shall produce written evidence of qualification satisfactory to the Engineer.

Electroslag and electrogas welding will not be permitted without the written approval of the Engineer.

**304-1.10 Torch Cutting.** The use of a cutting torch is permissible if the metal being cut is not carrying stress during the operation. The radius of re-entrant flame-cut fillets shall be as large as possible, but never less than 19 mm (3/4 inch). To determine the net area of members so cut, 3 mm (1/8 inch) shall be deducted from the flame-cut edges. Stresses shall not be transmitted through a flame-cut surface.

Where cutting with a torch, cuts shall be true to line with a maximum deviation of 1.5 mm (1/16 inch). All burned edges shall be finished by grinding.

**304-1.11 Bent Plates.** Cold-bent, load-carrying, rolled steel plates shall conform to the following:

- 1) They shall be taken from the stock plates so that the direction of bending will be at right angles to the direction of rolling.
- 2) The radius of bend, measured to the concave face of the metal, shall not be less and preferably shall be greater than shown in the following table, in which "T" is the thickness of the plate:
- 3) Before bending, the corners of the plate shall be rounded to a radius of 1.5 mm (1/16 inch) throughout that portion of the plate at which the bending is to occur.

If a shorter radius is essential, the plates shall be bent hot, and such plates shall conform to requirement 1) above.

**TABLE 304-1.11 (A)**

Angle Through Which Plate is Bent	Minimum Radius
61° to 90°	1.0 T
91° to 120°	1.5 T
121° to 150°	2.0 T

**304-1.12 Measurement and Payment.**

**304-1.12.1 General.** Steel structures will be paid for at a unit price per kg (pound) for structural steel, and at prices per kg (pound) for cast steel and cast iron or as indicated in the Bid. The pay quantities shall be determined by scale weights or, if permitted by the Engineer, by computed weights obtained as provided in this 304-1.12.3. The Contractor will be paid only for material actually used in the completed structure.

Computed weights shall be used to determine pay quantities of alloy and carbon steel when members contain both alloy and carbon steel.

The weight of erection bolts, paint, boxes, crates, and other containers used for packing and the materials used for supporting members during transportation will not be included in the weights of material for pay purposes.

The weight of structural steel to be paid for shall not exceed the computed weight by more than 1-1/2 percent. The weight of cast steel or cast iron to be paid for shall not exceed the computed weights by more than 7-1/2 percent. If the scale weight of any member is less than 97-1/2 percent of the computed weight of that member, the member will be rejected and will not be included in pay quantities.

If computed weights are used, the weight to be paid for will be the calculated weight as established by the Engineer, and no allowance will be made for weight in excess thereof.

When the estimated quantities of structural steel, cast steel, and cast iron required for the work as described in the Specifications and shown on the Plans as final quantities, said estimated quantities shall be the final quantities for which payment will be made unless the dimensions of the work as shown on the Plans are revised by the Engineer. If such revisions result in an increase or decrease in the quantity of structural steel, cast steel, or cast iron, the final quantities for payment will be revised accordingly. The estimated quantities of structural steel required for the work shall be considered as approximate only. No allowance will be made in the event quantities determined from the details and dimensions as shown on the Plans do not equal the estimated quantities. These provisions concerning basis of payment shall not be construed to waive the specification of ASTM A 6.

**304-1.12.2 Scale Weights.** Scale weight shall be actual weight of the members as determined on accurate scales. When carload or truck weights are used, a record shall be submitted to the Engineer, which shall contain an itemized statement of the dunnage and the members included in each lot.

For any protective coating, scale weights will be reduced as follows:

0.25% for each coat of oil

0.5% for each shop coat of paint

3.5% for hot-dip galvanizing

Scale weights of members will not be required when the quantities of structural steel are designated on the Plans or in the Specifications as final quantities.

**304-1.12.3 Computed Weights.** The computed weight shall be obtained by the use of the following rules and assumptions:

- 1) The density of structural and cast steel shall be assumed at  $7849 \text{ kg/m}^3$  (0.2833 pound per cubic inch). The density of cast iron shall be assumed at  $7208 \text{ kg/m}^3$  (0.2604 pound per cubic inch).
- 2) The weights of rolled shapes and of structural plates shall be computed on the basis of their nominal weights and dimensions, as shown on the shop drawings, deducting for copes, cuts, and open holes, exclusive of rivet and bolt holes.
- 3) Since no deduction is made in the computed weight of structural steel members by reason of rivet or bolt holes, the computed weights of the completed members will be obtained by adding to the above weights the weights of the heads of all rivets and bolts in the structure, both shop-driven and field-driven. Full compensation for all rivets and bolts furnished in excess of the actual number in place in the completed structure shall be considered as included in the price paid per kg (pound) for structural steel in place and no additional compensation will be allowed therefore.

Should the computed weights be used to determine pay quantities, the weight of rivet heads shall be assumed as follows:

TABLE 304-1.12.3 (A)

Diameter of Rivet		Weight of 100 Heads	
mm	(in)	kg	(lbs)
13	(1/2)	2.3	(5.0)
16	(5/8)	4.4	(9.7)
19	(3/4)	7.3	(16.0)
22	(7/8)	10.9	(24.0)
25	(1)	15.9	(35.0)
29	(1-1/8)	22.2	(49.0)
32	(1-1/4)	35.4	(78.0)

Should computed weights be used to determine pay quantities of high strength steel bolts, the weights of portions of bolts outside the grip (including two washers and one nut) shall be assumed as follows:

TABLE 304-1.12.3 (B)

Diameter of Bolt		Weight of 100 Bolts (Each complete with 2 washers and one nut, less grip length)	
mm	(in)	kg	(lbs)
16	(5/8)	21	(46)
19	(3/4)	32	(71)
22	(7/8)	48	(105)
25	(1)	66	(145)
29	(1-1/8)	88	(194)
32	(1-1/4)	117	(259)

- 4) The weight of castings and fillets shall be computed from the dimensions shown on the shop drawings, deducting for all openings or cuts in the finished casting.
- 5) The weight of pins and rollers shall be computed from the dimensions shown on the shop drawings, deducting for all holes, openings, pockets, and metal removed by machine finishing.  
Pilot nuts and driving nuts for each size of pin shall be furnished for erection work and the weights of such nuts will not be included in the weight of structural steel for which payment is made.
- 6) The weight of bolts, cap screws, anchor bolts, nuts, washers, except as limited by 3) above, and anchor pipe sleeves remaining in the finished structure shall be computed on the basis of their nominal weights and dimensions as shown on the shop drawings.
- 7) No allowance will be made for the weight of paint in computing the weights of metal for payment.

8) The weight of shop and field fillet welds shall be assumed as follows:

**TABLE 304-1.12.3 (C)**

Size of Filled Weld		Weights	
mm	(in)	kg/m	(lbs per ft)
5	(3/16)	0.098	(0.08)
6	(1/4)	0.141	(0.14)
8	(5/16)	0.251	(0.22)
10	(3/8)	0.392	(0.30)
13	(1/2)	0.663	(0.55)
16	(5/8)	1.005	(0.80)
19	(3/4)	1.417	(1.10)
22	(7/8)	1.899	(1.50)
25	(1)	2.453	(2.00)

9) If computed weights are used to determine the pay quantities of galvanized metal, the weight to be added to the calculated weight of the base metal for the galvanizing shall be determined from the table of weights of zinc coatings specified by ASTM A 153.

**304-1.12.4 Payment.** Structural steel, cast steel, cast bronze, or cast iron will be paid for by the pound as shown in the Bid. If the Plans or Specifications require the metal to be galvanized, the weight of the metal shall include the weight of the zinc coating.

Full compensation for furnishing and placing sheet piling, preformed fabric pads, elastomeric or elastic bearing pads, and caulking, and for grouting masonry or bearing plates as shown on the Plans, shall be considered as included in the price paid for structural steel and no separate payment will be made therefore.

Cleaning and painting structural steel will be paid for as provided in Section 310.

**304-2 METAL RAILINGS.**

**304-2 CROSS REFERENCES**

Metal Railings .....	206-5
Galvanizing .....	210-3

**304-2.1 Metal Hand Railings.**

**304-2.1.1 General.** The materials for metal hand railings shall conform to the requirements of 206-5.1. Except where a standard drawing is referred to on the Plans, the Contractor shall in accordance with 2-5.3, submit shop drawings showing the details and dimensions of all metal hand railings.

**304-2.1.2 Fabrication.** Welding shall conform to the requirements of the "Structural Welding Code" AWS D1.1 for steel, and to the requirements of the "Specifications for Aluminum Structures" of the Aluminum Association, for aluminum alloys. All exposed welds shall be ground flush with adjacent surfaces.

Railing panels shall be straight and true to dimensions. Adjacent railing panels shall align with each other with a variation not to exceed 1.5 mm (1/16 inch). Joints shall be matchmarked.

For structures on curves, either horizontal or vertical, the railing shall conform closely to the curvature of the structure by means of series of short chords. The lengths of the chords shall be the distance center to center of rail posts.

Steel railing units shall be galvanized after fabrication in accordance with 210-3.

Completed aluminum railing units shall be anodized after fabrication conforming to the Aluminum Association Standard for Anodized Architectural Aluminum, Class I Anodic Coating, AA-C22-A41.

**304-2.1.3 Installation.** The railing shall be erected in accordance with the Plans on anchor bolts, or in holes formed by inserts provided in the concrete railing base to receive the railing posts. Sheet metal inserts shall be removed before the erection of the railing.

No railing shall be erected on the structure until the sidewalk to which it is to be attached is completed and all falsework supporting the system is released.

The railing shall be carefully erected, true to line and grade. Posts and balusters shall be vertical with the deviation from the vertical for the full height of the panel not exceeding 3 mm (1/8 inch).

After erecting the railing, any abrasions or exposed steel shall be repaired in accordance with 210-3.5.

**304-2.1.4 Measurement and Payment.** The various types of railing will be measured and paid for by the linear meter (foot) from end to end along the face of the railing, including terminal sections.

### **304-2.2 Flexible Metal Guard Rail.**

**304-2.2.1 General.** This work shall consist of the construction of metal beam guard railing, at the locations and in accordance with the Plans and Specifications. Materials for metal beam guard rail shall conform to 206-5.2.

**304-2.2.2 Installation.** The posts shall be firmly placed in the ground. The space around posts shall be backfilled with selected earth, free of rock, placed in layers approximately 100 mm (4 inches) thick, and each layer shall be moistened and thoroughly compacted.

Posts shall be placed at equal intervals as shown on the Plans, except that the end posts may be spaced closer to adjacent posts if directed by the Engineer.

The bolted connection of the rail element to the post shall withstand a 22 kN (5,000-pound) pull at right angles to the line of the railing.

The metal work shall be fabricated in the shop, and no punching, cutting, or welding will be permitted in the field. Rail elements shall be lapped so that the exposed ends will not face approaching traffic. Terminal sections shall be installed in accordance with the manufacturer's recommendations.

Surplus excavated material remaining after the guard rail has been constructed shall be removed from the Work site.

**304-2.2.3 Measurement and Payment.** The railing will be measured and paid for by the linear foot from end to end along the face of the railing, including terminal sections.

### **304-3 CHAIN LINK FENCE.**

#### **304-3 CROSS REFERENCES**

Chain Link Fence..... 206-6

**304-3.1 General.** Materials for chain link fence shall conform to 206-6.

**304-3.2 Fence Construction.** Posts shall be spaced at not more than 3 m (10 foot) intervals, measured from center to center of posts and shall be vertical.

Corner posts shall be installed at changes in fence line where the horizontal angle of deflection is greater than 30 degrees. Slope posts shall be installed at changes in surface grade greater than 5 percent.

Footings for fence posts shall be concrete of the class specified in Table 201-1.1.2 (A). Footings shall be crowned at the top to shed water. Line post footings for fabric 1.5 m (5 feet) or less in height shall have a minimum depth of 750 mm (30 inches) and a minimum diameter of 200 mm (8 inches). Line post footings for fabric more than 1.5 m (5 feet) in height shall have a minimum depth of 900 mm (36 inches) and a minimum diameter of 200 mm (8 inches). All other footings, unless otherwise indicated on the Plans or in the Specifications, shall have a minimum depth of 900 mm (36 inches) and a minimum diameter of 300 mm (12 inches).

End and gate posts shall be braced to the nearest line post. Corner and slope posts shall be braced to the nearest line post on each side. The bracing shall consist of a horizontal brace 300 mm (12 inches) below the top of the fence fabric and a diagonal tension member. The tension member shall be a 9.5 mm (3/8 inch) steel rod with turnbuckle or other approved tightening device. When a top rail is specified, the horizontal brace shall be omitted at intermediate, slope, end, and corner posts.

Unless otherwise specified, all fences shall be installed with a top rail and a bottom tension wire. When the top rail is omitted, a top and bottom tension wire shall be used.

The fabric shall be placed on the outward facing side of the posts and shall be installed so that the top edge projects over the top rail of the fence and the bottom tension wire by 75 mm (3 inches). The fabric shall be stretched taut and securely fastened to the posts, the top rail, and the bottom tension wire. The tension wire shall be installed parallel to the line of the fabric. The bottom of the fabric shall extend to within 50 mm (2 inches) of the natural ground or paved surface. High points of ground shall be excavated to clear the bottom of the fabric and depressions shall be filled and compacted to within 25 mm (1 inch) of the bottom of fabric.

The fabric shall be fastened to end, corner, slope, and gate posts with 5 mm (3/16 inch) thick by 19 mm (3/4 inch) wide carbon steel tension bars and the tension bars shall be fastened with steel tension bar bands spaced at 400 mm (16 inches) intervals. Steel tension bar bands shall have a minimum thickness of 3 mm (1/8 inch) and a minimum width of 25 mm (1 inch). The fabric shall be fastened to line posts, top rails, and tension wires with tie wires or metal bands. Tie wires or metal bands shall be placed on line posts at intervals of approximately 400 mm (16 inches), and on top rail and tension wire at intervals of approximately 600 mm (24 inches).

**304-3.3 Installation of Gates.** The widths of any gates to be installed will be indicated on the Plans or in the Specifications.

Gates with fabric 2 m (7 feet) or more in height shall have a horizontal stiffener. Vertical stiffeners shall be installed at a maximum of 2.4 m (8 foot) centers. A 9.5 mm (3/8 inch) adjustable tension rod shall be installed on all gates over 1.2 m (4 feet) in width.

The corners of gate frames shall be fastened together and reinforced with a fitting designed for the purpose or by welding. All welds shall be ground smooth.

Chain link fence fabric shall be attached to the gate frame by the use of tension bars and tie wires as specified for fence construction, and suitable tension connectors spaced at approximately 400 mm (16 inch) intervals.

The swing gates shall be hung by at least two steel or malleable iron hinges, designed to securely clamp to the gate post and permit the gate to be swung back 180 degrees.

Gates shall be provided with a combination steel or malleable iron catch and locking attachment of approved design. Stops to hold gates open and a center rest with catch shall be provided where required.

**304-3.4 Measurement and Payment.** Chain link fence will be measured parallel to the ground slope along the line of the completed fence, deducting the widths of gates and openings.

Gates will be paid for at the Contract Unit Price for each size of gate required by the Plans, which price shall include full compensation for furnishing the gates together with all necessary fittings and hardware, and doing all the work involved in installing the gate complete in place. If double gates are required, each double gate will be paid for at the Contract Unit Price and such unit price shall include furnishing and installing both leaves.

Full compensation for clearing the line of the fence and disposing of the resulting material, excavating high points in the existing ground between posts, excavating and furnishing and placing concrete footings, connecting new fences to structures and existing fence as shown on Plans and any other related work shall be considered as included in the Contract Unit Price per linear meter (foot) of fence and no additional compensation will be made therefore.

**304-4 STRUCTURAL STEEL PLATE PIPE AND ARCH CONSTRUCTION.**

**304-4.1 General.** The materials for structural steel plate pipe and arches shall be as designated on the Plans or in the Specifications and as specified in 207-12.

Damage to galvanized surfaces during construction shall be repaired in accordance with 210-3.5. Damage to other coatings shall be repaired in accordance with the coating requirements for the original material. Asphalt mastic coating in accordance with 207-11.5.4 may be applied after field assembly of the structure.

**304-4.2 Structures and Footings.** Footings and arch bearings shall be constructed as shown on the Plans. Where shown on the Plans, inlet and outlet structures shall be constructed in connection with structural steel plate installations. When such structures are constructed, the ends of plates shall be placed flush or cut off flush with the structures face, unless otherwise directed by the Engineer.

**304-4.3 Plate Assembly.** Structural steel plates shall be assembled in accordance with the manufacturer's instructions. A copy of the manufacturer's instructions shall be furnished to the Engineer prior to assembling the plates. Each side of the arch shall rest on a galvanized steel angle or channel anchored to the footings. When plates of two dissimilar thicknesses are involved in one cross section of an installation, the thickness of structure steel plates will be identified in the Plans or Specifications.

Distorted circular plate pipes shall be placed with the major axis vertical. When distortion is accomplished by use of field devices, they shall not be removed until the supporting earthfill is completed, unless otherwise permitted by the Engineer. The devices shall be removed prior to construction of inlet or outlet structures and before acceptance of project.

The method for distorting plates in the field shall conform to details shown on the Plans. The vertical diameter throughout that portion of the pipe between outer shoulder lines of the roadway shall be increased to the approximate percentages listed in the following table:

Pipes using 7.11 mm or 6.32 mm (0.280 in or 0.249 in) top and side plates .....	1%.
Pipes using 5.54 mm or 4.78 mm (0.218 in or 0.188 in) top and side plates .....	2%.
Pipes using 4.27 mm, 3.31 mm, or 2.77 mm (0.168 in, 0.138 in, or 0.109 in) top and side plates .....	3%.

Between the outer shoulder lines of the roadway and the outer ends of the pipe, the distortion may be decreased uniformly to zero.

## SECTION 305 - PILE DRIVING AND TIMBER CONSTRUCTION

### 305-1 CROSS REFERENCES

Project Site Maintenance .....	7-8
Treatment with Preservatives .....	204-2
Timber Piles .....	205-1
Steel Piles .....	205-2
Concrete Piles .....	205-3

### 305-1 PILE DRIVING.

**305-1.1 General.** Piles shall be accurately located, and driven either vertically or to the prescribed batter as indicated on the Plans. No greater variation from the vertical or specified batter line than 20 mm/m (1/4 inch per foot) of length will be permitted. Piles driven with greater variation and those seriously damaged in driving shall be removed or cut off, and replaced with new piles. Should any pile be heaved by the subsequent driving of adjacent piles it shall be redriven.

The pile tip elevations shown on the Plans are approximate, and are to be used as a basis for establishing quantities for piling, including exploratory piles, for bidding purpose only.

When required in the Specifications, one pile of the type selected or designated for the Work shall be driven in each pier and abutment area as an exploratory pile. The location of these piles will be determined by the Engineer.

Exploratory piles shall be driven to determine the length and penetration that will be required for the balance of the piles. No piles other than exploratory piles shall be driven at each pier or abutment until such determination has been made by the Engineer, and has been reported to the Contractor.

The conditions under which the exploratory piles are to be driven shall be as ordered by the Engineer. These exploratory piles shall be furnished and driven by the Contractor, and under normal circumstances shall be left in place and utilized as one of the specified piles.

Exploratory piles shall be driven with the same size and type hammer operating with the same effective energy and efficiency as that to be used in driving the remainder of the piles.

The Engineer will specify the tip elevation to which the piling shall be driven for each pier or abutment. All piles shall be driven to the tip elevation established by the Engineer, or deeper if necessary, to develop the bearing value as determined by the formula prescribed in 305-1.5.

Excavations required in the areas through which the piles are to be driven shall be made before any pile is driven. No excavation may be made below the bottom of the pile footing elevation, unless approved by the Engineer.

When piles are to be driven through the bridge approach embankment and the depth of the embankment at the pile location is in excess of 1.5 m (5 feet), the pile shall be driven in a hole drilled through the embankment. The hole shall have a diameter of not less than the butt diameter of the pile plus 150 mm (6 inches). After driving the pile, the annular space around the pile shall be filled to ground surface with dry sand or pea gravel.

No piles shall be driven within 7.5 m (25 feet) of any concrete that has not attained a minimum compressive strength of 14 MPa (2,000 psi).

To eliminate hazard to life and to preclude dirt or debris from falling or being thrown into them, the tops of driven pile shells or drilled holes shall be securely covered immediately upon withdrawal of the mandrel or drilling equipment.

**305-1.2 Driving Equipment.** Pile hammers shall be approved types that develop sufficient energy to drive the pile at a penetration rate of not less than 3 mm (1/8 inch) per blow at the required bearing value, and shall develop energy per blow at each full stroke of the piston of not less than 3 Joules for each kilogram (1 foot-pound for each pound) of weight driven. Vibratory pile hammers may be used only when approved by the Engineer.

Drop hammers may be used on timber piles only. Drop hammers shall weigh not less than 1350 kg (3,000 pounds) and shall be equipped with proper leads and hoisting equipment to handle the work efficiently. The fall of the hammer shall not exceed 3 m (10 feet).

Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturers of the hammers being used. The boiler or compressor shall be equipped at all times with an accurate pressure gage. The valve mechanism and other parts of steam or air hammers shall be maintained in first-class condition so that the length of stroke and number of blows per minute for which the hammer is designed can be obtained at all times. Steam or air hammers not meeting the Specifications shall be removed from the Work.

When necessary to obtain the specified penetration and with the approval of the Engineer, the Contractor may be required to supply and operate one or more water jets and pumps; or to furnish the necessary drilling apparatus and drill holes and drive the piles therein as specified in 305-1.3.

The use of jets at locations where the stability of embankments or other improvements would be endangered will not be permitted. Jetting normally will not be permitted in cohesive soils. All jetting must be suspended and the pile driven for the last 1 m (3 feet) to specified bearing.

The cost of any jetting or drilling that may be required shall be included in the price bid for driving piles, or for other applicable items of work.

The use of followers, underwater hammers, or hammers not in leads will not be permitted unless authorized by the Engineer. When a follower or underwater hammer is authorized, the first pile in each bent shall be furnished sufficiently long for it to be driven without a follower or underwater hammer, and the bearing value and penetration shall be determined from this pile.

### **305-1.3 Drilled Holes.**

**305-1.3.1 Driven Piles.** When approved by the Engineer, piles may be driven in predrilled holes. The holes shall have a diameter not greater than the diameter of the pile at ground surface. The depth of the predrilled hole shall be adjusted by the Contractor (as directed by the Engineer) as the work proceeds in order to maintain adequate bearing. Piles shall be driven sufficiently to secure full bearing. Minimum penetration of the pile below the bottom of the predrilled hole shall be 1.5 m (5 feet) unless otherwise authorized by the Engineer.

**305-1.3.2 Drilled Holes for Cast-in-Place-Piles.** Holes for cast-in-place concrete piles shall be drilled dry to the tip elevations shown on the Plans or determined by the Engineer. All holes shall be inspected for straightness prior to placing concrete therein. When viewed from the top, more than one-half of the entire bottom area must be visible.

**305-1.3.3 Drilling Material.** All loose material existing at the bottom of the hole after drilling operations have been completed shall be removed before placing concrete in the hole.

Material resulting from drilling holes shall be disposed of as provided in 7-8.1.

**305-1.3.4 Water.** The use of water for drilling operations, or for any other purpose where it may enter the hole, will not be permitted. Surface water shall not be permitted to enter the hole and all water which may have infiltrated into the hole shall be removed before placing concrete therein.

**305-1.3.5 Casings.** Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is placed therein. Casing used in drilling operations shall be removed from the hole as concrete is placed therein. The bottom of the casing shall be maintained not more than 1.5 m (5 feet) nor less than 0.3 m (1 foot) below the top of the concrete during withdrawal and placing operations, unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided by hammering or otherwise vibrating the casing.

**305-1.3.6 Reinforcing Cage.** The reinforcing cage shall be placed and secured symmetrically about the axis of the pile and shall be securely blocked to clear the sides of the hole.

**305-1.3.7 Concrete.** Care shall be exercised to ensure that the concrete in the hole is dense and homogeneous. Vibration of the concrete during placing will not be required. After the hole has been filled with concrete, the top 3 m (10 feet) of the concrete, or the length of the reinforcing, whichever is the greater, shall be vibrated.

**305-1.4 Driving.** During driving operations, the pile heads shall be protected and held in position by the use of a steel driving block or anvil. Timber piles shall be shaped to closely fit the driving head. The heads of the piles may be protected by means of heavy steel or wrought iron rings. The heads of concrete piles or casings shall be protected from direct impact of the hammer by a cushion block which shall be maintained in good condition during the entire driving operation. This cushion block shall be arranged so that any reinforcing bars projecting above the piles will not be displaced or damaged in driving. For driving steel H-beam piles and shells without a mandrel for cast-in-place concrete piles, steel combination driving heads and pilots shall be used. The driving heads shall closely fit the top of the steel pile or shell and shall extend down the sides of the pile at least 100 mm (4 inches). Piles materially out of line, as determined by the Engineer, shall be pulled and replaced.

**305-1.5 Bearing Value.** Piles shall be driven to the penetration and bearing value shown on the Plans as a minimum. Timber piles shall not be driven to a bearing value exceeding 180 kN (20 tons). The bearing value shall be determined from the applicable formula in the following schedule:

**For piles driven with a drop hammer**

Metric Equation: 
$$P = \frac{WL}{6(s + 2.54)}$$

U.S. Standard Measures Equation: 
$$P = \frac{2WL}{s + 1}$$

**For piles driven with a single acting steam or air hammer**

Metric Equations: 
$$P = \frac{WL}{6(s + 2.54)}$$
 or 
$$P = \frac{E}{6(s + 2.54)}$$

U.S. Standard Measures Equations: 
$$P = \frac{2WL}{s + 0.1}$$
 or 
$$P = \frac{2E}{s + 0.1}$$

**For piles driven with a double acting steam or air hammer**

Metric Equations: 
$$P = \frac{L(W + ap)}{6(s + 2.54)}$$
 or 
$$P = \frac{E}{6(s + 2.54)}$$

U.S. Standard Measures Equations: 
$$P = \frac{2L(W + ap)}{s + 0.1}$$
 or 
$$P = \frac{2E}{s + 0.1}$$

Where:

P = Safe bearing load developed by the pile in **kN (pounds)**.

W = Weight of the hammer in **Newtons (pounds)**.

L = Length of stroke or height of fall of the hammer in **meters (feet)**.

s = Penetration of the pile into the ground per blow in **millimeters (inches)** taken as the average over the last 10 blows. Penetration shall be measured at a time when there is no appreciable rebound of the hammer and the preceding blow was struck upon a sound pile head or driving block.

A = Effective area of the piston in **m<sup>2</sup> (in<sup>2</sup>)**.

p = Mean effective steam pressure in the case of steam hammers or mean effective air pressure in the case of air hammers, in **Pascals (psi)**.

E = Manufacturer's rating of energy developed by the hammer in **Joules (foot-pounds)**.

**305-1.6 Cutoff and Extension.** Timber piles which are to be capped shall be accurately cut off so that true bearing is obtained on every pile without the use of shims. Other timber piles shall be cut off on the square at the elevation designated. Piles inaccurately cut off shall be replaced. Splicing of timber piles will not be permitted, except upon written permission of the Engineer.

Except for piles that are to be capped with concrete, the tops of treated piles, after cutoff, shall be treated as specified in 204-2.3.

Concrete piles shall be cut off at such elevations that they will extend into the cap or footing as indicated on the Plans. Concrete piles may be cast the full length of the reinforcing bars, provided that the concrete is cut off to expose the steel as shown on the Plans after the piles have been driven. When concrete piles are driven or cut off below the elevation of the bottom of the cap, the pile section shall be

extended to the elevation of the bottom of the cap by means of a reinforced concrete extension constructed in accordance with the details shown on the Plans. Concrete shall be removed from the end of the pile to expose sufficient reinforcing steel to permit a lap of at least 35 diameters.

Steel shells or concrete casings for cast-in-place concrete piles shall be cut off at the designated elevations. The work of cutting off precast concrete piles or concrete casings shall be performed in such a manner as to avoid spalling or damaging the pile below cutoff. In case of such damage, the pile shall be replaced or repaired as required by the Engineer.

All cut off lengths of piling shall become the property of the Contractor and shall be disposed of outside the project area.

**305-1.7 Load Testing.** If load tests are required, they shall be performed on the exploratory piles. The loading shall not be applied until 48 hours after the pile is driven or, in the case of cast-in-place piles, the concrete has attained a minimum compressive strength of 14 MPa (2,000 psi).

A loading test shall consist of the continuous application of a load of twice the design load to the pile being tested. The pile shall be considered to have a bearing value equal to the design load if the permanent settlement produced by such test loading is not greater than 6 mm (1/4 inch).

Unless otherwise permitted by the Engineer, the loading tests shall be completed before the remaining piles are cast or driven.

When a loading test is required, the Contractor shall provide suitable facilities and equipment by means of which a prescribed test load can be transmitted vertically to each pile to be tested. Provisions for varying the applied load shall also be made, and the loads must be in known and measurable increments, applied axially to the pile.

The marks, gages, dials, or other instruments of any loading equipment required to determine settlement of the pile, shall be arranged so as to provide convenient observation thereof without danger to the observer or the equipment. All test equipment shall be accurately calibrated and shall be approved by the Engineer.

The test loads shall be applied under the direction of the Engineer and at such rate or in such increments as he may specify. When a load test of a pile is commenced, the test shall be continuous, and the Contractor shall furnish all facilities on a 24-hour-day, 7-day-week basis until the test is completed. Forty-eight hours after all deflection and settlement has ceased, or sooner if directed by the Engineer, the test load shall be removed at such rate or in such increments as the Engineer may direct. If the results of the above-described operations indicate that excessive permanent settlement of the test pile has occurred, the pile shall be driven to such additional depths as the Engineer may specify, and the above-described test loading operations repeated. Each complete operation, which shall include loading and unloading as above-prescribed, shall be considered as an individual test.

### **305-1.8 Payment.**

**305-1.8.1 General.** Timber, steel, and concrete piles will be paid for at the Contract Unit Price per linear meter (foot) for furnishing piling and the Contract Unit Price per pile for driving piles. Load tests will be paid for at the Contract Unit Price per load test. Test piles that become a part of the completed structure will be paid for at the Contract Unit Prices for furnishing piling and for driving piles. No payment will be made for piles rejected prior to driving or for piles which are driven out of place or are damaged in handling or driving.

**305-1.8.2 Payment for Furnishing Piles.** The length of timber, steel, and concrete piles to be paid for shall be the total length in place of the completed work, measured from the tip of pile to the plane of pile cutoff, except when otherwise specified that the Engineer will determine the length of pile to be furnished.

The Contract Unit Price paid per linear meter (foot) for furnishing timber, concrete, or steel piling shall include full compensation for furnishing the piles at the site for driving, including steel shells and concrete casings and the filling materials for cast-in-place concrete piles, and constructing reinforced concrete extensions as shown on the Plans or in the Specifications.

Payment for furnishing piles shall also include full compensation for the attaching and fitting of steel shoes when they are specified for timber piles, and the furnishing and attachment of brackets, lugs, core stoppers, and cap plates necessary, including fins, brackets, plates, or other devices ordered by the Engineer to increase the bearing value of steel piles.

If the Contractor manufactures concrete piles to the full length of the reinforcement bars to facilitate driving, no payment will be made for that portion over Plan length where concrete must be removed in order that the bars may project as shown on the Plans.

**305-1.8.3 Payment for Driving Piles.** The Contract Unit Price paid per pile for driving piles shall include full compensation for doing all the work involved in driving timber, concrete, and steel piles; driving steel shells or concrete casings for cast-in-place concrete piles; drilling holes for concrete piles cast in drilled holes; placing concrete for cast-in-place concrete piles; and cutting off piles, all complete in place to the required bearing and penetration as shown on the Plans or in the Specifications.

Full compensation for all jetting, drilling, or other work necessary to obtain the specified penetration and bearing of the piles, for drilling holes through embankment and filling the space remaining around the pile with sand or pea gravel, for disposing of material resulting from drilling holes, for splicing steel piles, and for all excavation and backfill involved in construction of concrete extensions as shown on the Plans or in the Specifications, shall be considered as included in the Contract Unit Price paid for driving piles and no additional compensation will be allowed therefore.

## **305-2 TIMBER STRUCTURES AND TIMBER CONSTRUCTION.**

### **305-2 CROSS REFERENCES**

Lumber and Plywood .....	204-1
Treatment with Preservatives.....	204-2
Paint .....	210-1
Painting .....	310

**305-2.1 General.** Timber structures erected under these specifications shall conform to the dimensions and details of design shown on the Plans.

**305-2.2 Materials.** The materials to be used shall conform with the requirements or indicated on the Plans or in the Specifications.

Timber and lumber that is stored prior to its use shall be neatly piled on skids to raise it from the ground, and shall be protected from the sun when so required. The materials shall be stored or piled in such a manner to permit ready access for the purpose of inspection.

The use of cant hooks, peavies, or other pointed tools and hooks, will not be permitted in the handling of structural timber, lumber, or piles. Precautions shall be exercised in handling treated material to prevent damage to the surface thereof to the extent that untreated wood is exposed. Any piece so damaged will be rejected.

If treated timber or piling is cut after treatment, such cuts shall be treated in accordance with 204-2.3. This requirement shall also apply to any surface that has become abraded to the extent of exposing untreated wood. All borings and holes in such material shall be similarly treated, and holes which are not to be used for rods, bolts, pins, screws, spikes, and the like, or which will not subsequently be otherwise closed, shall be tightly filled with treated plugs.

Timber for floors and decks, and that which is to be used in the construction of split ring or shear plate connected trusses, shall be well seasoned and thoroughly air dried before being placed or incorporated in the work. This requirement shall apply to treated material as well as to that which is untreated.

**305-2.3 Workmanship.** Workmanship shall be first class throughout. Framing shall be true and exact and none but thoroughly competent workers shall be employed or engaged in connection with the erection of any structure under these specifications. All lumber and timber shall be cut and framed to a close fit and shall have even bearing over the entire contact surfaces. No shimming will be permitted in making joints. All members shall be true to size for the full depth thereof.

Holes for drift pins in untreated lumber shall be bored with a bit 1.5 mm (1/16 inch) less in diameter than the pin or dowel. Holes for drift pins and dowels in treated lumber shall be bored with a bit of the same diameter as the pin or dowel. Holes for truss rods or bolts shall be bored with a bit 1.5 mm (1/16 inch) larger than the rod or bolt. Holes for lag screws shall be bored with a bit not larger than the base of the thread. In small timbers where the prevention of splitting is necessary, holes shall be bored for spikes with a bit having a diameter not larger than that of the spike.

In the installation of metal timber connectors, care shall be exercised to ensure that the connector is installed concentric with its corresponding bolt; and if more than one connector bolt is installed in any individual joint, all bolts in such joint shall be drawn up to an even and uniform tension. The grooves for split-ring and shear-plate connectors shall be carefully cut to a uniform width and depth for the full perimeter therefore. The dimensions of these grooves, and the manner and means of cutting, shall be as recommended by the manufacturer of the particular connector to be installed, and any special tool or equipment used in cutting the grooves shall be operated in the manner and at the speed similarly recommended. Toothed-ring and spiked-grid connectors shall be installed by means of pressure equipment of a type intended for the purpose. However, split-ring connectors shall not be forced on, but shall be expanded to such an extent as to readily slip over the core formed by the groove without damaging the wood.

Unless otherwise indicated on the Plans, all bolts shall be 19 mm (3/4 inch) in diameter or larger and shall be of sufficient length to project beyond the nut when the nut is drawn tight. Bolts shall be fitted at each end with either a malleable iron (ogee) washer or a steel plate at least 75 mm x 75 mm (3 inch square) and not less than 9.5 mm (3/8 inch) thick, or as otherwise shown on the Plans.

**305-2.4 Framing.** Mudsills shall be firmly and evenly bedded on solid material. Sills and caps shall have a full, even bearing on the pedestals, posts, or piles and shall be secured in place as indicated on the Plans.

Bents shall be accurately aligned before the bracing is placed. Bracing shall be fastened at the ends and at each intersection by bolts. Bracing shall be of such length as will provide a minimum distance of 200 mm (8 inches) between the outside bolt and the end of the brace. Treated posts or piles shall not be cut to accommodate the bracing. Treated filler blocks shall be used if necessary to fill any space that may occur between the bracing and the member of the bent.

In placing joists, the best edge shall be placed down. The elevation of the tops of adjacent joists shall not vary more than 3 mm (1/8 inch). Outside joists shall have butt joints, Interior joists shall be lapped and shall extend the full width of the cap to obtain full bearing. Bridging between joists shall be solid

and fastened to the joists near the top of the block and on each side of the bottom of the block. Bridging shall be accurately cut to fit closely between the joists.

Trusses, when completed, shall show no irregularity of line. Chords shall be straight and true from end to end in horizontal projection, and in vertical projection shall show a smooth curve through panel points conforming to the correct camber. Uneven and rough cuts at the points of bearing will be cause for rejection of the piece containing the defect.

Laminated bridge floors shall be constructed as shown on the Plans. The planks shall be laid with the best edge down.

Spiking of deck planking in roadway areas of bridges and similar structures shall be accomplished by the means of an air hammer equipped with a suitable driving head so designed and constructed as to ensure that the spikes are driven to sufficient depth to draw the planking tightly to the joints without damaging or abrading the surface of the plank.

**305-2.5 Painting.** The railing of timber bridges, including the posts, the entire outer edge of bridge decks, except treated surfaces, and any other surfaces indicated on the Plans to be painted, shall be painted as prescribed in 210-1.5 and Section 310.

The surface of wooden guard rails above the ground shall be painted as prescribed in 210-1.5 and Section 310.

The lumber shall be cut to fit and the entire surface shall be given the specified prime coat. The remaining coats shall be applied after the structure has been erected.

**305-2.6 Measurement and Payment.** Timber structures will be paid for as provided in the Bid. Where cubic meter (board measure) is used as the basis of payment, the quantity to be paid for will be determined from actual (nominal) widths and thicknesses and the actual lengths of the pieces in the finished structure, except that in the case of laminated timber flooring, the number of laminations to be paid for shall be the required number of the size specified after dressing and the length of each lamination shall be considered as the full width or length of the floor.

The price paid per thousand cubic meter (board measure), per linear meter (foot) of structure, or the lump sum, shall include full compensation for furnishing all nails, hardware, paint, and wood preservative.

## SECTION 306 - UNDERGROUND CONDUIT CONSTRUCTION

### 306 CROSS REFERENCES

Pipe, Section .....	207
Removal and Disposal of Materials .....	300-1.3
Roadway Surfacing .....	302
Concrete Curbs, Walks, Gutters, Cross Gutters, Alley, Intersections, Access Ramps, and Driveways .....	300-5

### 306-1 OPEN TRENCH OPERATIONS.

#### 306-1.1 Trench Excavation.

**306-1.1.1 General.** For the purpose of shoring or bracing, a trench is defined as an excavation in which the depth is greater than the width of the bottom of the excavation.

Excavations for appurtenant structures, such as but not limited to manholes, transition structures, junction structures, vaults, valve boxes, catch basins, thrust blocks, and boring pits shall, for the purpose of shoring and bracing, be deemed to be in the category of trench excavation.

Excavation shall include the removal of all water and materials of any nature which interfere with the construction work. Removal of groundwater to a level below the structure subgrade will be necessary only when required by the Plans or Specifications.

Excavation for conduits shall be by open trench unless otherwise specified or shown on the Plans. However, should the Contractor elect to tunnel or jack any portion not so specified, he shall first obtain approval from the Engineer. Payment for such work will be made as though the specified methods of construction had been used.

**306-1.1.2 Maximum Length of Open Trench.** Except by permission of the Engineer, the maximum length of open trench where prefabricated pipe is used shall be 150 m (500 feet) or the distance necessary to accommodate the amount of pipe installed in a single day, whichever is the greater. The distance is the collective length at any location, including open excavation, pipe laying and appurtenant construction and backfill which has not been temporarily resurfaced.

Except by permission of the Engineer, the maximum length of open trench in any one location where concrete structures are cast in place will be that which is necessary to permit uninterrupted progress. Construction shall be pursued as follows: excavation, setting of reinforcing steel, placing of floor slab, walls, and cover slab or arch. Each shall follow the other without any one operation preceding the next nearest operation by more than 60 m (200 feet).

Failure by the Contractor to comply with the limitations specified herein may result in an order to halt the work until such time as compliance has been achieved.

**306-1.1.3 Maximum and Minimum Width of Trench.** For pipe (except corrugated steel pipe), the minimum and maximum width of trench permitted shall be as indicated on the Plans or Standard Plans.

For corrugated steel pipe, the trench shall be at least 400 mm (16 inches) wider than the diameter of the pipe to be installed.

If the maximum trench width is exceeded, the Contractor shall provide additional bedding, another type of bedding, or a higher strength of pipe, as shown on Plans or approved by the Engineer, at no additional cost to the Agency.

Additional payments or deductions from the Contract Unit Price per trench excavation for conduits will be based upon a calculated volume. The width used in calculating the volume of excavation for prefabricated conduit will be the maximum width of trench shown on the Plan and measured at the top of the pipe. In case of sewers or storm drains formed and cast in place, such volume will be based upon the outside width of the structure being constructed plus 0.9 m (3 feet).

Additional payment or deductions from Contract Price for trench resurfacing will be based upon an area determined by the maximum width of trench as specified herein.

**306-1.1.4 Access to Trenches.** Safe and suitable ladders which project 0.6 m (2 feet) above the top of the trench shall be provided for all trenches over 1.2 m (4 feet) in depth. One ladder shall be provided for each 15 m (50 feet) of open trench, or fraction thereof, and be so located that workers in the trench need not move more than 7.5 m (25 feet) to a ladder.

**306-1.1.5 Removal and Replacement of Surface Improvements.** Bituminous pavement, concrete pavement, curbs, sidewalks, or driveways removed in connection with construction shall be removed in accordance with 300-1.3 and reconstructed in accordance with 302 or 303-5.

**306-1.1.6 Bracing Excavations.** The manner of bracing excavations shall be as set forth in the rules, orders, and regulations of the Division of Industrial Safety of the State of California.

Prior to commencing the excavation of a trench 1.5 m (5 feet) in depth or greater and into which a person will be required to descend, the Contractor shall first obtain a permit to do so from the Division of Industrial Safety pursuant to 7-10.4.1.

Should the bracing system utilize steel H-beams or piles or other similar vertical supports, driving of said vertical supports will not be permitted except for the last 1.2 m (4 feet). The vertical supports shall be placed in holes drilled to a depth of 1.2 m (4 feet) above the proposed bottom of pile, except where this procedure is impracticable. The vertical support may then be driven to the required depth, not to exceed 1.2 m (4 feet). During the drilling and driving operations, the Contractor shall take care to avoid damage to utilities.

At locations where the drilling of such holes is impracticable because of the existence of rocks, running sand, or other similar conditions, and provided said impracticability is demonstrated to the satisfaction of the Engineer by actual drilling operations by the Contractor, the Engineer may, upon request of the Contractor, approve the use of means other than drilling for the purpose of placing the vertical support. Such other means, however, must be of a nature which will accomplish, as nearly as possible, the purpose of the drilling, namely, the prevention of damage to existing surface or subsurface improvements, both public and private. All costs for this work shall be included in the prices bid for the items involved.

If sheeting is used to support the excavated trench, the sheeting shall be removed by the Contractor, and no such sheeting will be permitted to remain in the trench. When field conditions, the type of sheeting, or methods of construction used by the Contractor are such as to make the removal of sheeting impracticable, the Engineer may permit portions of the sheeting to be cut off to a specified depth and remain in the trench.

### **306-1.2 Installation of Pipe.**

#### **306-1.2 CROSS REFERENCES**

Cement Mortar.....	201-5
Pipe .....	207
Pipe Joint Types and Materials.....	208

#### **306-1.2.1 Bedding.**

(A) **General.** Bedding material and placement shall be as specified herein except as modified in 306-1.2.1(B). Bedding zone shall be defined as area containing the material specified that is supporting, surrounding, and extending to 0.3 m (1 ft) above the top of pipe. Where it becomes necessary to remove boulders or other interfering objects at subgrade for bedding, any void below such subgrade shall be filled with the bedding material designated on the Plans. Where concrete is specified to cover the pipe, the top of the concrete shall be considered as the top of the bedding.

If soft, spongy, unstable, or other unsuitable material is encountered upon which the bedding material or pipe is to be placed, this material shall be removed to a depth ordered by the Engineer and replaced with bedding material suitably densified. Additional bedding so ordered, over the amount required by the Plans or Specifications, will be paid for as provided in the Bid. If the necessity for such additional bedding material has been caused by an act or failure to act on the part of the Contractor or is

required for the control of groundwater, the Contractor shall bear the expense of the additional excavation and bedding.

Bedding material shall first be placed on a firm and unyielding subgrade so that the pipe is supported for the full length of the barrel. There shall be 100 mm (4 in) minimum of bedding below the pipe barrel and 25 mm (1 in) minimum clearance below a projecting bell for sewer, storm drain and water pipe. There shall be a minimum side clearance of 150 mm (6 in) on each side of the pipe barrel. For pipes and cables not requiring bedding by their Owners, the trench width shall be appropriate to obtain the required compaction around the installation by mechanical equipment, except where cement slurry or CLSM is used. The material in the bedding zone shall be placed, and densified either by jetting or by mechanical compaction. When jetting is used, the lifts shall not exceed 1.2 m (4 ft). Mechanical compaction shall be per 306-1.3.2.

When densifying the bedding material by jetting, the trench wall shall have a minimum sand equivalent of 15. The jet pipe shall meet the requirements of 306-1.3.3 and be of sufficient length to reach within 0.6 m (2 ft) of the bottom of the pipe. Jetting shall provide enough water to thoroughly saturate and densify, without voids, the bedding material around the pipe. The jet pipe shall be inserted at intervals of 1 m (3 ft) maximum, contiguous along each side of the pipe. Neither flooding, nor free standing water will be permitted. Unless the sheeting or shoring is to be cut off and left in place, densification of bedding for pipe shall be accomplished after the sheeting or shoring has been removed from the bedding zone, and prior to the placement of backfill.

Except where otherwise specified, bedding material shall be sand, gravel, crushed aggregate, or native free-draining granular material having a sand equivalent of not less than 30 or having a coefficient of permeability greater than 35 mm per hour (1.4 inches/hour), or other material approved by the Engineer.

Concrete used for bedding shall be as specified in 201-1. Concrete shall be cured for the indicated time period prior to backfilling.

In cases where native free-draining granular material is suitable for the use as bedding, the trench may be excavated to a point above the invert grade and the trench bottom hand shaped so that the bottom segment of the pipe is firmly supported on undisturbed material.

Unless otherwise specified, special pipe bedding will not be required for steel or iron water pipe, and the trench bottom need not be shaped to the outside diameter of the pipe. However, the trench bottom shall provide firm and uniform bearing.

**(B) Bedding for Narrow Trenches.** Narrow trenches are defined as 250 mm (10 in) or less in width. Bedding for narrow trenches shall be placed as specified in 306-1.2.1 (A) except as modified herein.

Bedding for narrow trenches meeting the requirements of this subsection shall be specified by the owner of the installation. When bedding is specified by the owner, it shall be placed on firm and unyielding subgrade so as to support the pipe or cable for its full length. Bedding shall not be jetted unless specified by the owner of the installation.

When the Contractor is permitted to place the pipe or cable without bedding, it shall be placed on firm and unyielding subgrade.

These excavations shall be backfilled as specified per 306-1.3.4. The Contractor shall take all necessary precautions to prevent the pipe or substructure from floating when placing trench backfill slurry or CLSM.

**306-1.2.2 Pipe Laying.** Pipe will be inspected in the field before and after laying. If any cause for rejection is discovered in a pipe after it has been laid, it shall be subject to rejection. Any corrective work shall be approved by the Engineer and shall be at no cost to the Agency.

When connections are to be made to any existing pipe, conduit, or other appurtenances, the actual elevation or position of which cannot be determined without excavation, the Contractor shall excavate for, and expose, the existing improvement before laying any pipe or conduit. The Engineer shall be given the opportunity to inspect the existing pipe or conduit before connection is made. Any adjustments in line or grade which may be necessary to accomplish the intent of the Plans will be made, and the Contractor will be paid for any additional work resulting from such change in line or grade in the manner provided in 3-2.

Pipe shall be laid up-grade with the socket or collar ends of the pipe up-grade unless otherwise authorized by the Engineer.

Corrugated metal pipe shall be laid with external laps of the circumferential seams toward the inlet end. Corrugated pipe shall be shipped and handled in such a manner as to prevent damage to protective coatings.

When specified, circular corrugated steel pipe shall be elongated in the shop or in the field before backfilling. The pipe shall be vertically elongated from a true circle to provide an increase in the diameter of approximately 5 percent for the full length.

Installation of slotted corrugated steel pipe shall not be started until after paving of the traffic lanes adjacent to the pipe has been completed at the locations where the pipe is to be placed. The slot shall be covered with roofing paper or other approved covering during backfilling operations to prevent infiltration of material into the pipe.

Pipe shall be laid to Plan line and grade, with uniform bearing under the full length of the barrel of the pipe. Suitable excavation shall be made to receive the socket or collar, which shall not bear upon the subgrade or bedding. Any pipe which is not in true alignment or shows any undue settlement after laying shall be taken up and re-laid at the Contractor's expense.

Pipe sections shall be laid and jointed in such a manner that the offset of the inside of the pipe at any joint will be held to a minimum at the invert. The maximum offset at the invert of pipe shall be 1 percent of the inside diameter of the pipe or 10 mm (3/8 inch), whichever is smaller.

In joining socket-and-spigot pipe, the spigot of each pipe shall be so seated in the socket of the adjacent pipe as to give a minimum of 10 mm (3/8 inch) annular space all around the pipe in the socket. Unavailable offsets shall be distributed around the circumference of the pipe in such a manner that the minimum offset occurs at the invert.

When pipe is laid in a sheeted trench, all sheeting against which concrete cradle is to be placed shall be faced with at least one thickness of building paper and the sheeting shall be withdrawn without displacing or damaging the cradle, except as otherwise provided in 306-1.1.6.

After the joints have been made, the pipe shall not be disturbed in any manner.

At the close of work each day, or whenever the work ceases for any reason, the end of the pipe shall be securely closed unless otherwise permitted by the Engineer.

**306-1.2.3 Field Jointing of Clay Pipe.** Unless otherwise indicated on the Plans, any of the following joints may be used for sewers constructed of clay pipe:

a) **Type "D" Joints (Rubber-Sleeve Coupling with Shear Ring for Plain-End Clay Pipe).**

Pipe joints shall be made with the couplings described in 208-2.2. Unless otherwise specified, pipe shall be delivered to the jobsite with the rubber sleeve and shear ring installed on one end of the pipe or fitting. Before installing compression bands, the surface of the rubber sleeve shall be thoroughly wetted with a silicone base lubricant. This lubricant shall not be injurious to the sleeve, stainless steel bands, or plastic shear ring. Joints installed on to pipe in the plant shall

have compression bands torqued to 8N•m (70 inch-pounds), minimum. When the joint is installed in the field, the plain end of the pipe to be joined shall be inserted into the sleeve and the compression bands torqued to 8N•m (70 inch-pounds), minimum, and shall provide uniform tension. Type "D" Joints may be used on pipe on curves in accordance with Item c) below.

b) **Type "G" Joints (Polyurethane Compression).** Type "G" joints shall be made with pipe prepared as specified in 208-2.3.

Prior to jointing, the matting surfaces shall be clean, and lubricated with a lubricant recommended by the pipe supplier. The pipe shall be joined spigot into socket and when jointing is completed shall be within the following joint space tolerance:

TABLE 306-1.2.3 (A)

Pipe Size		Joint Space	
mm	(in)	mm	(in)
375 - 450	(15 - 18)	16	(5/8)
525 - 1050	(21 - 42)	22	(7/8)

This joint space shall not be increased because of deflected joints on curve. Straight pipe with Type "G" joints is permitted for pipelines on curves in accordance with Item c) below.

c) **Straight Nonbeveled Pipe On Curves.** Straight nonbeveled pipe with Type "D" or "G" joints is permitted for pipelines on curves, provided the radius of curvature is not less than that shown in the following table. For radius of curvature less than that shown, beveled pipe or shorter lengths shall be provided.

TABLE 306-1.2.3 (B)

D Pipe Size		For Pipe Length		Min. Radius of Curvature		Max. Deflection Per Joint (Degrees)	Max. Deflection Per Length	
mm	in	m	ft	m	ft		mm	in
150	6	1.5	5	37	120	2.4	63	2-1/2
to	to	1.7	5-1/2	40	132	2.4	70	2-3/4
300	12	1.8	6	44	144	2.4	76	3
375	15	1.5	5	49	160	1.8	47	1-7/8
to	to	1.7	5-1/2	54	176	1.8	52	2-1/16
600	24	1.8	6	59	192	1.8	57	2-1/4
		2.3	7-1/2	73	240	1.8	71	2-13/16
675	27	1.5	5	73	240	1.2	31	1-1/4
to	to	1.7	5-1/2	80	264	1.2	34	1-3/8
900	36	1.8	6	88	288	1.2	38	1-1/2
		2.3	7-1/2	110	360	1.2	47	1-7/8
975	39	1.5	5	97	320	0.9	23	1-5/16
to	to	1.7	5-1/2	107	352	0.9	27	1-1/16
1050	42	1.8	6	117	384	0.9	28	1-1/8

NOTE: All deflections are based on ASTM C 425.

For pipe lengths not included above, use the following:

TABLE 306-1.2.3 (C)

D Pipe Size		Maximum Allowable Deflection $\Delta d$		Equation for Minimum Radius of Curvature (L = Pipe Length)
mm	in	mm/m of Pipe	in/ft of Pipe	
150 to 300	6 to 12	42	1/2	$r = 24L$
375 to 600	15 to 24	31	3/8	$r = 32L$
675 to 900	27 to 36	21	1/4	$r = 48L$
975 to 1050	39 to 42	16	3/16	$r = 64L$

### 306-1.2.4 Installation, Field Jointing, and Inspection of Reinforced Concrete Pipe.

(a) **General.** Circular concrete pipe with elliptical reinforcement shall be laid with the minor axis of the reinforcement cage in the vertical position. The minor axis shall be marked by the manufacturer with a 100 mm (4 in) high "T". Normally lay pipe with socket end up hill starting at the bottom of the line. Plastic lined reinforced concrete pipe shall be jointed and otherwise treated in accordance with this subsection and the applicable requirements of 311-1.

(b) **Tongue-and-Groove (T&G) Self-Centering Joints.** All joints shall be cleaned with a wire brush and wetted before mortaring. All mortar shall conform to the applicable provisions of 201-5.1 for Class C mortar.

No mortaring of outside joints will be required except where concrete pipe is used on curves, unless otherwise specified.

Pipes used on curves shall have one or both ends beveled, or shall be pulled to provide a smooth curve. Pipes used on curves shall have one or both ends beveled, or shall be pulled to provide a smooth curve. If the extreme ends of the pipe do not overlap and the resulting clear space between the extreme ends does not exceed 25 mm (1 inch) the space shall be filled with Class C mortar for the full thickness of the pipe wall. If the clear space between the extreme ends of the pipes is more than 25 mm (1 inch) but less than 75 mm (3 inches), a concrete cover is required for the joint using Class 310-C-17 (520-C-2500) concrete to a minimum depth of 150 mm (6 inches) for a width of 380 mm (15 inches) centered about the joint. Such concrete cover shall be placed from the bottom of the pipe to a point where the extreme ends of the pipe overlap. Sandbags or dirt sacks will be acceptable side forms. The inside of the joint shall be mortared as above. If the clear space between the extreme ends of the pipe is 75 mm (3 inches) or greater but less than 150 mm (6 inches) a concrete collar is required. If the clear space is 150 mm (6 inches) or greater, a transition structure is required.

When pipe is under 600 mm (24 inches) in diameter, the joints shall be made by filling the outer joint space with mortar.

When the pipe is 600 mm (24 inches) or greater in diameter, the entire interior annular space of the joint shall be filled to its full depth to ensure a strong, level, and tight joint. The mortar shall be forced tightly into the joint, completing the joint with a level, smooth, troweled finish. The joint area shall then be wiped clean of excess mortar. The jointing procedure shall be as follows:

- 1) When the entire trench is to be jetted or flooded, no joints shall be mortared before the next two joints in advance are laid. However, the mortaring of joints shall be completed as specified herein before jetting is started.

- 2) When the entire trench is to be compacted mechanically, no interior joints shall be mortared until the compaction has been completed. The joint shall then be completed as specified herein.
- 3) Where the lower portion of the trench is to be jetted and the remainder mechanically compacted, the joints shall be mortared in two operations. Before jetting is started, the inside joints shall be filled to within approximately 25 mm (1 inch) of the inside surface, the mortar being pressed into place to make a firm and tight joint.

After jetting and compaction have both been completed, the inside joints shall be cleaned and completed as specified herein.

- 4) For gravity sewer pipe, the top half of the outside joint shall be filled with mortar by means of troweling or wiping prior to placement of backfill, and the inside joints shall be completed as specified herein.

In all cases, the entire depth of the finished inside joint shall be filled with mortar in such a manner as to ensure a strong, watertight joint.

(c) **Collar Joints.** Pipe with collar joints shall be laid with the collar end up-grade. The pipes shall be tightly butted together and uniform caulking space left between the pipe and the collar. When the entering pipe has been placed and checked for line and grade, the body of the pipe shall be backfilled with earth on both sides to hold the pipe firmly in place. The caulking space shall then be completely filled with stiff mortar tamped firmly in small increments by means of a caulking tool and hammer.

(d) **Gasket-Type Joints for Reinforced Concrete Pipe.** The ends of the pipe shall be so formed that, when the pipes are laid together and joined, they shall make a continuous and uniform line of pipe with a smooth and regular surface.

Joints shall be watertight and flexible. Each joint shall contain a gasket per 208-3 or other material approved by the Engineer, which shall be the sole element responsible for water tightness of the joint. This gasket shall be a circular or profile-type cross section unless otherwise approved by the Engineer. The length and cross-sectional dimension of the gasket, the annular space provided for the gasket, and all other joint details shall be such as to produce a watertight joint. The slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed 2 degrees.

Under ordinary laying conditions, the work shall be scheduled so that the socket end of the pipe faces in the direction of laying.

For O-ring type gaskets, prior to placing the spigot into the socket of the pipe previously laid, the spigot groove, the gasket, and the first 50 mm (2 in) of the inside surface of the socket shall be thoroughly cleaned, then lubricated with a soft vegetable soap compound.

The gasket after lubrication shall be uniformly stretched when placing it in the spigot groove so that the gasket is distributed evenly around the circumference.

For pipe in which the inside joints are to be pointed, suitable spacers shall be placed against the inside shoulder of the socket to provide the proper space between abutting ends of the pipe.

For profile type gaskets, follow the requirements of the manufacturer for lubrication and assembly to provide a watertight joint.

Where steel joint rings are used, a suitable cloth, plastic, or paper band shall be placed around the outside of the pipe and centered over the joint to prevent dirt from entering the joint recess.

The joint band shall be bound to the pipe by the use of steel box strapping or by an equivalent method, and shall completely and snugly encase the outside joint except for an opening near the top where grout is to be poured into the joint recess. Grout shall be poured and allowed to set before densification of bedding and backfill materials by jetting or flooding methods. In any case, joints shall be grouted before backfill is placed over the top of the pipe. With the jointing band properly secured, the joint recess shall be moistened with water and then filled with Class "C" mortar. The mortar grout shall completely fill the outside annular space between the ends of the pipe and around the complete circumference. After the recess has been filled, the jointing band shall be replaced over the opening left for pouring and the mortar allowed to set. After the bedding and backfill have been densified, the inside joint recess shall first be moistened, then filled with stiff Class "C" mortar. The finished joint shall be smooth and flush with the adjacent pipe surfaces.

After the joint is assembled, a thin metal feeler gage shall be inserted between the socket and the spigot and the position of the gasket checked around the complete circumference of the pipe. If the gasket is not in the proper position, the pipe shall be withdrawn, the gasket checked to see that it is not cut or damaged, the pipe relayed, and the gasket position again checked.

(e) **Field Inspection of Reinforced Concrete Pipe.** Installed pipe shall be inspected after completion of the backfill operation for:

1. Joint offset tolerances per 306-1.2.2.
2. Joints installed per this subsection.
3. Compliance with 207-2.8 or 207-3.2 for the respective pipe material except as modified below.

Unless otherwise specified, installed and backfilled pipe shall not exhibit cracks with widths in excess of those shown in Table 207-2.9.2 (A).

#### **306-1.2.5 Field Jointing of Nonreinforced Concrete Pipe.**

(a) **Tongue-and-Groove Joints.** The groove end of pipe shall be buttered with a stiff mixture of Class "C" mortar prior to joining pipe. The pipe joint shall then be carefully wiped on the inside.

(b) **Socket-and-Spigot Mortar Joints.** In making the joints, the entire annular space shall be completely and compactly filled with Class "C" mortar.

Mortar placed in the joint to assist in the assembling and centering of the pipe shall not be considered as filling that portion of the joint in which it is placed. The mortar shall be beveled on a 1-to-1 slope from the outer edge of the socket, and the interior of the pipe cleaned of surplus mortar or other foreign material.

When approved by the Engineer, a narrow gasket of oakum or lead may be caulked into each joint in wet trenches, after which the mortar shall be placed therein.

Interior joints in pipe shall be neatly wiped on the inside.

(c) **Socket-and-Spigot Gasket Joints.** The outside of the spigot and the inside of the socket of the pipe shall be thoroughly cleaned prior to laying. The gasket and the socket interior shall be lubricated with a soft vegetable soap compound before the pipes are joined.

#### **306-1.2.6 Field Jointing of Iron Pipe.**

(a) **General.** The type of joint to be used will be indicated on the Plans or in the Specifications. If not designated, the type of joint may be any of those listed below:

(b) **Cement Joints.** A gasket of untarred jute or oakum twisted into a rope of about the same diameter as the joint space and thoroughly saturated with neat cement grout shall be well driven against the base of the socket. After placing this gasket, caulking cement shall be pushed into the socket with a steel caulking tool until the interior of the socket is completely filled and then it shall be thoroughly tamped with a caulking tool.

The joint shall then be beveled off from the outer edge of the socket to the sides of the pipe, special care being taken to obtain good work on the lower part of the joint.

The joints shall be protected from the sun immediately after they are caulked.

(c) **Lead Joints.** A gasket of twisted or braided jute or oakum shall be driven tightly into the socket so that the lead, after having been poured and caulked, shall have a depth of at least 50 mm (2 inches) in the socket. The socket shall be free from dirt, grease, and water, and the runner shall be firmly held in place before the lead is poured. The melting pot shall be kept near the joint to be poured and each joint shall be made at one pouring. Dross and slag shall not be allowed to accumulate in the melting pot ladles. After the joints have cooled sufficiently, they shall be properly caulked by hand or mechanical methods so as to secure a tight joint.

(d) **Flanged Joints.** Flanged joints shall be firmly and fully bolted with machine bolts of proper size. Approved gaskets shall be used at all flanged joints.

(e) **Mechanical Joints.** The outside of the spigot and the inside of the socket shall be thoroughly cleaned of foreign matter. The gland and gasket shall then be slipped on to the spigot end of the pipe. The gasket shall be pressed evenly into the socket only after the spigot is seated in the socket.

The gland shall be brought up evenly by tightening alternately the nuts spaced 180 degrees apart.

(f) **Slip-On Joint.** The gasket and gasket seal inside the socket shall be wiped clean before the gasket is inserted. A thin film of soft vegetable soap compound shall be applied to the gasket and the outside of the spigot end of the pipe. The spigot shall then be positioned inside the socket and shoved home. Lubricant other than that furnished with the pipe shall not be used unless approved by the Engineer.

**306-1.2.7 Field Jointing of Corrugated Metal Pipe.** Where metal pipe and/or couplings and metal pipe and/or couplings with metallic coatings are joined with dissimilar metals, the contact points shall be coated with asphalt mastic per 207-11.5.2. Pipe sections shall be laid in the trench with a maximum spacing between sections of 38 mm (1-1/2 inches). Annular corrugated pipe shall be laid in the trench with outside laps or circumferential joints upgrade. The pipe coupling corrugations or projections shall properly engage the pipe sections before bolts are tightened. Care shall be taken to ensure that dirt or other particles do not get between the outside of pipe and the pipe coupling.

Aluminum pipe and aluminized steel pipe shall not be in contact with reinforcing steel or structural steel members. Aluminum pipe and aluminized steel pipe shall be coated with asphalt mastic coating per 207-11.5.2 where concrete or slurry backfill is required or where the pipe is to be embedded in concrete.

Paved inverts shall be placed and centered on the bottom of the trench. Any damage to the protective lining and coating shall be repaired prior to the backfilling around the pipe.

Watertight joints, when required by the Plans or Specifications, shall conform to 207-11.2.2.

**306-1.2.8 (Deleted.)**

**306-1.2.9 Field Jointing of Solvent-Welded ABS and PVC Pipe.** Solvent-welded jointing of ABS and PVC pipe shall be in accordance with the approved manufacturer's printed instructions which shall be furnished to the Engineer. Solvent cement shall be in accordance with 207-15.1 for ABS pipe and 207-17.3.3 for PVC pipe.

The spigot end shall be inserted to the proper depth of the socket as indicated by the home mark.

**306-1.2.10 Field Jointing of Gasket-Type ABS and PVC Pipe.** Jointing of pipe shall be in accordance with the approved manufacturer's printed instructions which shall be furnished to the Engineer. Gaskets shall be in accordance with 208-3.

The spigot end shall be inserted to the proper depth of the socket as indicated by the home mark.

**306-1.2.11 Field Jointing of Injection-Sealed PVC Pipe.** Injection-seal jointing of PVC pipe shall be in accordance with the approved manufacturer's printed instructions which shall be furnished to the Engineer.

The spigot end shall be inserted to the full depth of the socket as indicated by the home mark and driven into the locking taper as recommended by the manufacturer.

The ports in the socket end shall be positioned to allow observance of flow of the adhesive from the exhaust port. The adhesive compound shall be injected until air is no longer observed to bubble from the exhaust port. Escape of adhesive compound beyond the retainer ring will be cause for rejection of the joint.

**306-1.2.12 Field Inspection for Plastic Pipe and Fittings.** Installed pipe shall be tested to ensure that vertical deflections for plastic pipe do not exceed the maximum allowable deflection. Maximum allowable deflections shall be governed by the mandrel requirements stated herein and shall nominally be:

- 1) 3 percent of the maximum average ID for ABS or PVC Composite Pipe.
- 2) For all plastic pipe other than ABS or PVC Composite Pipe, the percentage listed of the maximum average ID shall be as follows:

**TABLE 306-1.2.12 (A)<sup>2</sup>**

Nominal Pipe Size		Percentage Deflection Allowed <sup>1</sup>
Millimeters	Inches	
Up to and including 300 mm	Up to and including 12 in	5.0
Over 300 -to and including 750 mm	Over 12-to and including 30 in	4.0
Over 750 -to and including 1500 mm	Over 30-to and including 60 in	3.0
Over 1500-to and including 2250 mm	Over 60-to and including 90 in	2.5
Over 2250-to and including 3000 mm	Over 90-to and including 120 in	2.0
Over 3000 mm	Over 120 in	1.5

1. 30 days after installation

2. Deflections of up to 6.5% of the nominal inside diameter are acceptable for drainage applications.

The maximum average ID shall be equal to the average OD per applicable ASTM Standard minus two minimum wall thicknesses per applicable ASTM Standards. Manufacturing and other tolerances shall not be considered for determining maximum allowable deflections.

Deflection tests shall be performed not sooner than 30 days after completion of placement and densification of backfill. The pipe shall be cleaned and inspected for offsets and obstructions prior to testing.

For all pipes 600 mm (24 inch) ID or smaller, a mandrel shall be pulled through the pipe by hand to ensure that maximum allowable deflections have not been exceeded. Prior to use, the mandrel shall be certified by the Engineer or by another entity approved by the Engineer. Use of an uncertified mandrel or a mandrel altered or modified after certification will invalidate the test. If the mandrel fails to pass, the pipe will be deemed to be overdeflected.

Unless otherwise permitted by the Engineer in conformance with 3-1, any overdeflected pipe shall be uncovered and, if not damaged, reinstalled. Damaged pipe shall not be reinstalled, but shall be removed from the Work site. Any pipe subjected to any method or process other than removal, which attempts, even successfully, to reduce or cure any overdeflection, shall be uncovered, removed from the Work site, and replaced with new pipe.

The mandrel shall:

- 1) Be a rigid, nonadjustable, odd-numbered-leg (9 legs minimum) mandrel having an effective length not less than its nominal diameter.
- 2) Have a minimum diameter at any point along the full length as follows:

**TABLE 306-1.2.12 (B)<sup>2</sup>**

Pipe Material	Nominal Size		Minimum Mandrel Diameter <sup>1</sup>	
	mm	Inches	mm	Inches
PVC-ASTM D 3034 (SDR 26)	150	6	139.78	5.503
	200	8	187.10	7.366
	250	10	233.86	9.207
	300	12	278.41	10.961
	375	15	344.40	13.559
PVC-ASTM D 3034 (SDR 35)	150	6	142.72	5.619
	200	8	191.11	7.524
	250	10	238.89	9.405
	300	12	284.25	11.191
	375	15	351.76	13.849
PVC-ASTM F 679 (T-1 Wall)	450	18	429.87	16.924
	525	21	506.78	19.952
	600	24	570.13	22.446
	675	27	642.54	25.297
	750	30	723.95	28.502
ABS or PVC Composite Pipe ASTM D 2680	150	6	143.15	5.636
	200	8	194.64	7.663
	250	10	243.43	9.584
	300	12	291.47	11.475
	375	15	364.64	14.356
CCFRPM ASTM D 3262 318 Kpa (46 psi)	300	12	300.23	11.820
	450	18	450.32	17.729
	500	20	499.39	19.661
	600	24	597.59	23.527
	750	30	742.42	29.229
	900	36	899.24	35.403

1. Metric mandrel diameters are direct conversions of mandrel diameters in U.S. Standard Measures. If and when the above types of pipe are available and specified by the appropriate ASTM in metric dimensions, as the primary measure, the Engineer shall determine the appropriate mandrel diameter per the requirements of this subsection.

2. Deflections of up to 6.5% of the nominal inside diameter are acceptable for drainage applications.

- 3) Be fabricated of steel, be fitted with pulling rings at each end, be stamped or engraved on some segment other than a runner indicating the pipe material specification, nominal size, and mandrel OD (e.g., PVC D3034-200 mm - 187.10 mm; ABS Composite D2680-250 mm - 243.43 mm; PVC D3034-8"-7.366"; ABS Composite D 2680-10"-9.584"); and be furnished in a suitable carrying case labeled with the same data as stamped or engraved on the mandrel.

The maximum average ID shall be measured in the field prior to installation. For pipe ID's nominally greater than 600 mm to 900 mm (24 to 36 inches), deflections shall be determined by a method submitted to and approved by the Engineer. If a mandrel is selected, the minimum diameter, length and other requirements shall conform to the dimensions and requirements as stated above. Deflection measurement for ID's nominally larger than 900 mm (36 inches) shall be determined using a 25 mm (1 inch) diameter rigid, Agency-certified, nonadjustable metal bar; a minimum-radius rigid template; or by a method approved by the Engineer.

All costs incurred by the Contractor attributable to mandrel and deflection testing, including any delays, shall be borne by the Contractor at no cost to the Agency.

**306-1.2.13 Installation of Plastic Pipe and Fittings.** Plastic pipe and fittings, including but not limited to:

<u>PIPE</u>	<u>SUBSECTION</u>
ABS Solid Wall Pipe .....	207-15
ABS or PVC Composition Pipe .....	207-16
PVC Solid Wall Pipe .....	207-17
PE Solid Wall Pipe .....	207-19
Centrifugally Cast Fiberglass Reinforced Plastic Mortar Pipe .....	207-20

shall, except as required by this subsection or the Plans or Specifications, be bedded in conformance with 306-1.2.1.

No internal or external bracing of the pipe shall be allowed during or after pipe placement, bedding or backfill.

The bedding zone shall extend down to not less than 100 mm (4 inches) below the pipe or bell, whichever is lower in elevation. The bedding zone shall extend to not less than 300 mm (12 inches) above the pipe or bell, whichever is higher in elevation. The bedding zone shall extend on each side of the pipe or bell as follows:

**TABLE 306-1.2.13 (A)**

Nominal Pipe Size mm (inches)	Side Clearance mm (in)	
	Min.	Max.
Up to and including 375 (15)	200 (8)	300 (12)
Over 375 (15) to and including 750 (30)	300 (12)	450 (18)
Over 750 (30)	See Project Plans	

For all plastic pipe and fittings except ABS or PVC Composite pipe, the bedding material shall be composed of crushed rock conforming to 200-1.2 and the following:

**TABLE 306-1.2.13 (B)**

Nominal Pipe Size mm (inches)	Maximum Rock Gradation
Up to and including 375 mm (15 inch)	12.5 mm ( 1/2 inch)
Over 375 mm (15 inch)	19.0 mm ( 3/4 inch)

For ABS or PVC Composite pipe and fittings, the bedding zone shall conform to the above requirements, except that the bedding materials shall conform to 306-1.2.1.

Bedding materials shall be placed and densified to the requirements shown on the Plans, if so indicated.

Connections of plastic pipe and fittings to a manhole shall be watertight. The use of manhole water stops per manufacturer's requirements shall be approved by the Engineer prior to the installation of any pipe or fitting. All junction connecting any pipe or fitting to a plastic pipe shall utilize a "Wye" fitting. "Tee" connections will not be permitted on any plastic pipe. Plastic pipe may be used on curves only if approved deflection fittings or couplings are used, or by bending solid wall pipe without any application of heat and subject to the following limitations:

**TABLE 306-1.2.13 (C)**

Nominal Pipe Diameter		Minimum Centerline Radius	
mm	inches	m	feet
150	6	64	210
200	8	85	280
250	10	107	350
300	12	128	420
375	15	160	525
Greater than 375	Greater than 15	See Project Plans	See Project Plans

Following the placement and densification of backfill and prior to the placing of permanent pavement, all pipe shall be cleaned and measured for obstructions (deflections, joint offsets, and lateral pipe intrusions). For nominal pipe sizes 600 mm (24 inches) or less, a rigid, odd-numbered-leg (9 legs minimum) mandrel, with a circular cross section having a diameter of at least 95 percent of the specified nominal ID, shall be pulled through the pipe by hand. The minimum length of the circular portion of the mandrel shall be equal to the ID of the pipe.

For nominal pipe sizes 600 to 900 mm (24 to 36 inches), deflections shall be checked by means which do not require an inspector to enter the pipeline. For nominal pipe sizes greater than 900 mm (36 inches), deflections may be checked by a method which allows an inspector to enter the pipeline.

### **306-1.3 Backfill and Densification.**

**306-1.3.1 General.** Backfill shall be placed as follows except as modified in 306-1.3.4. Backfill shall be considered as starting at the top of the bedding zone. For concrete encasement the backfill shall be considered as starting at the top of the concrete encasement.

Backfill or fill shall start at the subgrade for cast-in-place structures such as, but not limited to, manholes, transition structures, junction structures, vaults, valve boxes, and reinforced concrete box conduits

Backfill, except that within State Highway, shall be placed as specified in 306-1.3.2 and 306-1.3.3. Compaction requirements shall be in accordance with 306-1.3.5.

When the depth of cover of the top pipe or cable is less than 760 mm (30 in), the top 610 mm (24 inches) of backfill, measured from the surface, shall be compacted to 90 percent relative compaction.

Except where the pipe must remain exposed for force main leakage test and subject to the provisions herein, the Contractor shall proceed with backfilling operations as soon as possible. Care shall be exercised so that the pipe will not be damaged or displaced. If the pipe is supported by concrete bedding that does not cover the pipe, the remainder of any bedding material shall be placed to 0.3 m (1 foot) over the top of the pipe. The backfill above the concrete bedding shall not be placed nor sheeting pulled until concrete bedding has been cured per 201-1.

The Contractor may place fill or backfill against or over the top of any cast-in-place structure in accordance with Table 306-1.3.1(A), unless otherwise specified or approved by the Engineer.

**TABLE 306-1.3.1 (A)**

Operation	Location	
	Against Sides of Structures (Days)	Over Top of Structure (Days)
Placement of Loose Backfill	5	21
Densification of Backfill	7	28 <sup>1</sup>

1. Or 100 percent of the specified compressive strength.

Rocks greater than 150 mm (6 inches) in any dimension will not be permitted in backfill placed between 0.3 m (1 foot) above the top of any pipe or box and 0.3 m (1 foot) below pavement subgrade.

When the trench is wider than 0.9 m (3 feet), rocks not exceeding 300 mm (12 inches) in greatest dimension, which originate from the trench, will be permitted in the backfill from 0.3 m (1 foot) above the top of any pipe or box to 1.5 m (5 feet) below the finished surface.

Rocks greater than 60 mm (2-1/2 inches) in any dimension will not be permitted in backfill placed within 0.3 m (1 foot) of pavement subgrade.

Where rocks are included in the backfill, they shall be mixed with suitable excavated materials to eliminate voids.

Subject to the provisions specified herein, the material obtained from project excavations may be used as backfill provided that all organic material, rubbish, debris, and other objectionable materials are first removed. However, broken portland cement concrete and bituminous-type pavement obtained from the project excavations will be permitted in the backfill subject to the same limitations as rocks.

Where it becomes necessary to excavate beyond the limits of normal excavation lines in order to remove boulders or other interfering objects, the voids remaining after the removal of the boulders shall be backfilled with suitable material and densified as approved by the Engineer.

The removal of all boulders or other interfering objects and the backfilling of voids left by such removals shall be at the expense of the Contractor and no direct payment for the cost of such work will be made. The cost of such work shall be included in the prices bid for the various items of work.

Voids left by the removal of sheeting, piles and similar sheeting supports shall be immediately backfilled with clean sand which shall be jetted or vibrated into place to ensure dense and complete filling of the voids.

Densification shall proceed as soon as possible.

If the Engineer determines that it is not practical to attain the required compaction by mechanical methods, or jetting, such as in areas around utilities, vaults, or other structures, trench backfill slurry per Table 201-1.1.2 (A) will be required.

**306-1.3.2 Mechanically Compacted Backfill.** Backfill shall be mechanically compacted by means of tamping, sheepsfoot, pneumatic tire, or vibrating rollers, or other mechanical tampers. All such equipment shall be of size and type approved by the Engineer. Impact-type pavement breakers (stompers) shall not be permitted over or adjacent to pipe, duct, or cable, unless permitted by the Engineer.

Permission to use specific compaction equipment shall not relieve the contractor from responsibility to ensure that the use of such equipment will not result in damage to adjacent ground, existing

improvements, or improvements installed under the Contract. The Contractor shall make its own determination in this regard.

Mechanically compacted backfill shall be placed in horizontal layers of thickness compatible to the material being placed and the type of equipment being used. Each layer shall be evenly spread, moistened (or dried, if necessary), and then tamped or rolled until the specified relative compaction has been attained.

Unless otherwise approved by the Engineer, material for mechanically compacted backfill shall be placed in lifts which, prior to compaction, shall not exceed the thickness specified below for the various types of equipment:

- 1) Impact, free fall, or "stomping" equipment- maximum lift thickness of 0.6 m (24 inches)
- 2) Vibratory equipment, including vibratory plates on backhoe dipsticks, vibratory smooth-wheel rollers, and vibratory pneumatic-tired rollers - maximum lift thickness of 0.5 m (18 inches).
- 3) Rolling equipment, including sheepsfoot (both vibratory and nonvibratory), grid, smooth-wheel (nonvibratory), grid, smooth wheel (nonvibratory), and segmented wheels - maximum lift thickness of 0.2 m (8 inches).
- 4) Hand-directed mechanical compactors such as vibratory plates or tamper - maximum lift thickness of 100 mm (4 inches).

**306-1.3.3 Jetted Backfill.** Backfill to be densified by water shall be jetted. Jetting will be permitted only if the soils of the trench walls have a minimum sand equivalent of 15. Jetting shall be accomplished by the use of a jet pipe to which a hose is attached, carrying a continuous supply of water under pressure.

Backfill shall be jetted in accordance with the following requirements:

- 1) The jet pipe shall consist of a minimum 38 mm (1-1/2 inch) diameter pipe to which a minimum 50 mm (2 inch) diameter hose is attached at the upper end. The jet shall be of sufficient length to project to within 0.6 m (2 feet) of the bottom of the lift being densified.
- 2) The Contractor shall jet to within 0.6 m (2 feet) of the bottom of the lift and apply water in a manner, quantity and at a rate sufficient to thoroughly saturate the thickness of the lift being densified. The jet pipe shall not be moved until the backfill has collapsed and the water has been forced to the surface.
- 3) The lift of backfill shall not exceed that which can be readily densified by jetting, but in no case shall the undensified lift exceed 4.5 m (15 feet).
- 4) Suitable backfill material to be jetted shall have a sand equivalent of 15 or greater.
- 5) Where the nature of the material excavated from the trench is generally unsuitable for densification with water, the Contractor may, at no cost to the Agency, import from an approved source suitable material for jetting or densify the excavated material by other methods as approved by the Engineer. The backfill shall be allowed to thoroughly drain until the surface of the backfill is in a firm and unyielding condition prior to commencement of any subsequent improvements. The Engineer may require the Contractor, at the Contractor's expense, to dig a sump and provide a pump to remove any accumulated water.
- 6) The Contractor shall make its own determination that jetting will not result in damage to adjacent structures or facilities. Any resulting damage shall be repaired at the Contractor's expense.

- 7) The Contractor shall have available a continuous supply of water at a minimum pressure of 40 psig. If a water truck is used to supply water, it shall have a pump capable of supplying water at 40 psig and shall have the capacity to jet the trench without refill.
- 8) After jetting trench backfill, the Contractor shall prepare the top of the backfill to comply with 306-1.3.5 and to provide a firm and unyielding subgrade conforming to 301-1. Jetting maybe supplemented with mechanical methods.

**306-1.3.4 Backfilling Narrow Trenches.** Narrow trenches are defined as 250 mm (10 in) or less in width. Backfill for narrow trenches shall be placed as specified in 306-1.3.1 except as modified herein. Narrow trenches shall be backfilled by the use of trench backfill slurry per 201-1 or CLSM per 201-6, unless otherwise approved by the Engineer.

When narrow trenches are backfilled using trench backfill slurry or CLSM, the Contractor may place the material in a single lift using vibrators for consolidation. The Contractor shall take all necessary precautions to prevent the pipe or substructure from floating or becoming displaced. The top of the trench backfill slurry or CLSM shall be placed flush with top of the pavement when steel plates are not placed over narrow trenches. The trench backfill slurry or CLSM shall be cut back to a minimum of 25 mm (1 in) but no greater than 200 mm (8 in) below the existing pavement prior to placing permanent paving. For trenches 150 mm (6 in) or less in width, the compacted thickness of asphalt concrete shall be 75 mm (3 in).

Backfill to be mechanically compacted in narrow trenches shall be placed per 306-1.3.1 and 306-1.3.2, except as modified herein. Backfill shall not have any rocks greater in any dimension, than 1/4 the width of the trench. Mechanically compacted backfill shall meet the relative compaction requirements of 306-1.3.6. In place density for narrow trenches shall be determined in accordance with ASTM D 2937 or by a method approved by Engineer.

**306-1.3.5 Jetted Bedding and Backfill Compaction Requirements.** Except as specified otherwise, trench bedding and backfill densified thru jetting shall be densified to the following minimum relative compaction:

1. 85 percent Relative Compaction:
  - a) From the bottom of the trench to the beginning of the upper 0.9 m (3 feet), measured from the pavement surface (or finish grade where there is no pavement) within native material or unengineered embankments.
  - b) Outside the traveled way, shoulders, and under sidewalks, in the upper 0.9 m (3 feet), measured from the pavement surface (or finish grade where there is no pavement).
  - c) Under sidewalks.
2. 90 percent Relative Compaction:
  - a) In the upper 0.9 m (3 feet), measured from the pavement surface (or finish grade where there is no pavement), within the existing or future traveled way, shoulders, and other paved areas (or areas to receive pavement).
  - b) Within engineered embankments.
  - c) Where lateral support is required for existing or proposed structures.
3. 95 percent Relative Compaction where required by 301-1.3.

**306-1.3.6 Mechanical Compaction Requirements.** Except as specified otherwise, mechanically compacted trench backfill shall be densified to the following minimum relative compaction:

1. 85 percent Relative Compaction:
  - a) In the bedding zone.
  - b) Outside the traveled way and other paved areas (or areas to receive pavement).
  - c) Under Sidewalks.
2. 90 percent Relative Compaction:
  - a) In the upper 0.9 m (3 feet) measured from the pavement surface (or finish grade where there is no pavement), within the existing or future traveled way, shoulders, and other paved areas (or areas to receive pavement).
  - b) Within engineered embankments.
  - c) Where lateral support is required for existing or proposed structures.
3. 95 percent Relative Compaction where required by 301-1.3.

**306-1.3.7 Imported Backfill.** If the Contractor elects to import material from a source outside the project limits for use as backfill, said materials shall be clean soil, free from organic material, trash, debris, rubbish, broken portland cement concrete, bituminous materials, or other objectionable substances.

Whenever the Contractor elects to use imported material for backfill, it shall deliver, not less than 10 days prior to intended use, a sample of the material to the Engineer. The sample shall have a minimum dry weight of 45 kg (100 pounds) and shall be clearly identified as to source, including street address and community of origin. The Engineer will determine the suitability, the minimum relative compaction to be attained, and the placement method.

Should the imported material not be substantially the same as the approved sample, it shall not be used for backfill and shall be removed from the Work site at the Contractor's expense.

The densification method for imported material authorized by the Engineer will be dependent upon its composition, the composition of the in-place soil at the point of placement, and the relative compaction to be obtained.

**306-1.3.8 Transported Backfill.** The Contractor may transport or back-haul material to be used as backfill material from any portion or line of a project to any other portion or line of the same project, or from any project being constructed under one contract to any other project being constructed under that same contract. Such transported material shall be clean soil, free from organic material, trash, debris, rubbish, or other objectionable substances except that broken portland cement concrete or bituminous type paving as specified in 306-1.3.1 may be included.

#### **306-1.4 Testing Pipelines.**

**306-1.4.1 General.** All leakage tests and all post-installation closed circuit television (CCTV) inspections shall be completed and approved prior to placing of permanent resurfacing.

When leakage or infiltration exceeds the amount allowed by the specifications, the Contractor at its expense shall locate the leaks and make the necessary repairs or replacements in accordance with the Specifications to reduce the leakage or infiltration to the specified limits. Any individually detectable leaks shall be repaired, regardless of the results of the tests. Leakage tests shall be made on completed pipelines as follows:

- 1) Storm Drains - Not required unless called for on Plans or in Specifications.
- 2) Gravity Sanitary Sewers 600 mm (24 inches) or less in diameter where difference in elevation between inverts of adjacent manholes is 3 m (10 feet) or less - Water

- exfiltration test or water infiltration test as directed. The Engineer may allow substitution of an air pressure test for the water exfiltration test.
- 3) Gravity Sanitary Sewers 600 mm (24 inches) or less in diameter where difference in elevation between inverts of adjacent manholes is greater than 3 m (10 feet) - Air pressure test or water infiltration test as directed.
  - 4) Gravity Sanitary Sewers 600 mm (24 inches) or greater in diameter - Air pressure test or water infiltration test as directed.
  - 5) Gravity Sanitary Sewers which are in service and a bypass system is not available - the Contractor shall perform post-installation CCTV inspection per 500-1.1.5 and payment shall be per 500-1.1.9.
  - 6) Pressure Sanitary Sewers (force mains) - Water pressure test at 120 percent of maximum operating pressure.
  - 7) Water Pipelines - Water pressure test: Pipe specified by pressure classification, 350 kPa (50 psi) over pressure classification. Other type of pipe, 120 percent of maximum operating pressure.

**306-1.4.2 Water Exfiltration Test.** Each section of sewer shall be tested between successive manholes by closing the lower end of the sewer to be tested and the inlet sewer of the upper manhole with stoppers. The pipe and manhole shall be filled with water to a point 1.2 m (4 feet) above the invert of the sewer at the center of the upper manhole; or if groundwater is present, 1.2 m (4 feet) above the average adjacent groundwater level.

The allowable leakage will be computed by the formulae:

$$E_{SI} = 0.00009 LD \sqrt{H} \text{ for mortared joints}$$

$$(E_{US} = 0.0001 LD \sqrt{H} \text{ for mortared joints.})$$

$$E_{SI} = 0.000018 LD \sqrt{H} \text{ for all other joints.}$$

$$(E_{US} = 0.00002 LD \sqrt{H} \text{ for all other joints.})$$

**Where:**

L = length of sewer and house connections tested, in meters (feet).

$E_{SI}$  ( $E_{US}$ ) = the allowable leakage in liters (gallons) per minute of sewer tested.

D = the internal diameter of the pipe in millimeters (inches).

H = is the difference in elevation meters (feet) between the water surface in the upper manhole and the invert of the pipe at the lower manhole; or if groundwater is present above the invert of the pipe in the lower manhole, the difference in elevation between the water surface in the upper manhole and the groundwater at the lower manhole.

The Contractor shall, at its expense, furnish all water, materials and labor for making the required test. All tests shall be made in the presence of the Engineer.

**306-1.4.3 Water Infiltration Test.** If, in the opinion of the Engineer, excessive groundwater is encountered in the construction of a section of the sewer, the exfiltration test for leakage shall not be used.

The end of the sewer at the upper structure shall be closed sufficiently to prevent the entrance of water, and pumping of groundwater shall be discontinued for at least 3 days, after which the section shall be tested for infiltration.

The infiltration into each individual reach of sewer between adjoining manholes shall not exceed that allowed by the formula in 306-1.4.2 where H is the difference in the elevation in meters (feet) between the groundwater surface and the invert of the sewer at the downstream manhole.

Unless otherwise specified, infiltration will be measured by the Engineer using measuring devices furnished by the Agency.

**306-1.4.4 Air Pressure Test.** The Contractor shall, at its expense, furnish all materials, equipment, and labor for making an air test. Air test equipment shall be approved by the Engineer unless otherwise provided on the Plans or in the Specifications.

The Contractor may conduct an initial air test of the sewer mainline after densification of the backfill, but prior to installation of the house connection sewers. Such tests will be considered to be for the Contractor's convenience and need not be performed in the presence of the Engineer.

Each section of sewer shall be tested between successive manholes by plugging and bracing all openings in the sewer mainline and the upper ends of all house connection sewers. Prior to any air pressure testing, all pipe plugs shall be checked with a soap solution to detect any air leakage. If any leaks are found, the air pressure shall be released, the leaks eliminated, and the test procedure started over again. The Contractor has the option of wetting the interior of the pipe prior to the test.

The final leakage test of the sewer mainline and branching house connection sewers, shall be conducted in the presence of the Engineer in the following manner:

Air shall be introduced into the pipeline until 20 kPa (3.0 psi) gage pressure has been reached, at which time the flow of air shall be reduced and the internal air pressure shall be maintained between 17 kPa and 24 kPa (2.5 and 3.5 psi) gage pressure for at least 2 minutes to allow the air temperature to come to equilibrium with the temperature of the pipe walls. Pressure in the pipeline shall be constantly monitored by a gage and hose arrangement separate from hose used to introduce air into the line. Pressure in the pipeline shall not be allowed to exceed 34 kPa (5 psi) gage pressure.

After the temperature has stabilized and no air leaks at the plugs have been found, the air pressure shall be permitted to drop and, when the internal pressure has reached 17 kPa (2.5 psi) gage pressure, a stopwatch or sweep-second-hand watch shall be used to determine the time lapse required for the air pressure to drop to 10 kPa (1.5 psi) gage pressure.

If the time lapse (in seconds) required for the air pressure to decrease from 17 to 10 kPa (2.5 to 1.5 psi) gage pressure exceeds that shown in Table 306-1.4.4 (A), Low Pressure Air Test for Sewers, the pipe shall be presumed to be within acceptance limits for leakage.

If the time lapse is less than that shown in the table, the Contractor shall make the necessary corrections to reduce the leakage to acceptance limits.

TABLE 306-1.4.4 (A)

Time in Seconds for Pressure to Drop from 17 to 10 KPa (2.5 to 1.5 psi) Gage Pressure

Main Line 100 mm (4 in) House Connection Main Line 150 mm (6 in) House Connection

Nominal Diameter mm (in)	Length m (feet)	House Connection Length					Diameter mm (Inches)	Length m (Feet)	House Connection Length				
		0 m (0 ft.)	30 m (100 ft.)	60 m (200 ft.)	90 m (300 ft.)	120 m (400 ft.)			0 m (0 ft.)	30 m (100 ft.)	60 m (200 ft.)	90 m (300 ft.)	120 m (400 ft.)
200 (8)	0 (0)	0	20	40	50	70	200 (8)	0 (0)	0	40	80	100	100
	15 (50)	40	50	70	90	80		15 (50)	40	70	110	110	110
	30 (100)	70	90	100	100	90		30 (100)	70	110	120	110	110
	45 (150)	110	120	110	100	100		45 (150)	110	120	120	120	110
	60 (200)	140	120	110	110	100		60 (200)	140	130	120	120	120
	90 (300)	140	130	120	110	110		90 (300)	140	130	120	120	120
120 (400)	140	130	120	120	110	120 (400)	140	130	130	120	120	120	
250 (10)	15 (50)	50	70	90	100	90	250 (10)	15 (50)	50	90	120	120	110
	30 (100)	110	130	120	110	110		30 (100)	110	140	130	130	120
	60 (200)	170	150	140	130	120		60 (200)	170	150	140	140	130
	90 (300)	170	160	150	140	130		90 (300)	170	160	150	140	140
	120 (400)	170	160	150	150	140		120 (400)	170	160	150	150	140
	15 (50)	80	100	110	110	110		300 (12)	15 (50)	80	120	140	130
30 (100)	160	170	150	140	130	30 (100)	160		170	150	140	140	
60 (200)	200	180	170	160	150	60 (200)	200		180	170	160	150	
90 (300)	200	190	180	170	160	90 (300)	200		190	180	170	160	
120 (400)	200	190	180	180	170	120 (400)	200		190	180	180	170	
15 (50)	120	140	160	140	130	375 (15)	15 (50)		120	160	160	150	140
30 (100)	250	220	190	170	160		30 (100)	250	210	190	170	160	
60 (200)	260	230	220	200	190		60 (200)	260	230	210	200	190	
90 (300)	260	240	230	220	210		90 (300)	260	240	220	210	200	
120 (400)	260	240	230	220	220		120 (400)	260	240	230	220	210	
15 (50)	180	200	190	170	150		450 (18)	15 (50)	180	220	190	170	160
30 (100)	310	260	230	210	190	30 (100)		310	260	220	200	190	
60 (200)	310	280	260	250	230	60 (200)		310	280	260	240	220	
90 (300)	310	290	280	260	250	90 (300)		310	290	270	260	240	
120 (400)	310	290	280	270	260	120 (400)		310	290	280	270	260	
15 (50)	240	260	230	200	180	525 (21)		15 (50)	240	260	220	200	180
30 (100)	360	310	280	250	230		30 (100)	360	300	260	240	220	
60 (200)	360	330	310	290	280		60 (200)	360	330	300	280	260	
90 (300)	360	340	320	310	300		90 (300)	360	330	320	300	290	
120 (400)	360	340	330	320	310		120 (400)	360	340	330	310	300	
15 (50)	320	320	270	240	210		600 (24)	15 (50)	320	310	260	220	200
30 (100)	410	360	320	290	270	30 (100)		410	350	310	280	260	
60 (200)	410	380	360	340	320	60 (200)		410	370	350	320	310	
90 (300)	410	390	370	360	350	90 (300)		410	380	360	350	330	
120 (400)	410	390	380	370	360	120 (400)		410	390	370	360	350	
15 (50)	400	370	310	280	250	675 (27)		15 (50)	400	350	290	260	230
30 (100)	460	410	370	340	310		30 (100)	460	390	350	320	290	
60 (200)	460	430	410	390	370		60 (200)	460	420	390	370	350	
90 (300)	460	440	420	410	390		90 (300)	460	430	410	390	380	
120 (400)	460	450	430	420	410		120 (400)	460	440	420	410	390	
15 (50)	490	420	360	310	280		750 (30)	15 (50)	480	490	330	290	260
30 (100)	510	460	420	380	360	30 (100)		510	440	390	360	330	
60 (200)	510	480	460	440	420	60 (200)		510	470	440	420	390	
90 (300)	510	490	470	460	440	90 (300)		510	480	460	440	420	
120 (400)	510	500	480	470	460	120 (400)		510	490	470	460	440	
15 (50)	560	460	400	350	320	825 (33)		15 (50)	560	440	370	320	290
30 (100)	560	510	460	430	400		30 (100)	560	490	440	400	370	
60 (200)	560	530	510	490	460		60 (200)	560	520	490	460	440	
90 (300)	560	540	520	510	490		90 (300)	560	530	510	490	470	
120 (400)	560	550	530	520	510		120 (400)	560	540	520	510	490	
15 (50)	610	510	440	390	360		900 (36)	15 (50)	610	480	410	360	320
30 (100)	610	560	510	480	440	30 (100)		610	540	480	440	410	
60 (200)	610	580	560	530	510	60 (200)		610	570	540	510	480	
90 (300)	610	600	580	560	540	90 (300)		610	590	560	540	520	
120 (400)	610	600	580	570	560	120 (400)		610	590	570	560	540	
15 (50)	660	560	490	440	390	975 (39)		15 (50)	660	530	450	390	350
30 (100)	660	610	560	520	490		30 (100)	660	590	530	480	450	
60 (200)	660	630	610	580	560		60 (200)	660	620	590	560	530	
90 (300)	660	640	620	610	590		90 (300)	660	640	610	590	570	
120 (400)	660	650	630	620	610		120 (400)	660	640	620	610	590	
15 (50)	710	610	540	480	430		1050 (42)	15 (50)	710	580	490	430	390
30 (100)	710	660	610	570	540	30 (100)		710	640	580	530	490	
60 (200)	710	680	660	630	610	60 (200)		710	670	640	610	580	
90 (300)	710	690	680	660	640	90 (300)		710	690	660	640	620	
120 (400)	710	700	680	670	660	120 (400)		710	690	670	650	640	

**306-1.4.5 Water Pressure Test.** Preparatory to testing, the section of the pipeline to be tested shall be filled with water and placed under a slight pressure for at least 48 hours. The pipeline shall then be brought up to the test pressure specified and maintained on the section under test for a period of not less than 4 hours.

Accurate means shall be provided for measuring the quantity of water required to maintain full pressure on the line for the test period, which volume shall not exceed:

$$\text{For SI Units:} \quad L_{SI} = \frac{CND \sqrt{P}}{32,600}$$

$$\text{For U.S. Std. Measure:} \quad L_{US} = \frac{CND \sqrt{P}}{1,850}$$

Where:

$L_{SI}$  ( $L_{US}$ ) = Maximum allowable leakage in liters (gallons) per hour for section of pipeline tested.

N = Number of joints in length tested.

D = Diameter of pipe in mm (inches).

P = Test pressure in kPa (psi).

C = 1.0 for reinforced concrete pressure pipe with rubber joints, cylinder type.

C = 3.0 for reinforced concrete pressure pipe with rubber joints, non-cylinder type.

C = 0.50 for cast iron pipe with mechanical or rubber gasket joints and asbestos-cement pipe.

C = 1.0 for other type of cast iron joints (caulked and other types of pipe.)

No leakage is allowed for welded steel pipe with welded joints.

**306-1.4.6 Leakage Test for Corrugated Metal Pipelines.** After the pipe has been laid and assembled, and when required, the pipeline shall be filled with water to a hydrostatic pressure head of 3.0 m (10 feet) above the point in the line to be tested.

A hydrostatic test shall be conducted for a period of not less than 24 hours, during which time an accurate measure of the water required to maintain the test pressure shall be made. Any leakage developed by the test shall not exceed 90 mL per mm (0.60 gallon per inch) of inside diameter per 30 m (100 feet) of pipe per hour. Any leakage in excess of this amount shall be stopped in a manner satisfactory to the Engineer, and the test repeated until the total leakage does not exceed the amount specified. All obvious leaks shall be stopped in a manner satisfactory to the Engineer, whether or not the leakage from the line exceeds that permitted herein.

### 306-1.5 Trench Resurfacing.

**306-1.5.1 Temporary Resurfacing.** Unless permanent pavement is placed immediately, temporary bituminous resurfacing 50 mm (2 inches) thick shall be placed and maintained at locations determined by the Engineer wherever excavation is made through pavement, sidewalk or driveways. In sidewalk areas the temporary bituminous resurfacing shall be at least 25 mm (1 inch) thick; in all other areas it shall be at least 50 mm (2 inches) thick. At major intersections and other critical locations, a greater thickness may be ordered. Temporary resurfacing shall be placed as soon as the condition of the backfill is suitable to receive it and shall remain in place until the condition of the backfill is suitable for permanent resurfacing.

The bituminous mixture used for temporary trench resurfacing shall conform to Class D2 asphalt concrete mixture in 203-6.4.3; and bitumen conforming to grade SC-800 liquid asphalt in the Slow Curing Product table, 203-2.4.

The mixture may be furnished from stockpiles or directly from the plant and may be laid cold, at the option of the Contractor. Prior to placing temporary resurfacing, the Contractor shall level and compact the backfill on which the surfacing is to be placed. The grade of the backfill on which the resurfacing is to be placed shall be such as to provide the full thickness of temporary resurfacing specified. The temporary resurfacing shall be placed, rolled, maintained, and removed and disposed of by the Contractor.

On improvements being constructed under contract with the Agency, the Proposal will contain a bid item for an estimated number of tonnes (tons) of temporary bituminous resurfacing materials. The price bid shall include full compensation for furnishing, placing, maintaining, removing, and disposing of such temporary resurfacing materials.

Payment will be limited to that quantity of material ordered placed by the Engineer and shall include material used to maintain the temporary resurfacing until the permanent resurfacing is placed. Material which is placed by the Contractor for its convenience shall be at no cost to the Agency.

**306-1.5.2 Permanent Resurfacing.** Unless otherwise shown on the Plans, Permit or in the Specifications, all surface improvements damaged or removed as a result of the Contractor's operations shall be reconstructed by the Contractor to the same dimensions, except for the pavement thickness, and with the same type of materials used in the original work. Trench and excavation resurfacing shall be 25 mm (1 inch) greater in thickness than existing pavement.

Subgrade for trench resurfacing shall conform to Section 301 and the pavement reconstruction shall comply with the applicable provisions of Section 302. Asphalt concrete pavement shall also comply with Section 306-1.5.3. Aggregate base, when encountered within the structural section area, shall be compacted to a minimum density of 95% and compacted in lifts per subsection 301-2.2. The thickness of aggregate base shall be equal to that existing adjacent to the excavation.

**306-1.5.3 Placement of Permanent Repair Hot Mixed Asphalt Concrete.** The asphalt concrete shall be placed in compacted lifts per Table 306-1.5.3.

**TABLE 306-1.5.3**

Compaction Equipment	Maximum Compacted Thickness mm (in)
Vibratory Plate	38 (1-1/2)
Pneumatic Plate	50 (2)
Vibratory Rammers	50 (2)
Steel Wheel Roller*	63 (2-1/2)
Vibratory Roller*	75 (3)
Pneumatic Tired Rollers	Not Permitted

\* Rollers must fit entirely within the trench.

After placement of the backfill and/or aggregate base, the sides of the excavation shall be cleaned prior to the application of an asphalt tack coat. The tack coat may be an emulsified asphalt conforming to 203-3 or a paving asphalt conforming to 203-1. This tack coat when cured or cooled shall be of sufficient thickness to uniformly cover all vertical surfaces of the existing asphalt concrete. An extra heavy application of the tack to the vertical edges will not be cause for rejection. Excess tack on the horizontal surface of the aggregate base or subgrade shall be spread uniformly over the surface and may require the application of a blotting sand to prevent bleed through. Areas that are not sufficiently coated

shall have the tack reapplied. Care must be exercised by the Contractor to insure that the tack coat is not damaged during the placement of the asphalt concrete.

**306-1.5.4 Base Course for Asphalt Concrete Placement.** The base course shall be a B or C gradation and shall be placed by either a spreader box, paving machine or "shoe" attachment.

For trenches less than 1 m (3 ft) wide and individual excavations or bore holes having an area of less than 5 m<sup>2</sup> (50 ft<sup>2</sup>), the base course pavement shall be placed in such a manner as to obtain the specified density and smoothness.

The compacted surface shall not deviate from the planned base course elevation by more than 6 mm (1/4 in).

**306-1.5.5 Finish Course for Asphalt Concrete Placement.** The finish course shall be a C or D gradation. For trenches 2.5 m (8 ft) or greater in width, the final lift of asphalt concrete shall be placed with a paving machine or a full width spreader box. When the total tonnage required for the final lift of asphalt concrete on the project is greater than 100 tonnes (110 tons), a paving machine shall be used.

For trench widths 1 m (3 ft) or greater and less than 2.5 m (8 ft), the final lift shall be placed with a narrow paving machine or a spreader box when the total tonnage required for the final lift of asphalt concrete on the project is greater than 15 tonnes (17 tons).

For trenches less than 1 m (3 ft) wide and individual excavations or bore holes having an area of less than 5 m<sup>2</sup> (50 ft<sup>2</sup>), the final lift shall be placed in such a manner as to obtain the specified density and smoothness.

**306-1.5.6 Density and Smoothness.** For trench width 1 m (3 ft) or greater, the Contractor shall compact all lifts with a self propelled steel wheeled roller meeting the N/mm (PLI) requirement specified in 302-5.6.

For trench widths less than 1 m (3 ft) wide, the Contractor shall compact all lifts by steel wheel rollers, vibratory plates, or rammers of such width to fit within the sides of the excavation. The N/mm (PLI) requirements of 302-5.6 shall not apply except for the final lift. The final lift shall be compacted using a steel wheel roller meeting the N/mm (PLI) requirements of 302-5.6.

For individual excavations or bore holes having an area of less than 5 m<sup>2</sup> (50 ft<sup>2</sup>), the Contractor shall compact all lifts by steel wheel rollers, vibratory plates, or rammers of such width to fit within the sides of the excavation. The N/mm (PLI) requirements of 302-5.6 shall not apply.

Pneumatic tire rollers or truck tires shall not be allowed on any of the lifts.

Trenches of any width backfilled with CLSM or trench backfill slurry will not require aggregate base. Asphalt concrete shall be replaced to the full depth of existing asphalt concrete plus 25 mm (1 in), except for trenches specified in 306-1.3.4.

For trench widths 1 m (3 ft) or greater, the compaction temperatures of the asphalt concrete mat shall be per 302-5.6. For trench width less than 1 m (3 ft), the compaction of the asphalt concrete mat shall be initiated before the material cools to less than 94 °C (200 °F).

The minimum compaction after rolling shall be 95 percent of the density obtained in accordance with the methods specified in 302-5.6.2. When the density is determined by a core sample, it shall be based on a full depth sample, as specified in 302-5.6.2.

The final pavement surface for trenches wider than 1 m (3 ft) and parallel to the centerline of the street shall meet the smoothness requirements of 302-5.6.2. Trenches less than 1 m (3 ft) wide, individual excavations or bore holes having an area less than 5 m<sup>2</sup> (50 ft<sup>2</sup>), and trenches of any width not parallel to the centerline of the street shall match the smoothness of the existing pavement, except final pavement surface tolerances are minus 0 to plus 3 mm (1/8 in) based on the existing pavement on either side of the excavation. Final pavement below the existing surface is not acceptable.

Finish courses with deviations exceeding the above requirements shall be removed and replaced. Such pavement shall be removed to a minimum depth of 38 mm (1-1/2 in) for the full width of the trench. The minimum length of removal along the trench shall extend for 1.2 m (4 ft) beyond the ends of the deviations, but in no case exceed the limit of the original excavation.

**306-1.5.7 Concrete Resurfacing.** Replacement of PCC pavement for trench or individual excavations or bore holes shall be 1 inch greater in thickness than existing the pavement. The existing concrete pavement shall be saw cut per 300-1.3. The concrete shall conform to and be placed per 302-6.

**306-1.6 Basis of Payment for Open Trench Installations.** Pipe and conduit shall be measured along the longitudinal axis between the ends as laid and shall include the actual pipe in place and shall not include the inside dimensions of structures. House connection sewers shall be measured from the center of the main sewer to the upper end of the house connection sewer. Catch basin connections shall be measured from the inside face of the catch basin to the inside face of conduit or structure to which connection is being made. Chimney pipe shall be measured vertically from the upper end of the chimney to the invert of the sewer.

The price per linear meter (foot) for pipe and conduit in place shall be considered full compensation for all wyes, tees, bends, monolithic catch basin connections, and specials shown on the Plans; the removal of interfering portions of existing sewers, storm drains, and improvements; the closing or removing of abandoned conduit and structures; the excavations of the trench; the control of ground and surface waters; the preparation of subgrade; placing and joining pipe; backfilling the trench; permanent resurfacing; and all other work (excluding temporary resurfacing) necessary to install the pipe or conduit, complete in place.

Payment for structures such as manholes, junction structures, lamp holes, and catch basins shall be made at the price bid for each structure shall be full payment for each structure complete in place, including excavation, backfill, constructing inverts, furnishing and installing castings, restoration of the street surface, and all other work, excluding temporary resurfacing, necessary to complete the Work.

## **306-2 JACKING OPERATIONS.**

**306-2.1 General.** Before starting excavation, the Contractor shall, in accordance with 2-5.3, submit drawings of jacking pit bracing, casing (or conduit), and jacking head proposed to be used.

Unless otherwise specified, the methods and equipment used in jacking casing or conduit shall be optional with the Contractor, provided that the proposed method is approved by the Engineer. Such approval, however, shall in no way relieve the Contractor of the responsibility for making a satisfactory installation meeting the criteria set forth herein. Only workers experienced in jacking operations shall be used in performing the work.

The leading section of conduit shall be equipped with a jacking head securely anchored thereto to prevent any wobble or variation in alignment during the jacking operation.

The driving ends of the conduit shall be properly protected against spalling and other damage, and intermediate joints shall be similarly protected by the installation of sufficient bearing shims to properly distribute the jacking stresses. Any section of conduit showing signs of failure shall be removed and replaced with a new section of precast conduit, or with a cast-in-place section, which is adequate to carry the loads imposed upon it.

Excavation shall not be made in excess of the outer dimensions of the conduit being jacked unless approved by the Engineer. Every effort shall be made to avoid any loss of earth outside the jacking head. Excavated material shall be removed from the conduit as excavation progresses, and no accumulation of such material within the conduit will be permitted.

Once the jacking operation has commenced, it shall be continued uninterrupted around the clock until the conduit has been jacked between the specified limits. This requirement may be modified if the Contractor submits to the Engineer for prior approval methods and details that shall prevent the "freezing" of the conduit and ensure that the heading is stable at all times.

Upon completion of the jacking operations, all voids around the outside face of the conduit shall be filled by grouting.

Grouting equipment and material shall be on the Work site before jacking operations and drilling of grout holes are completed in order that grouting around the jacked conduit may be started immediately after the jacking operations have finished.

Should appreciable loss of ground occur during the jacking operation, the voids shall be backpacked promptly to the extent practicable with soil-cement consisting of a slightly moistened mixture of 1 part cement to 5 parts granular material. Where the soil is not suitable for this purpose, the Contractor shall import suitable material at its expense. The soil-cement shall be thoroughly mixed and rammed into place as soon as possible after the loss of ground.

**306-2.2 Jacking Reinforced Concrete Pipe.** When pipe is specified to be jacked into place, the design of such pipe is based upon the superimposed loads and not upon the loads which may be placed upon the pipe as a result of the jacking operations. Any increase in pipe strength in order to withstand jacking loads shall be the responsibility of the Contractor.

Where pipe 1500 mm (60 inches) or greater in nominal inside diameter is to be jacked for a distance greater than 10 m (32 feet), a pilot tunnel shall be constructed first to ensure accuracy of grade and alignment. The dimension and support of the pilot tunnel will be optional with the Contractor subject to the approval of the Engineer. Such approval shall in no way relieve the Contractor of the responsibility for damage of any nature which might occur as a result of the method used.

Supports for pilot tunnels shall be removed as jacking progresses.

Unless the Contractor submits an alternate proposal to the Engineer for approval, the following method shall be used for supporting and guiding the pipe:

After the pilot tunnel has been constructed, a concrete cradle shall be placed true to line and grade and conforming to the outside radius of the pipe. The cradle shall be of such dimensions as to adequately and uniformly support the pipe under the lower 60-degree sector measured on the outside of the pipe. The curved surface shall be formed or accurately screeded to the proper dimensions. It shall be reinforced with not less than 0.3 percent of longitudinal steel and not less than 0.5 percent of transverse steel with respect to the cross-sectional area of the cradle. The transverse steel shall be bent on a radius equal to the radius of the outside of the pipe plus 50 mm (2 inches) and shall extend to within 25 mm (1 inch) of the edge of the cradle.

In lieu of the concrete cradle specified above, the Contractor may, subject to the approval of details by the Engineer, set steel rails in the concrete base slab to true line and grade.

The Contractor shall place grout holes, pipe, and fittings in the pipe invert on centers not greater than 1.5 m (5 feet) and shall perform such pressure grouting as is necessary to fill voids and to secure uniform bearing between the cradle and the pipe. The grout shall be neat cement grout. Grouting pressures shall be as determined in the field by the Engineer.

All costs involved in the performance of the work of constructing pilot tunnels and cradles shall be included in the price bid for jacking pipe.

**306-2.3 Jacking Steel Casing.** Unless otherwise specified on the Plans, the size and wall thickness of the casing to be jacked to accommodate the contract pipeline shall be at the Contractor's option, except that the casing thickness shall be not less than 9.5 mm (3/8 inch), and the Contractor shall be fully responsible for the sufficiency of the casing provided.

The joints of sections of casing to be jacked shall be welded with a continuous circumferential weld. It shall be the Contractor's responsibility to provide stress transfer across the joints which is capable of resisting the jacking forces involved.

All clay pipe installed in a jacked casing shall have mechanical compression joints. The pipe shall be braced or filled to prevent shifting or flotation during backfilling operations.

Backfill shall be gunite sand, gunite concrete, or pressure concrete, except where specified otherwise in the Plans or in the Specifications. Pressure concrete shall not be placed until the mix design, placement method, and equipment have been approved by the Engineer.

If the pressure concrete mix cannot be readily pumped or placed by the placing equipment, additional water may be added, provided the water-cement ratio of the approved mix design is not exceeded.

Guniting sand backfill shall conform to 306-3.7. Where guniting sand backfill is used, the pipe shall be laid on a concrete subbase or on gravel bedding where shown on the Plans or approved by the Engineer.

Where guniting concrete or pressure concrete backfill is to be used, the pipe shall be laid on a subbase of pipe bedding concrete as specified in 201-1 at least 125 mm (5 inches) thick at the centerline.

The pipe barrels shall rest upon concrete support blocks with the pipe sockets clearing the concrete subbase by at least 13 mm (1/2 inch).

In addition to submitting details of the jacking pit bracing, casing, and jacking head required in 306-2, the Contractor shall submit to the Engineer for approval details of the following in advance of the proposed jacking operation: concrete support blocks, bracing to prevent pipe shifting or flotation, and pressure concrete mix design, placement method, and equipment.

**306-2.4 Jacking Corrugated Steel Pipe.** Corrugated steel pipe to be jacked in place between the limits shown on the Plans shall conform to provisions of these specifications and the following: The thickness of the pipe designated in the contract item will be the minimum thickness permitted. Any heavier thickness of pipe or other facilities required to withstand jacking pressure shall be determined and furnished by the Contractor at its expense.

Corrugated pipe lengths may be joined by field riveting. Variation from theoretical alignment and grade at the time of completion of placing shall not exceed 8 mm per 10 m (1 inch per 100 feet).

The diameter of the excavated hole shall not be more than 30 mm (0.1 foot) greater than the outside diameter of the pipe. Sluicing or jetting with water will not be permitted. When material tends to cave in from outside these limits, a shield shall be used ahead of the first section of pipe or the face of the excavation shall not extend beyond the end of the pipe greater than 0.5 m (1-1/2 feet), unless permitted by the Engineer.

**306-2.5 Tolerances.** Concrete conduit shall be jacked true to line and grade and the Contractor shall modify the jacking operation to correct any deviation. Unless otherwise shown on the Plans or in the Specifications, when a pilot tunnel is required to be constructed in connection with jacking reinforced concrete pipe or box sections, the Contractor will be permitted a tolerance from exact grade or alignment of 8 mm per 10 m (1 inch per 100 feet).

**306-2.6 Payment.** The price per meter (foot) of jacked conduit shall include full compensation for excavation; constructing, supporting, and removing pilot tunnels; constructing reinforced concrete

cradles where required; providing grout holes, grout, and grouting where necessary; and doing whatever else is appurtenant to jacking conduit within the limits shown on the Plans and as specified herein.

Except when a bid item is provided for jacked casing, the cost of furnishing and jacking casing in place shall be included in the Contract Unit Price per linear meter (foot) bid for that portion of the pipeline or conduit to be installed within the casing.

When a section of reinforced concrete pipe conduit is specified to be constructed by jacking methods, the specified limits for jacking may be increased by the Contractor with the approval of the Engineer. Such increased limits may require an increase in the strength of the pipe to be jacked. When reinforced concrete pipe conduit is specified to be constructed by open trench method, the Contractor may construct said conduit by jacking methods, with the approval of the Engineer. Such methods may require an increase in strength of the pipe.

When a change in construction method or an increase in jacking limits as specified herein is requested by the Contractor and authorized by the Engineer, payment for the work will be based on the Contract Unit Prices as though the specified method had been used.

### **306-3 TUNNELING OPERATIONS.**

**306-3.1 General.** Required pipe tunnel locations and lengths are shown on the Plans. However, tunnels may be constructed at the Contractor's option in lieu of trench construction. The Contractor shall, in accordance with 2-5.3, submit a proposed plan of tunnel operation which shall include drawings showing details of the following:

- 1) Tunnel shaft bracing and dimensions.
- 2) Tunnel supports (see 306-3.4).
- 3) Method of backpacking tunnel supports.
- 4) Method of transporting pipe in tunnel.
- 5) Bracing to prevent pipe shifting and flotation.
- 6) Pressure concrete mix design, placement method and equipment.

Isolated tunnels or undercrossings less than 6 m (20 feet) in length shall be adequately supported, subject to inspection and approval by the Engineer in the field. Submission of shop drawings in accordance with 2-5.3 will not be required for this case.

All provisions regarding backpacking and backfilling contained in 306-3.6 and 306-3.7 shall apply to such tunnels, except that if the roof of any such tunnel, or portion thereof, is sloped upward toward the ends of the tunnel for the full width of the excavation at an angle of 45 degrees or greater with the horizontal, the backfill within the sloped portion of the tunnel may be made with material removed from the excavation and densified by flooding or jetting, or mechanically compacted to a minimum relative density of 85 percent.

If the supporting base of any substructure is disturbed or any sewer or storm drain is exposed or partially exposed, it shall be supported with a concrete wall.

**306-3.2 Excavations.** Access shafts or portals shall be located where shown on the Plans or designated in the Specifications. Where no such locations are given, the Contractor shall have the option of determining such locations subject to approval by the Engineer. In general, access shafts or portals will not be permitted within street intersections.

The Contractor shall excavate all materials encountered in the tunnel within the width and height necessary to install tunnel supports, place pipe, make joints, properly place backfill to fill all void space around the pipe and do whatever else is necessary to complete the pipe installation in the tunnel.

Clearances shown on the tunnel details on the plans are minimum and no encroachment within the dimensions shown will be permitted. The spring line clearances shown shall be increased by 75 mm (3 inches) for any tunnel to be constructed on a curve with a centerline radius of less than 90 m (300 feet).

All drilling and blasting shall be performed in such a manner to avoid undue shattering or loosening of material. The Contractor shall remove all material which is likely to fall or appears dangerous to workers or the Work. The fact that such removal may enlarge the excavation beyond the required limits shall not relieve the Contractor from the necessity of performing such work, and the Contractor shall not be entitled to any additional compensation by reason of such tunnel enlargement.

Loose material in the invert shall be removed to a reasonably clean rock surface or undisturbed foundation prior to placing pipe bedding and installing pipe. Deep depressions may be filled with suitable material approved by the Engineer. The work of removing loosened invert material and filling the resulting depressions or enlargement of the tunnel from overshooting or overexcavating shall be considered a part of tunnel excavation and no additional compensation will be allowed therefore.

**306-3.3 Dewatering.** All water encountered in constructing the tunnel shall be disposed of by the Contractor in such manner as will not damage public or private property or create a nuisance or health menace. The Contractor shall furnish, install, and operate pumps, pipes, appliances, and equipment of sufficient capacity to keep all tunnel excavations and accesses free from water until the tunnel is backfilled, unless otherwise authorized by the Engineer. The Contractor shall provide all means or facilities necessary to conduct water to the pumps. Water, if odorless and stable, may be discharged into an existing storm drain, channel, or street gutter in a manner approved by the Engineer. When required by the Engineer, a means shall be provided for desilting the water before discharging it.

**306-3.4 Tunnel Supports.** Unless otherwise shown on the Plans, the materials used for tunnel supports may be timber, metal, concrete, or a combination thereof at the option of the Contractor. Steel liner plates, if used, shall be provided with grout connections sufficient in number to permit backpacking by means of grout, should such action prove necessary. All tunnel supports shall conform to the requirements set forth in the Tunnel Safety Orders of the State of California. The Contractor shall, in accordance with 2-5.3, submit drawings of tunnel supports proposed to be used. Such drawings shall include full details of the proposed tunnel supports (including connections), longitudinal and transverse bracing and foot blocks, the proposed method of pipe installations, the proposed method of backpacking tunnel supports, and other pertinent details.

The tops of foot blocks shall be installed below the pipe barrel a distance of  $1/16$  the pipe diameter or a minimum of 100 mm (4 inches), whichever is greater. Transverse timber struts, spreaders, and footings will be permitted only where necessary to support horizontal thrust from the tunnel sides. Timber bracing, where necessary, may be left in place provided it lies entirely below the bottom of the pipe the distance specified herein for foot blocks and does not occupy more than 15 percent of the bottom area of the tunnel.

Vertical and horizontal clearance dimensions between pipe sockets and the inside face of continuous tunnel supports, lagging, splining, or steel liner plates as specified herein or as shown on the Plans, will be considered minimum dimensions. The clearance dimensions between pipe sockets and such intermittent timber and steel members as timber sets or steel rib sets are also minimum dimensions and no encroachment within the dimensions specified will be permitted. It shall be the responsibility of the Contractor to increase tunnel dimensions where necessary in order to provide adequate room for workers and equipment and such space shall be at no increase in cost to the Agency.

Unless otherwise specified or shown on the Plans, the minimum clearances shall be as follows:

For tunnels to be backfilled with pressure concrete, the minimum side clearance at the spring line of pipe sockets to continuous steel or timber shall be 300 mm (12 inches), and to intermittent sets or ribs shall be 250 mm (10 inches). The minimum overhead clearance from pipe sockets to nearest inside face of any steel or timber member shall be 250 mm (10 inches).

For tunnels to be backfilled with gunite concrete or gunite sand, the minimum side clearance at the springline of pipe sockets shall be as for pressure concrete backfill specified above, but the minimum overhead clearance shall be increased to 450 mm (18 inches).

The minimum side and top clearances prescribed herein shall be increased by 75 mm (3 inches) for pipe without projecting sockets or collars and shall apply to the barrel of the pipe.

No exterior work will be required on the following types of joints:

- 1) Socket and spigot pipe with rubber gasket or mechanical compression joints.
- 2) Pipe 600 mm (24 inches) or larger in internal diameter.
- 3) Steel-ring-and-gasket-type reinforced concrete pipe for sewers, if the tunnel backfill and bedding under the pipe are concrete; or where the tunnel backfill is concrete and the bedding material under the pipe is granular and the Contractor beds the pipe for 100 mm (4 inches) on each side of the joint in fresh mortar at least 75 mm (3 inches) thick and extending 50 mm (2 inches) above the top of the granular bedding material.

The Contractor will be required to do such reconstruction of tunnel supports at its expense as may be necessary to meet the foregoing requirements. The Agency may make minor revisions in the horizontal tunnel alignment where possible in sections at least 15 m (50 feet) long to minimize the extent of such reconstruction. Similar changes in vertical alignment will generally not be approved.

All timber collar braces and, to the extent practicable, timber supports, lagging and blocking shall be removed prior to backfilling tunnels, except where such removals would be hazardous to persons or the structure. Material to remain in place shall be cleaned of adhering tunnel muck or other material not suitable for backfill.

**306-3.5 Subgrade and Bedding.** Pipe shall be placed and bedded as shown on the Plans or drawings specifying the methods of laying and bedding pipe in trenches.

If an invert slab is required or otherwise placed separately, it shall be 125 mm (5 inches) minimum thickness, the full width of the tunnel, and the concrete shall be tunnel backfill concrete as specified in 201-1. Concrete shall not be placed until placement method and equipment have been approved. The slab, when placed separately, shall be cured for at least 5 days prior to the application of heavy loading.

Payment for rock or other base material required to the extent shown on the Plans or drawings for pipe bedding in trenches, shall be considered as included in the price paid for pipe complete in place and no additional compensation will be made therefore.

All rock required to fill voids caused by overexcavation or to maintain the tunnel bottom to support construction equipment and tunnel supporting members, or to control water throughout the period of tunnel excavation, shall be furnished and placed by the Contractor and the cost thereof shall be included in the price paid for pipe complete in place and no additional compensation will be made therefore.

When ordered by the Engineer, rock, in addition to that required by the Plans for bedding, shall be placed by the Contractor and payment therefore will be made as provided in 3-2.

**306-3.6 Backpacking Tunnel Supports.** Voids behind all temporary or permanent tunnel support systems, including overbreak, cave-ins, and chimneys, shall be backpacked as specified herein. Backpacking shall be placed progressively as soon as practicable after placement of tunnel supports. When ordered by the Engineer, the Contractor shall place backpacking immediately. The non-backpacked length of tunnel shall be held to the minimum practicable for the method of backpacking utilized by the Contractor.

Tunnels in rock supported by timber lagging, steel liner plate, or bolted steel plate tunnel lining shall be backpacked either with pressure grout or soil-cement except that tunnel spoil may be used to the mid-height of the tunnel. When voids  $0.03 \text{ m}^3$  (1 cubic foot) in size or larger exist behind lagging or sheeting in tunnels so supported in soil, the Contractor shall backpack behind such supports with either pressure grout or tunnel spoil when ordered by the Engineer.

Tunnels in rock or soil and supported by timber or steel sets with partial timber or metal lagging may be backpacked to the mid-height of the tunnel with tunnel spoil.

All spaces not filled with such backpacking shall be filled at the time of, and with material selected for, tunnel backfilling around the pipe.

Tunnel spoil used for backpacking shall be selected from the better spoil material available, and shall contain sufficient fines to fill all voids. Such material shall be rammed into place. Soft or wet clay may be used only if satisfactory compaction can be obtained. Otherwise the Contractor will be required to import granular material for backpacking at no additional cost to the Agency.

Soil-cement for backpacking lagged or fully lined tunnels shall consist of a slightly moistened mixture of 1 part cement to 5 parts of granular material selected from the tunnel spoil when such material is suitable. Otherwise, granular material shall be imported at the Contractor's expense. The soil-cement shall be thoroughly mixed and rammed into place immediately following placement of tunnel supports. The placement interval shall not exceed three rings of liner plate or the distance between tunnel sets. Mechanically or pneumatically operated tampers shall be used to ram the soil-cement into place unless another placing method is approved by the Engineer.

**306-3.7 Tunnel Backfill.** Pipe laying operations in tunnels shall not precede tunnel backfill by more than 45 m (150 feet) without the approval of the Engineer. Longer reaches may be approved if tunnel clearances are increased from the minimums shown in order to obtain additional working space around the pipe.

The space between the tunnel supports and the pipe shall be completely backfilled with the materials and methods specified herein. The backfill material shall be forced or packed into all the crevices and around all timber sets or steel ribs from the tunnel invert to its crown. The Contractor shall provide whatever wedging or bracing is needed to ensure against pipe movement during placement of backfill.

Backfill for tunnels in rock shall be limited to pressure concrete or gunite concrete.

The approval of the use of gunite concrete for backfill is contingent upon the prior backpacking of tunnel supports with acceptable materials other than gunite concrete.

Unless the Plans for tunnels to be constructed in soil require the use of pressure concrete or gunite concrete for backfill, the Contractor may use gunite sand for backfill.

Gunite sand shall be placed with a pneumatic gun in accordance with the requirements for placing gunite concrete except that no portland cement need be added. The Contractor may add up to 60 kg of cement per cubic meter (100 pounds of cement per cubic yard) to improve placement stability at its option and expense. In either case, water sufficient to saturate the material and ensure proper packing and minimize rebound shall be added to the mixture. The nozzleperson shall operate in the immediate vicinity of the backfill face to ensure compaction and complete filling of voids.

The Contractor shall submit to the Engineer for approval, at least 30 days prior to backfill operations, a proposed mix design and method of placing concrete, including placing equipment. No pressure concrete backfill shall be placed until mix design, placement method, and equipment have been approved. If the approved mix cannot be readily pumped or placed by the Contractor's placing equipment, additional water may be added, provided the water-cement ratio of the approved mix design is not exceeded.

The pressure concrete shall be placed by methods capable of forcing it into crevices and filling all void spaces in the tunnel. Unless otherwise provided on the Plans, the concrete backfill shall be placed under pressure by means of a "slick" line and pneumatic or positive displacement pumps.

The combined length of the slick line and delivery line shall not exceed the recommendation of the manufacturer of the concrete pump or, if no manufacturer's performance data is available, 45 m (150 feet). The discharge end of the slick line shall be rigid conduit with a minimum length of 3 m (10 feet). It shall be kept buried in at least 1.5 m (5 feet) of fresh concrete during concrete placement. Concrete shall be pumped continuously during withdrawal of the slick line to eliminate voids.

**306-3.8 Pressure Grouting of Voids.** Where the Engineer has reasonable doubt that the tunnel void spaces are completely filled, the Contractor shall pressure grout such locations as ordered through grout pipes to be installed either from the ground surface or from within the conduit. At least two grout holes will be required at each location to permit escape of air. The location of surface grout pipes may be adjusted as may be required, dependent upon traffic requirements on overhead streets.

Grout for filling voids shall be low pressure grout (less than 70 kPa (10 psi)). Neat cement grout shall be used except that large voids shall be filled with pressure concrete or grout containing sand.

Grout shall be placed by means of pumps of positive displacement or pneumatic type and capable of placing grout at pressures up to 700 kPa (100 psi) unless otherwise approved by the Engineer. Grout shall be placed at pressures which are requisite for the conditions encountered, and will ordinarily be less than 70 kPa (10 psi) except in cases where large cave-ins or other adverse conditions may require higher pressures.

Regardless of the materials or methods of backfilling or filling voids used, the Engineer shall reserve the right to require filling of void spaces known to remain by additional grouting. Such work will be deemed to have resulted from the Contractor's operations and shall be done at its expense.

**306-3.9 Payment.** Unless the Specifications provide for unit prices for individual work items included in tunnel work, the lump sum or unit price per linear meter (foot) for tunnel as set forth in the Bid shall include full compensation for dewatering, backpacking, maintaining tunnel supports, placing tunnel backfill, low pressure grouting, providing access shafts of portals including excavation, backfill and replacement of surface or other improvements, furnishing and installing pipe, and doing whatever else is appurtenant to tunnel construction within the limits shown on the Plans or in the Specifications. Unless otherwise specified, payment for tunnel excavation shall include the excavating of any type of material encountered. High-pressure grouting required by the Engineer, and not resulting from an act or failure to act on the part of the Contractor, will be paid for as extra work as provided in 3-2.

For pipe laid through tunnel access shafts, payment shall be made as provided in 306-1.6.

#### **306-4 CAST-IN-PLACE NON REINFORCED CONCRETE PIPE (CIPCP).**

**306-4.1 General.** These specifications are for cast-in-place nonreinforced concrete pipe intended to be used for gravity and low head drains and irrigation systems.

- 1) Trench construction shall conform to 306-1.1.2, and
- 2) Where soils encountered are not capable of standing unsupported from the bottom of trench to the top of the pipe without sloughing and where soils are saturated or contain

water quantities or other conditions harmful to the concrete, the Contractor shall install an alternate pipe as directed by the Engineer. The substitution of alternate pipe shall be at no additional expense to the Agency.

**306-4.2 Materials.** Concrete, unless otherwise specified, shall conform to 201-1, Class 330-C-23 (Class 560-C-3250), except that:

- 1) The slump shall be 25 mm (1 inch) minimum and 75 mm (3 inches) maximum and measured only after all water has been added. No water shall be added after the slump test material has been sampled, and
- 2) Concrete shall not be placed when temperature of the concrete exceeds 32°C (90°F) or is less than 10°C (50°F). The soil adjacent to the trench shall be at a temperature above freezing, and
- 3) Batch proportions shall be designed by the Contractor and submitted to the Engineer for written approval 7 days in advance of any work.

**306-4.3 Excavation.** Trenches shall be excavated to ensure the pipe is constructed on the alignment and to the grades shown on the Plans and Specifications. The subgrade shall be fine graded to the tolerances specified in 306-4.6.5. No concrete shall be placed unless the trench is within the specified grade and alignment tolerances.

**306-4.3.1 Trench Width.** Except for curves and structures, the trench shall not exceed the width of the pipe OD plus 50 mm (2 inches) for a height of 0.3 m (1 foot) above the top of the pipe. The bottom of the trench shall be shaped to serve as the outside form of the pipe. The trench shall provide full, firm, and uniform support over the bottom 210 degrees of the pipe, which is referred to as the "trench form". See Plans for curves and structures.

**306-4.3.2 Isolated Rock.** Where isolated rock is encountered within the trench form, it shall be removed. If the rock is too large to be removed by hand, all portions of the rock within 150 mm (6 inches) of the lower 90 degrees of the trench form shall be removed. The void shall be refilled with the monolithically placed concrete, if approved by the Engineer, prior to construction of the pipe placed or backfilled with soil compacted to a minimum relative compaction of 90 percent.

**306-4.3.3 Extensive Rock.** Where extensive rock is encountered, the bottom 90 degrees of soil and rock shall be overexcavated to a depth of 150 mm (6 inches) below the trench form and 300 mm (12 inches) on the remaining portions of the trench forms. The void shall be refilled with the class of concrete used for the CIPCP or with soil compacted to a minimum relative compaction of 90 percent when approved by the Engineer.

**306-4.3.4 Soil Moisture.** At the time of concrete placement, all soils to be in contact with cast-in-place pipe shall be moistened, but shall not contain standing, seeping, or flowing water. Provisions shall be made to dewater the trench so that flowing or standing water is eliminated. The Contractor may, at its sole cost, place a layer of 25 mm (1 inch) maximum size rock 150 mm (6 inches) thick below the trench invert to assist in water control.

#### **306-4.4 Placement.**

**306-4.4.1 General.** Concrete placement shall be in accordance with 303-1.8 except as provided herein. The flowline grade and alignment of the finished pipe shall conform to the tolerances stated in 306-4.6.5.

**306-4.4.2 Concrete Forms.** The concrete shall be placed around the full circumference of the pipe in one operation by means of fixed forms and traveling forms. The internal fixed forms shall be of sufficient strength to withstand the vibrating or tamping of concrete. Inflatable internal forms shall not

be used. The internal fixed forms shall be of sufficient strength to prevent deformation during construction of the placed concrete. The concrete shall be vibrated, tamped, or worked with suitable devices until the concrete has been consolidated and completely fills the forms.

**306-4.4.3 Pipe Junction.** Where junction structures are to be constructed, the pipe shall be continuous through the structure locations. The pipe shall be cut away to the specified opening prior to the final set of concrete. Alternate methods may be used as approved in writing by the Engineer.

**306-4.4.4 Construction Stoppage.** When placement is stopped for a period of time that initial set is likely to occur or 20 minutes, whichever is less, a construction joint shall be made by sloping the end of the pipe at approximately 45 degrees and inserting 600 mm (24 inches) long No. 10M (No. 3) dowels 300 mm (12 inches) into the center of the pipe wall at approximately 450 mm (18 inches) intervals around the pipe circumference. The total exposed face shall be left in a roughened condition.

Before placing operations may resume, the concrete placed at the construction stoppage joint shall attain sufficient strength to permit an excavation to be made on each side of the joint to form a concrete collar. This collar shall be centered on the joint and have a minimum thickness of one and one-half times the pipe wall thickness and a length of 600 mm (24 inches). The joint shall be cleaned of laitance, foreign, and loose materials before resuming concrete placement.

**306-4.4.5 Form Removal.** Internal fixed forms shall remain in place until the concrete is self-supporting, after which they may be loosened but shall not be removed for at least 6 hours after placement. As soon as practical thereafter, the forms shall be removed to facilitate inspection and prompt repair. At times of low temperature or other adverse conditions the forms may be kept in place for longer periods of time.

**306-4.4.6 Finishing.** The interior of the pipe shall be at least as smooth as a steel trowel finish except for the form lap ridges permitted in 306-4.6.4

**306-4.4.7 Curing.** Immediately after concrete placement, the exposed top portion of the pipe shall be cured by placing a polyethylene film at least 0.038 mm (0.0015 inch) thick so as to completely cover the top surface. All openings in the pipe shall be covered with 0.038 mm (0.0015 inch) polyethylene and securely fastened for at least 7 days immediately after placement. At locations where work on the pipe is required, and only during the period that such work is actually in progress, shall necessary openings be uncovered.

**306-4.4.8 Repairing.** After the internal fixed forms have been removed, the inside of the pipe shall be inspected by the Engineer. All rock pockets, blisters, voids, or similar defects not extending through the wall and less than 0.18 m<sup>2</sup> (2 square feet) in area, shall be repaired immediately by removing the defective concrete and replacing it with properly bonded and cured mortar or other patching material approved by the Engineer.

All rock pockets, blisters, voids, or other defects greater than 0.18 m<sup>2</sup> (2 square feet) or which extend through the pipe wall shall be repaired by removing the entire pipe for 1 foot on each side beyond the limits of the defect.

Cracks shall not be repaired until the entire backfill is in place. However, the Contractor may remove and replace cracked pipe prior to placement of the entire backfill.

Subsequent to placement of the entire backfill, the Contractor shall notify the Engineer when the pipe is ready for reinspection. Cracks less than 0.255 mm (0.01 inch) in width or cracks greater than 0.255 mm (0.01 inch) but less than 300 mm (12 inches) long shall be painted with a cement paste. Longitudinal cracks exceeding 0.255 mm (0.01 inch) in width and 300 mm (12 inches) in length must be repaired by epoxy pressure grouting provided the total length of cracks for any reach is less than 25

percent. If the total length of cracks exceeds 25 percent, the entire reach shall be removed and replaced. A reach is any length between two structures.

Circumferential cracks exceeding 0.255 mm (0.01 inch) in width and 300 mm (12 inches) in length shall be repaired by removing at least 25 mm (1 inch) of concrete in width for a depth of at least one-half the wall thickness. After cleaning this area, it shall be filled with properly bonded and cured mortar.

Alternate repair methods shall be submitted in writing not less than 7 days prior to use for approval by the Engineer. Any repairs performed shall ensure the specified structural strength is not compromised and by techniques which have been approved by the Engineer.

**306-4.4.9 Rejection.** Pipe will be rejected for any of the following reasons:

- 1) Longitudinal cracks exceeding 0.255 mm (0.01 inch) in width and 300 mm (12 inches) or greater in length unless repaired per 306-4.4.8. If longitudinal cracks occur intermittently in 25 percent or more of a reach of pipe, the pipe shall not be repaired and shall be removed and replaced.
- 2) Circumferential cracks exceeding 0.255 mm (0.01 inch) in width and 300 mm (12 inches) or greater in length unless repaired per 306-4.4.8.
- 3) Longitudinal cracks exceeding 1/1000 the internal diameter or a maximum 1.5 mm (1/16 inch) in width.
- 4) Rock pockets, honeycombing, blisters, voids, or other defects that extend through the pipe wall.
- 5) A wall thickness less than the minimum as listed in 306-4.6.3.
- 6) A diameter that does not meet the requirements of 306-4.6.2.
- 7) Application of any wash coat of cement, grout, or other material prior to reinspection after the entire backfill has been placed.
- 8) Air bubble voids (bugholes) on the interior surface of the pipe exceeding 6 mm (1/4 inch) in depth unless pointed with mortar or other approved material.
- 9) Unpaired offsets or indentations, including transverse and longitudinal form offsets exceeding those allowed in 306-4.6.4
- 10) Deviation or departure from true grade or alignment exceeding that allowed in 306-4.6.5.
- 11) Concrete used that has a slump of less than 25 mm (1 inch) or more than 75 mm (3 inches) per 306-4.2. Concrete that has had water added after slump and/or cylinder samples have been taken or that does not meet the proportioning requirements of 201-1.
- 12) Concrete that has core strengths less than that required specifications per 306-4.2.
- 13) The pipe does not pass the load test per 306-4.7.4.
- 14) The pipe has been damaged in any manner including but not limited to placing or compacting the backfill.
- 15) Concrete that has been placed when the concrete temperature exceeded 32°C (90°F) or was less than 10°C (50°F), or when the soil adjacent to the trench was below freezing.
- 16) The trench does not provide full, firm, and uniform support over the bottom 210 degrees of the pipe or the trench width exceeds the OD per 306-4.6.3 by more than 50 mm (2 inches), except when meeting the requirements of 306-4.3.1, 4.3.2, and 4.3.3.
- 17) The interior of the pipe is not at least as smooth as a steel trowel finish except for the form lap ridges.

**306-4.5 Backfill.** Backfill for cast-in-place pipe shall be considered as starting at the top of the trench form and shall conform to 306-1.3. The method of backfilling shall be subject to the approval of the Engineer. The equipment used in placing the backfill shall not cause damage to the pipe or cause loads to be placed on the pipe which are in excess of design loads.

Backfilling will not be permitted over cast-in-place concrete pipe until the concrete attains the strength specified. The Contractor may place backfill prior to 28 days upon written approval by the Engineer provided the required 28-day strength has been attained and verified by a laboratory.

**306-4.6 Dimensions and Tolerances.**

**306-4.6.1 General.** The minimum nominal size of cast-in-place pipe shall be 600 mm (24 inch) ID.

**306-4.6.2 Diameter.** The internal diameter of the pipe at any point shall not be less than 99 percent nor more than 105 percent of the nominal diameter, and the average of any four measurements of the internal diameter made at 45-degree intervals shall not be less than the nominal diameter.

**306-4.6.3 Wall Thickness.** The wall thickness at any point shall not be less than specified on the Plans and in no case less than in the following table. Any length which fails to meet the thickness requirements will be rejected. The grade and alignment shall be controlled so that the wall thickness of the pipe is symmetrical.

**TABLE 306-4.6.3 (A)**

Internal Diameter		Minimum Wall Thickness	
Millimeters	Inches	Millimeters	Inches
600 and 750	24 and 30	76	3
900	36	89	3-1/2
1050	42	102	4
1200	48	127	5
1350	54	140	5-1/2
1500	60	153	6
1650	66	165	6-1/2
1800	72	178	7
1950	78	191	7-1/2
2100	84	203	8
2250	90	216	8-1/2
2400	96	229	9
2700	108	254	10
3000	120	305	12
3300	132	356	14
3600	144	381	15

For any ID not indicated above, the minimum wall thickness shall be equal to the next size larger pipe. Wall thickness will be determined in accordance with 306-4.7.4, or when applicable, with 306-4.7.1.

**306-4.6.4 Offsets and Indentations.** Any offset or indentation, including transverse and longitudinal form offsets and construction stoppage joints, shall not exceed 6 mm (1/4 inch) for pipe with specified ID of 1050 mm (42 inches) or less, and 10 mm (3/8 inch) for pipe with specified ID over 1050 mm (42 inches) and less than 1800 mm (72 inches), and 13 mm (1/2 inch) for all pipe diameters equal to or greater than 1800 mm (72 inches).

Reaches having offsets or indentations in excess of these limits shall be repaired as approved by the Engineer.

**306-4.6.5 Grade and Alignment.** Departure from and return to established grade shall not exceed 10 mm/m (3/8 inch per foot) and maximum departure shall not exceed 25 mm (1.0 inch). Maximum

departure from established alignment shall not exceed 50 mm (2 inches) on tangents and 100 mm (4 inches) on curves. Departure from and return to established alignment shall not exceed 20 mm/m (1/4 inch per foot). A laser grade control shall be used for all trenches.

If the departure exceeds the maximum allowed, the work shall be stopped and the necessary adjustments made. The affected portions of the conduit exceeding the above departure shall be removed and replaced at the proper grade and alignment.

### **306-4.7 Test Requirements.**

**306-4.7.1 Sequence of Sampling and Testing.** Sampling and testing shall be performed in the sequence described herein. Tests for portland cement concrete will be taken during concrete placing operations in accordance with 201-1.1.4. If the concrete cylinders do not meet the required 28-day strength, cores shall be obtained from the completed pipe. Cores shall be used to determine thickness and compressive strength. Strength test results shall be verified by a laboratory approved by the Engineer. If the strength of these cores fails to meet the design requirements, the pipe will be rejected.

The Engineer will determine the number and location of the samples and tests. The location shall be identified by station, and where applicable, the angle from vertical measured clockwise facing up-station.

**306-4.7.2 Thickness.** The Engineer will determine the wall thickness of the pipe as follows:

- 1) The thickness at the invert and crown of the pipe will be measured by probing at approximately 7.5 m (25 foot) intervals during placement of the concrete. The probe shall be forced through the concrete to make firm contact with the form at the crown and shall be held in a position normal to the surface when the measurement is taken. The invert shall be inspected by removing a small portion and measuring the thickness. The probe shall be 9.5 mm (3/8 inch) round bar, at least 50 mm (2 inches) longer than the wall thickness to be measured, rounded on one end with a tee handle on the other.
- 2) Thickness at the invert and springline will be measured through holes drilled by the Contractor. The holes shall be at least 19 mm (3/4 inch) in diameter and shall be drilled after the removal of the forms and within 72 hours of concrete placement.

Three holes shall be drilled every 15 m (50 feet) at the invert and both springlines and shall be located as determined by the Engineer. The Engineer may require additional holes on curves to determine the extent of thin sections.

After measurement, the Contractor shall fill all holes using Class C mortar per 201-5. All costs of probing, drilling, removing, and repairing shall be borne by the Contractor.

**306-4.7.3 Concrete Cores.** Cores, where required, shall be obtained from pipe and tested in accordance ASTM C 42. The cores shall have a length-to-diameter ratio of not less than one. The diameter of cores shall be at least three times the maximum size of the aggregate used in the concrete, except where the wall thickness is such that the length-to-diameter will be less than one, in which case the core diameter may be reduced to two and one-half times the maximum aggregate size used.

There shall be at least four cores taken for each 60 linear meters (200 linear feet), or fraction thereof, of pipe. Cores shall be taken at the following points at stations selected by the Engineer: one through the crown, one through the invert, and two in the lower half of the pipe 45 degrees from the vertical. The Engineer may require additional cores at any location. The Contractor shall patch all core holes in such a manner that the patch will be permanent, will not leak, and will have a smooth finish flush with the interior surface of the conduit. All costs of coring, testing, and patching core holes shall be borne by the Contractor.

**306-4.7.4 Load Bearing.** Load bearing tests shall be required for every 300 linear meters (1,000 feet) of pipe having the same size and wall thickness, with a minimum of one per size and two per project. The test locations will be specified by the Engineer. The test shall be performed in the presence of the Engineer, and the Contractor shall be responsible for all costs and risks involved. Failure of the test section will be cause for rejection of the conduit represented by the test.

The method and apparatus requirements for load bearing tests are as follows:

- 1) The test shall be performed with only the trench form providing bottom support. If the pipe has been constructed so that more than 210 degrees is in contact with the natural soil, the trench wall shall be re-excavated to provide 210 degrees of trench form without altering the existing bedded condition of the trench form.
- 2) The test length shall be at least 1.2 m (4 feet) and not more than 1.5 m (5 feet). At the option of the Contractor, the test section may be isolated from the completed pipe.
- 3) The test load shall be applied by use of a "sand box," consisting of a frame and bearing plate, in such a manner that sand carefully placed in the sand box forms a bearing symmetrically about the centerline and over the entire length of the test section. The width of the bedding shall be 0.7 times the specified ID of the pipe. The minimum thickness of the sand shall be 0.25 times the specified ID.
- 4) The frame and bearing plate shall be sufficiently rigid so that they will distribute the load uniformly and will not deform under the loaded condition. The interior surfaces of the frame shall be smooth. The lower surface of the bearing plate shall be a true plane. Cloth or plastic film shall be attached to the inside of the frame along the lower edges to prevent the loss of sand through the gap between the pipe and the frame. This type of apparatus is described in ACI Specification 346.
- 5) The frame shall be properly located on the pipe test section and filled with sand. The sand shall be clean and graded so that it will pass a 4.75 mm (No. 4) sieve. The sand shall be struck off level and covered with the bearing plate. During the test, the bearing plate shall not contact the frame.
- 6) The load shall be applied symmetrically on the bearing plate until the total required has been attained. The pipe shall remain loaded until the interior of the pipe has been inspected by the Engineer and results have been observed and recorded.
- 7) The applied load, in Newtons (pounds), shall equal the test load multiplied by the length of the test section, in meters (feet). The test load shall be calculated as follows:

SI Units:

$$\text{Test Load} = (20030H + 1.5LL + 10.48T) \text{ OD} + 5340 (\text{ID})^2$$

Where:

- ID = Specified inside diameter of the pipe in meters.  
 T = Specified wall thickness of the pipe in millimeters.  
 OD =  $\text{ID} + 2T/1000$  = Outside diameter of pipe in millimeters.  
 H = Depth of cover on pipe in meters.  
 LL = Live load on pipe in Pascals.

US Standard Measure:

$$\text{Test Load} = (127.5H + 1.5LL + 5.56T) \text{ OD} + 34.0 (\text{ID})^2$$

Where:

- ID = Specified inside diameter of the pipe in feet.  
 T = Specified wall thickness of the pipe in millimeters.  
 OD =  $ID + 2T/12$  = Outside diameter of pipe in feet.  
 H = Depth of cover on pipe in feet.  
 LL = Live load on pipe in pounds per square foot.

TABLE 306-4.7.4 (A)

Depth of Cover		Live Load (LL)	
Meters	Feet	Pascals	Lb./Feet <sup>2</sup>
0.9	3	23400	489
1.2	4	15000	314
1.5	5	11200	234
1.8	6	8710	182
2.0	7	6940	145
2.4	8	5700	119
2.7	9	5750	120
3.0	10	4310	90
Over 3.0	Over 10	N/A	N/A

8) The total test load shall be supported by the test section without the development of any additional cracking.

9) After the satisfactory completion of the test, the Contractor shall repair the pipe, resulting from isolating the test section, in a manner satisfactory to the Engineer.

In lieu of using a "sand box" as described above, the Contractor may conduct a wheel load test on a 1.2 m (4 foot) section of pipe when approved in writing by the Engineer. The load applied shall be determined by the equation in item 7 above applied to a section of pipe. The total test load shall be supported by the test section without the development of any additional cracking.

**306-4.8 Payment.** The contract price paid per linear foot for CIPCP shall include full compensation for doing all work involved in constructing the pipeline, including excavation, backfill, testing, repair, and replacement as specified or as directed by the Engineer.

**306-5 ABANDONMENT OF CONDUITS AND STRUCTURES.** When sanitary sewer or storm drain conduits have been or are to be abandoned and are found to interfere with construction, the interfering portion shall be removed and the remaining open portion securely sealed. Where the greater internal dimension of the conduit is 1.2 m (4 feet) or less, the seal shall consist of a wall of concrete not less than 150 mm (6 inches) thick or a 200 mm (8 inch) wall of brick and mortar. For larger openings, details of the seal will be shown on the Plans. In the case of catch basin connector pipes, the inlet opening to the mainline pipe shall also be sealed.

When a sanitary sewer or storm drain is to be abandoned within specified limits, all structures and appurtenances within said limits shall also be abandoned.

When catch basins or manholes are to be abandoned, the upper portion shall be removed to a depth of at least 0.3 m (1 foot) below street subgrade and the conduits connecting to the structure shall be sealed as provided herein. The bottom of such structures shall be perforated or broken to prevent the entrapment of water.

Structures designated on the plans to be removed shall be removed to the full depth of the structure, including its foundation. Voids resulting from abandoned or removed structures shall be filled with suitable material compacted to a relative compaction of 90 percent.

Cover sets, gratings, and other steel components (except reinforcing bars) of removed or abandoned structures shall be salvaged. The Contractor shall contact the owners and, if required, shall deliver to and load such material in the owner's truck at the Work site. Otherwise, such material shall become the property of the Contractor and shall be disposed of by it away from the Work site.

**306-6 REMODELING EXISTING SEWER FACILITIES.** Where the Plans indicate construction involving existing sewer facilities, the Contractor shall provide temporary seals, enclosures, forced ventilation, or other devices as may be necessary to prevent odor nuisance during construction. Sewers shall be open to the atmosphere only for a reasonable time necessary for construction.

All existing sewer facilities shall be considered potential permit-required confined spaces in accordance with 7-10.4.4. Hazards to which workers may be exposed, include, but are not limited to engulfment, hydrogen sulfide gas, explosive/flammable gases, and/or oxygen deficiency. When required, the Contractor shall implement a permit space program in accordance with 7-10.4.4.

Where a manhole bottom is to be remodeled on an existing sewer, the portion to be remodeled shall be removed to a minimum depth of 75 mm (3 inches) to permit construction of new channels and shelves. Sewage in new and remodeled manholes shall be controlled across the manhole in such a manner that sewage does not flow over concrete channels until they have cured for 24 hours. The controls shall prevent backup of sewage upstream from the manhole unless otherwise approved by the Engineer.

Where required by the Plans or Specifications, the Contractor shall submit shop drawings for control operations in accordance with 2-5.3.

**306-7 CURB DRAINS.** Drains shall be constructed beneath the sidewalk to connect building drains to curb outlets and to serve low areas on adjacent property as shown on the Plans or as directed by the Engineer.

The drain shall be a 75 mm (3 inch) diameter pipe for a 150 mm (6 inch) curb face, and a 100 mm (4 inch) diameter pipe for an 200 mm (8 inch) curb face or greater. The invert of the drain shall be located 13 mm (1/2 inch) above the gutter flowline. The drain pipe shall have a minimum 50 mm (2 inch) clearance from top of curb and be laid on a straight grade with a minimum slope of 10 mm/m (3/8 inch per foot) and terminate 25 mm (1 inch) back of the curb face.

Curb drains may be constructed using pipe materials specified in Section 207 or other pipe materials approved by the Engineer. The pipe shall be suitably joined in accordance with the manufacturer's standard jointing system.

### **306-8 MICROTUNNELING.**

#### **306-8.1 General.**

**306-8.1.1 Description.** Microtunneling is an unmanned entry method that uses a remotely operated microtunnel boring machine (MTBM) to install pipes underground with minimal surface disruption. Microtunneling continuously installs pipe behind a remotely controlled, steerable, laser-guided, full-face controlled, articulated MTBM. The pipe to be installed is connected to and follows the MTBM.

The length of drive which is possible to achieve is dependent upon the jacking force, pipe material, and pipe size.

The jacking force required is a function of many variables including the soil conditions, depth of the pipeline, annular space between the pipe and the soil, lubrication of the pipe, water table location, overburden loads, installation time, pipe material, out-of-roundness, diameter, and strength.

**306-8.1.2 Minimum Soil Cover.** The minimum depth of cover to the top of the installed pipe using this process shall be one and one-half to three times the outside diameter of the pipe being installed, or 2 m (6 feet), whichever is greater depending on the soil conditions. With prior approval of the Engineer, the minimum depth of cover may be reduced.

**306-8.1.3 Surface Description.** Unless otherwise noted in the Contract Documents, settlement or heave at the ground surface during and after construction shall not exceed 13 mm (1/2 inch) or unless specified in the Contract Documents as measured along the centerline of the conduit being installed. Zero settlement or heave may be required when specified in the Contract Documents or required by applicable permits.

**306-8.1.4 Definitions.**

**Annular Space** - The void created between the outside diameter of pipe being installed and extreme outer limits created by MTBM bore process.

**Earth Pressure Balance** - MTBM pressure applied to the cutting face equals the pressure of earth against the cutting face.

**Full Face Control** - Complete mechanical support of the excavated face at all times.

**Lubricant** - A substance applied between the pipe and soil to minimize friction and to fill the annular space.

**Microtunneling Boring Machine (MTBM)** - A remotely controlled, steerable, laser guided microtunnel boring machine consisting of an articulated boring machine shield and a rotating cutting head.

**Pipe String** - The succession of joined individual pipes being used to advance the excavation equipment.

**Shaft or Pit** - A vertical excavation to insert or receive microtunneling equipment and pipe.

**Slurry** - Water mixture, which may contain additives, that is used to transport spoils and counterbalance any ground water pressure.

**306-8.1.5 Submittals.** The Contractor shall submit the following items for review and approval by the Engineer in accordance with 2-5.3. The Contractor shall allow 20 working days for review by the Engineer. Approval of the submittal by the Engineer shall be obtained prior to ordering pipe materials and/or start of the microtunneling operations.

- 1) Manufacturers' data sheets and specifications describing in detail the microtunneling system to be used.
- 2) Description of similar projects with references on which the proposed system had been successfully used by contractor/operator.
- 3) Description of method to remove and dispose of spoil
- 4) Maximum anticipated jacking loads and supporting calculations.
- 5) Description of methods to control and dispose of groundwater, spoil, temporary shoring, and other materials encountered in the maintenance and construction of pits and shafts.
- 6) Shaft dimensions, locations, surface construction profile, depth, method of excavation, shoring, bracing, and thrust block design.
- 7) Pipe design data and specifications.
- 8) A description of the grade and alignment control system.
- 9) Intermediate jacking station locations and design.
- 10) Description of lubrication and/or grouting system.
- 11) Layout plans and descriptions of operational sequence.
- 12) A detailed plan for monitoring ground surface movement (settlement or heave) due to the microtunneling operation. The plan shall address the method and frequency of survey

measurement. At minimum, the plan shall measure the ground movement of all structures, roadways, parking lots, and any other areas of concern within 8 m (25 feet) on both sides of all microtunneling pipelines at a maximum spacing of 30 m (100 feet) along the pipeline route, or as required by the Engineer.

- 13) Contingency plans for approval for the following potential conditions: damage to pipeline structural integrity and repair; loss and return to line and grade; and loss of ground.
- 14) Procedures to meet all applicable OSHA requirements. These procedures shall be submitted for a record purpose only and will not be subject to approval by the Engineer.

At a minimum, Contractor shall provide the following:

- a) Protection against soil instability and ground-water inflow.
  - b) Safety for shaft access and exit, including ladders, stairs, walkways, and hoists.
  - c) Protection against mechanical and hydraulic equipment operations, and for lifting and hoisting equipment and material.
  - d) Ventilation and lighting.
  - e) Monitoring for hazardous gases.
  - f) Protection against flooding and means for emergency evacuation.
  - g) Protection of shaft, including traffic barriers, accidental or unauthorized entry, and falling objects.
  - h) Emergency protection equipment.
  - i) Safety supervising responsibilities.
- 15) Annular space grouting plan if required by Contract Documents.

#### **306-8.1.6 Subsurface Conditions.**

(a) **Microtunneling Specified by the Agency.** The Agency will make accessible to the Contractor all available subsurface information, if any, which is listed in 2-7 and 306-8.1.6 (c). All subsurface investigations deemed necessary by the Contractor to complete the work shall be included at no additional cost to the Agency. Copies of all reports and information obtained by the Contractor shall be provided to the Agency.

(b) **Microtunneling Requested by the Contractor.** When microtunneling is proposed by the Contractor as an alternative to the specified methods of conduit installation, the Contractor shall obtain and provide the Agency with the copies of the information and reports listed in 2-7 and 306-8.1.6 (c) at no additional cost to the Agency. Microtunneling operations must be approved by the Agency prior to commencement of work.

(c) **Subsurface Data.** The following subsurface information will affect equipment selection and the progress and practicality of microtunneling. The actual test data required will vary depending upon the scope of the project and soil conditions encountered and may include but not be limited to the following:

Particle-size analysis ASTM D 422

Soil Classification ASTM D 2487

Plastic limit ASTM D 4318

Liquid limits ASTM D 4318

Plasticity index ASTM 4318

Expansion index ASTM D 4829

Density ASTM D 1556, D 2037, D 5195, D 4564.

Water (Moisture) content ASTM D 4959, D 2216 D 5220, D 3017, D 4643 D 4944.

Shear strength:

Direct ASTM D 3080

Triaxial, C.U. ASTM D 4767

Unconfined compressive strength ASTM D 2166

Permeability ASTM D 2434

Apparent or unconfined soil cohesion.

Standard penetration test (SPT) ASTM D 1586.

Water table depth

Nature of fill material

Nature of pollutants

Rock type and color

Fracture index

Rock quality designation (RQD)

Core recovery, TCR.

All reasonable attempts will be made to collect subsurface test samples within 6 m (20 feet) horizontally of the centerline of the proposed conduit location. Subsurface test samples are to be collected to a minimum depth of one pipe diameter below conduit invert. The test samples should typically be collected at 60 m (200 ft) intervals or at manhole locations.

**306-8.1.7 Site Cleanup.** Unless otherwise specified, all existing surface improvements damaged or removed as a result of microtunneling operations shall be restored to their original condition.

### **306-8.2 Major Components of a Microtunneling System.**

**306-8.2.1 MTBM.** The MTBM selected shall be capable of installing the pipe while being compatible with the anticipated soil and geotechnical conditions. The MTBM cutter face shall at all times be capable of supporting the full excavated area without the use of ground stabilization and have the capability of measuring the earth pressure at the face and setting a calculated earth balancing pressure. The maximum radial annular space shall not exceed 25 mm (1 inch), unless otherwise specified in Contract Documents.

The MTBM shall be capable of controlling shield rotation by means of a bi-directional drive on the cutter head or by use of mechanical fins or grippers. The MTBM shall be mechanically articulated to enable remotely controlled steering of the shield. The MTBM shall control groundwater during excavation without the use of external dewatering equipment. The measuring and balancing of earth and groundwater pressure shall be achieved by use of a slurry or cased auger system. The system shall be capable of incremental adjustments to maintain face stability for the soil conditions encountered.

**306-8.2.2 Jacking Equipment.** The main jacks shall be mounted in a jacking frame and located in the jacking shaft. The MTBM shall be moved forward by the jacks advancing a successive string of connected pipes toward a receiving shaft.

A pipe lubrication system may be used to lower the friction developed on the surface of the pipe during jacking with approval of the Engineer. An approved lubricant, typically bentonite or polymers, may be injected at the rear of the MTBM or through lubrication ports. The pipe lubrication system pressure shall be continuously monitored, recorded, and controlled to prevent pipe buckling and/or ground heave.

A thrust block is required to transfer jacking loads into the soil. The thrust block shall be perpendicular to the proposed pipe alignment. The thrust block shall be designed to support the maximum jacking pressure developed by the main jacking system. Special care shall be taken when

securing the pipe guide rails and/or jacking frame in the jacking shaft to ensure correctness of the alignment, grade, and stability of the pipe. If a concrete thrust block or treated soil zone is utilized to transfer jacking loads into the soil, the MTBM shall not be jacked until the concrete or other materials have attained the required strength.

When intermediate jacking stations are utilized, the maximum jacking force shall not exceed the maximum allowable jacking load of the pipe.

**306-8.2.3 Excavation Controls.** The control equipment shall integrate the method of excavation and removal of soil and its simultaneous replacement by a pipe. As each pipe section is jacked forward, the control system shall synchronize spoils removal, excavation, and jacking speeds.

Operations shall be stopped when they result in pipe damage or any surface disruption. The Contractor shall propose immediate action for review and approval by the Engineer to remedy the problem at no additional cost to the Agency.

**306-8.2.4 Automated Spoils Transportation.** The MTBM shall include one of the following:

(a) **Slurry System.** The system shall be capable of measuring earth and groundwater pressure and making the adjustments required to counter-balance the earth and groundwater pressure to prevent loss of slurry or uncontrolled soil and groundwater inflow.

- 1) The slurry pressure at the excavation face shall be controlled by use of slurry pumps.
- 2) A slurry bypass method shall be included to allow for a change in direction of flow to be made and/or isolated.
- 3) Provide a separation process, properly sized for the tunnel being constructed, the soil type being excavated, and the workspace available at each area. Separate the spoil from the slurry so that slurry may be returned to the cutting face for reuse.
- 4) Monitor the composition of the slurry to maintain the slurry density and viscosity limits as approved in the submittals.

(b) **Cased Auger System.** The system shall monitor and continuously balance the soil and groundwater pressure. The system shall be capable of adjustments required to maintain face stability for the particular soil condition to be encountered to prevent loss of soil or uncontrolled groundwater inflow.

- 1) Maintain the pressure at the excavation face by controlling the volume of spoil removal with respect to the advance rate. Monitor the speed of the rotation of the auger and the amount of water added.
- 2) Submit an evaluation of equipment's ability to balance earth and water pressure at the face, stability of the soils, and the significance of the groundwater present for the Engineer's review.

**306-8.2.5 Active Steering Controls.** A remotely controlled steering mechanism shall be provided that allows for the operation of the system without the need for personnel to enter the microtunnel.

The steering information shall be monitored and transmitted to the operation console. The minimum steering information available to the operator on the control console shall include the position of the shield relative to the design reference, roll, inclination, attitude, rate of advance, installed length, thrust force, and cutter head torque.

**306-8.2.6 Guidance/Monitoring Equipment.** The MTBM display equipment shall continuously show and automatically record the position of the shield with respect to the project design line and grade. The automated recording system shall include real time information such as earth and ground pressure, roll, pitch, attitude, rate of advance, installed length, cutter head torque, jacking loads, slurry pressure, slurry flow, and slurry valve positions.

Line and grade shall be controlled by a guidance system that relates the actual position of the MTBM to a design reference (e.g., by a laser beam transmitted from the jacking shaft along the line of the pipe to a target mounted in the shield). The line and grade tolerances of pipe installed shall be  $\pm 25$  mm (1 inch) on grade and 38 mm (1-1/2 inches) in line between shafts, unless otherwise stated in the Contract Documents or approved by the Engineer.

The rate of return to line and grade shall not exceed 1:300 (1 inch in 25 feet), unless otherwise specified.

**306-8.3 Methods.** Prior to pipe installation, the Contractor shall implement the approved plan submittals to monitor ground movement.

**306-8.3.1 Intermediate Shafts.** If an intermediate shaft is requested, the Contractor shall obtain a written approval from the Engineer. The intermediate shaft shall not be located in areas prohibited the Contract Documents. The Contractor's request shall include all necessary permits and approvals, minimize public inconvenience and minimize impacting existing facilities.

**306-8.3.2 Annular Space Grouting.** the annular space created by the overcut of the MTBM in excess of 19 mm (3/4 inch) shall be filled with an approved material, unless otherwise specified by Contract Documents.

When grouting is specified, pressure-injected grout shall fill voids outside the limits of the excavation created by caving or collapse of earth cover over the excavation.

The Contractor shall furnish and operate suitable equipment for any required grouting operations depending on the condition of the application. The grouting operation shall not damage adjacent utilities or other properties. Grout shall be injected at a pressure that will not distort or imperil any portion of the work or existing installations or structures.

**306-8.3.3 Work Hours.** Work hours are not restricted unless stated otherwise in the Contract Documents. Multiple shifts may be used where permitted by the Contact Documents and if noise levels do not exceed local ordinances. Continuous microtunneling will be permitted where:

- 1) Expansive soils are encountered; or
- 2) The actual jacking forces required approach either the capacity of the jacking system or the designed jacking capacity of the pipe.

**306-8.3.4 Construction Zone.** Any microtunneling construction zone in the public right-of-way shall be limited to one lane traffic, or the Contractor shall maintain a minimum of one lane of traffic in each direction. The Engineer may specify a larger or smaller zone if circumstances warrant.

**306-8.3.5 Shafts.** Shafts shall be of a size commensurate with safe working practices and located as described in the Contract Documents. With the written approval of the Engineer, the Contractor may relocate shafts to better suit the capabilities of the microtunneling equipment proposed.

Shaft locations shall, where possible, be kept clear of road intersections and within a single traffic lane, in order to minimize disruption to the flow of traffic.

The design of the shafts shall ensure safe MTBM exit from the driving shaft and entry into the receiving shaft. The Contractor shall furnish and install equipment to keep the jacking shaft free of

excess water. The Contractor shall also provide surface protection during the period of construction to ensure that surface runoff does not enter shafts.

All shafts shall be backfilled per 306-1.3. All shoring materials, bracing, temporary supports, rubbish, and construction materials shall be removed from the jobsite and disposed of.

**306-8.3.6 Installation and Field Testing.** The pipe installation shall be tested in accordance with 306-1.4.

**306-8.4 Payment.** Unless the Specifications provide for unit prices for individual work items included in microtunneling work, the lump sum or unit price per lineal foot for microtunneling as set forth in the Bid shall include full compensation for grouting and lubricants; providing jacking/receiving/recovery shafts including excavation, disposal, dewatering, backfill and replacement of surface or other improvements; furnishing and installing pipe, excavating, and disposal of materials encountered by installation of the pipe; and all other work appurtenant to microtunneling within the limits described in the Contract Documents.

**306-8.5 Pipe Specification.** In general, pipe used for this subsection shall be specifically designed for microtunneling by the pipe manufacturer. The pipe shall be round, smooth, and with flush-jointed outer surfaces. The ends of the pipe shall be perpendicular to the longitudinal axis of the pipe with a maximum deviation of no more than 5 mm/m (1/16 inch per foot) of pipe diameter, with a maximum of 6 mm (1/4 inch), measured with a square and a straight edge across the end of the pipe. Pipe ends shall be square and smooth so that jacking loads are evenly distributed against the pipe end faces without point loads when the pipe is jacked. Pipe used for microtunneling shall be capable of withstanding the jacking forces imposed by the process of installation, as well as the final in-place loading conditions. The driving ends of the pipe and intermediate joints shall be protected against damage. The detailed method proposed to cushion and distribute the jacking forces shall be submitted to the Engineer for approval.

Damaged pipe shall be jacked through to the reception shaft and be removed. Other methods of repairing the damaged conduit may be used, as recommended by the manufacturer and approved by the Engineer.

The pipe manufacturer's design jacking loads shall not be exceeded during the installation process. The pipe shall be designed to take full account of all temporary installation loads. The pipe materials acceptable for microtunneling will be specified in the Contract Documents.

The maximum jacking capacity used shall not exceed the allowable jacking capacity of the pipe that has a minimum factor of safety of 2.5.

## SECTION 307 - STREET LIGHTING AND TRAFFIC SIGNALS

### 307 CROSS REFERENCES

Electrical Components .....	209
Paint and Protective Coatings.....	210
Galvanizing .....	210-3
Removal and Disposal of Materials.....	300-1.3
Concrete Curbs, Walks, Gutters, Cross Gutters, Alley Intersections, Access Ramps, and Driveway .....	303-5

**307-1 GENERAL.**

**307-1.1 Description.** The work shall consist of furnishing and installing, modifying, or removing one or more electrical systems, all as shown on the Plans and in the Specifications.

All materials furnished and used shall be new, except materials specified to be reused.

All incidental parts which are not shown on the Plans or in the Specifications, and which are necessary to complete or modify the existing systems, shall be furnished and installed as though such parts were shown on the Plans or specified herein. All systems shall be in satisfactory operations at the time of completion of the Work.

**307-1.2 Regulations and Codes.** All work shall be performed in accordance with the regulations and codes listed in 209-1.

**307-1.3 Equipment List and Drawings.** Unless otherwise authorized in writing by the Engineer, the Contractor shall, within 10 days following execution of the Contract, submit to the Engineer for approval, a list of equipment and materials that it proposes to install. The list shall be complete as to name of manufacturer, size, and identifying number of each item. In addition, the Contractor shall, in accordance with 2-5.3, submit detailed drawings and wiring diagrams for all electrical equipment to be used. The Agency will not be liable for any material purchased, labor performed, or delay to the Work prior to review of documents required above.

If ordered by the Engineer, the Contractor shall submit for review sample articles of the material proposed for use. After review, said sample articles will be returned to the Contractor.

Upon completion of the Work, the Contractor shall submit one complete set of corrected Plans showing in detail all construction changes.

**307-1.4 Warranties, Guaranties, and Instruction Sheets.** Manufacturer's warranties and guaranties furnished for materials used in the Work and instruction sheets and parts lists supplied with materials shall be delivered to the Engineer prior to acceptance of the Work. The duration of the warranty or guaranty shall be the standard of the industry with a minimum of 1 year from the date of acceptance of the Work.

**307-1.5 Maintenance of Existing Systems.** The Contractor, during the progress of the Work, shall maintain existing electrical systems or temporary replacements thereof, in effective operation. The Contractor shall notify the Engineer at least 2 working days prior to performing work on existing systems. Should any damage to an existing system occur, the Contractor shall immediately notify the Engineer. The Contractor shall arrange for the immediate repair and restoration to service of the damaged lighting system at no additional cost to the Agency. Electrical safety clearance shall be obtained before performing any work on existing energized street lighting circuits. A licensed electrical contractor shall make all temporary or permanent repairs. All equipment and materials used for the repair shall be approved by the Agency. The Contractor shall perform the required repairs or replacements within 24 hours of damaging the system or receiving the approval of the equipment and materials by the Agency, whichever takes longer. If the repairs are not completed within this period the Agency will make the repairs or replacements and the cost thereof will be deducted from any monies due or that will become due the Contractor.

In cases where a temporary removal or relocation of the existing street lighting system or equipment, that is not shown on the plans, and is requested by the Contractor, the Contractor shall submit a detailed plan to the Agency for review and approval before performing any such work. This plan shall show the changes to be made. All such work shall be accomplished by a licensed electrical contractor at no additional cost to the Agency.

Temporary wiring described herein shall not apply to circuits exceeding 150 volts to ground.

Temporary wiring may be either overhead or underground conductors. All temporary overhead conductors shall be slackspanned with 6.1 m (20 foot) minimum overhead clearance across thoroughfares and 3.7 m (12 foot) minimum clearance above sidewalk areas. No temporary conductor may run on top of the ground or across any sidewalk area unless adequately protected in an electrical raceway. Conductors less than 3.0 m (10 feet) above ground level must be protected in an electrical raceway. Overhead conductors shall be multi-conductor cable or single conductors, securely tied or taped at intervals not to exceed 1.5 m (5 feet). No spare conductors are required. All splices within 3.0 m (10 feet) above ground level shall be enclosed in metal junction boxes. Splices made at ground level shall be enclosed in pull boxes.

### **307-2 CONSTRUCTION GENERAL.**

**307-2.1 Excavation and Backfill.** The excavation required for the installation of conduit, foundations, and other equipment shall be performed in such a manner as to cause the least possible damage to the streets, sidewalks, and other improvements. Prior to the start of excavation the Contractor shall comply with all of the requirements of 5-1. The trenches shall not be excavated wider than necessary for the proper installation of the electrical equipment or foundations. Excavating shall not be performed until just prior to installation of equipment. The material from the excavation shall be placed in a location to cause the least obstruction to surface drainage and vehicular and pedestrian traffic.

Where excavations are required in parkways and lawns, existing sod shall be removed and preserved by the Contractor. After backfilling, the sod shall be replaced in accordance with 308-4.8.3, and the entire area restored to original grade and condition.

Where excavations are required in concrete sidewalk, cuts and joints shall conform to the applicable provisions of 300-1.3.

At the end of each day, and at all other times when construction operations are suspended, all equipment, material, and debris shall be removed from that portion of the right-of-way open for vehicular and pedestrian traffic. Barricades shall be erected at all excavations not backfilled or finished to final grade.

All excavations shall be kept filled and maintained in a smooth and well-drained condition until permanent repairs are completed. Excavations, including those resulting from removal of existing equipment as specified on the Plans, shall be backfilled, compacted, and the surface restored to match existing improvements in conformance with the applicable requirements of 306-1.3 and 7-9, respectively.

The work in the street or highway shall be performed in such a manner that not more than one lane of traffic is restricted in either direction at any time, unless approved by the Engineer.

**307-2.2 Foundations.** All work shall conform to line, elevation and grade as shown on the Plans or as established by the Engineer.

The longitudinal grade for the foundation cap shall be the same as the grade for the top of the existing curb. If there is no curb, the longitudinal grade will be established by the Engineer.

The transverse grade shall be established as follows:

- 1) Existing curb and no sidewalk - The grade shall slope upward from the top of the back face of curb at the rate of 20 mm per meter (1/4 inch per foot).
- 2) Existing curb and sidewalk - The grade shall be a straight line from the top of the back face of curb to the top of the near edge of sidewalk, and shall join all around in full-width sidewalk or sidewalk constructed adjacent to the curb.

- 3) Service road parkways - The grade shall be a straight line between the top of the back face of one curb to the top of the back face of the other curb.
- 4) If the lateral grade of the existing parkway exceeds a slope of plus or minus 80 mm/m (1 inch per foot), the Contractor shall install retaining walls and aprons as directed by the Engineer. Retaining walls not shown on the Plans will be considered as extra work.

The foundations shall be constructed in a single placement of concrete of the class specified in 201-1. The bottom of the foundations shall rest securely on firm, undisturbed ground. When a firm footing cannot be obtained at the depth shown on the Plans, or where the foundation cannot be constructed to standard dimensions because of an obstruction, the foundation shall be installed as directed by the Engineer.

Where forms are required because of soil conditions or grade, they shall be true to line and grade, firmly braced and secured in place, and shall not be removed until the concrete has set.

Foundations shall cure for 24 hours before erecting standards and 72 hours before erecting arms. Pile foundations shall cure for 48 hours before erecting standards and 7 days before erecting arms.

Wherever the edge of a concrete foundation extends within 450 mm (18 inches) of any existing concrete improvement, a concrete slab with a minimum thickness of 75 mm (3 inches) shall be extended to meet such improvement.

The foundation cap shall be of similar color, finish, and material as the adjacent sidewalk. It shall be a minimum of 75 mm (3 inches) thick and shall be placed after the standard is set in final position.

Concrete foundation and sidewalk construction shall conform to 303-1, 303-5, and 305-1.3.

All anchor bolts, nuts, and washers, including those required for existing standards to be relocated, shall be furnished by the Contractor and shall conform to 209-2.2.

Any foundation installed within the sidewalk or parkway shall pose no hazard to pedestrian traffic. The above ground portion of a foundation, if any, and/or anchor bolts, conduits etc. shall be marked with traffic control devices approved by the Engineer. The Contractor shall erect and attach these traffic control devices (i.e. cones, delineators, barricades etc.) to the foundation. These traffic control devices are to protect pedestrians from the above ground portion of the foundation, and/or exposed anchor bolts, conduit, etc. Adequate access shall be provided for disabled pedestrians adjacent to the foundation. These traffic control devices shall remain and be maintained in place until the related equipment is installed on the foundation.

**307-2.3 Standards and Steel Pedestals.** Plumbing of standards shall be accomplished by adjusting the nuts on the anchor bolts before the foundation cap is placed. Shims or other similar devices for plumbing or raking will not be permitted. If base covers or foundation caps are not used, anchor bolts shall be cut 6 mm (1/4 inch) above the nuts. If anchor bolts are cut, the cut surfaces shall be repaired in accordance with 210-3.5.

Holes left in the shafts of existing standards, due to removal of equipment, shall be repaired as follows:

**Steel shafts** – Welding a suitable disc, grinding smooth, and painting as provided for repairing damaged galvanized surfaces in 210-3.

**Concrete shafts** – Grouting to match existing texture and color.

**307-2.4 Pull Boxes.** Pull boxes shall be installed at the locations shown on the Plans. If not shown, they shall be approximately equally spaced, but not over 60 m (200 feet) for Traffic Signal Interconnect, 90 m (300 feet) for street lighting systems, and not over 183 m (600 feet) apart for fiber optic cable systems.

Pull boxes shall not be installed in any part of a driveway or other traveled way unless otherwise specified. Pull boxes shall be a minimum of 1.5 m (5 feet) from the top of the "X" dimension of

driveways and access ramps. It shall be the option of the Contractor, at its expense and subject to the approval of the Engineer, to install additional pull boxes that it may desire to facilitate the work.

The bottom of the pull box shall rest firmly on a 300 mm (12 inch) thick bed of 25 mm (1 inch) crushed rock extending 150 mm (6 inches) beyond the outside edges of the pull box.

The grade for the top of pull boxes shall be established as provided for in 307-2.2. Where practical, pull boxes shown in the vicinity of curbs shall be placed adjacent to the back of curb. Pull boxes where practical shall be installed with the long side parallel to the curb.

Where ballasts or transformers are installed in a pull box, a pull box extension shall be used.

**307-2.5 Conduit.** All conductors shall be run in conduit except where they are inside standards, or for overhead and temporary installations or otherwise specified.

All conduit shall be the rigid galvanized steel type unless otherwise specified. All threads shall be treated with approved joint compound before fittings are placed thereon. Where the galvanized coating of conduit or fittings has been damaged in handling or installing (other than by jacking operations), such damaged areas shall be thoroughly painted with a rust-preventive paint.

Detector, telephone interconnect, or street lighting conduit shall be 25 mm (1 inch) nominal size unless otherwise specified. Direct interconnect, utility service, or Traffic Signal conduit shall be 50 mm (2 inch) nominal size unless otherwise specified.

The Contractor may, at its expense, use conduit of a larger size than that shown or specified, provided the larger size is used for the entire length of the run. Reducing couplings shall not be used.

Conduit installed on the surface of poles or structures or other exposed locations or in concrete structures and foundations shall be unpainted, except that exposed conduit installed on a painted structure shall be painted the same color as the structure.

The conduit run on the surface of structures shall be secured with galvanized malleable iron clamps spaced not more than 1.5 m (5 feet) apart.

Expansion fittings, as detailed on the Plans, shall be installed where the conduit crosses an expansion joint in a structure. Each expansion fitting shall be provided with a No. 8 AWG copper bonding jumper.

Conduit shall be placed to a depth of not less than 750 mm (30 inches) nor more than 1500 mm (60 inches) below the flowline grade, except that conduit placed behind a curb shall not be less than 350 mm (14 inches) nor more than 900 mm (36 inches) below top of curb; and conduit placed under railroad tracks shall not be less than 900 mm (36 inches) nor more than 1500 mm (60 inches) below bottom of ties. Conduit shall be placed directly behind the curb. However, when there are obstructions such as foundations, pullboxes, water meter vaults, etc., the conduit may be placed further behind the curb. In no case shall the conduit be placed more than 900 mm (36 inches) behind the curb unless otherwise approved by the Engineer.

Conduit may be laid on top of the existing pavement within curbed medians being constructed on top of said pavement.

Conduit laid in open trench shall not be covered nor shall any trench or inspection hole be backfilled until the Engineer has approved the installation.

Conduit shall be placed under existing pavement by jacking, drilling, or directional boring methods. Pavement shall not be disturbed without permission from the Engineer, except at potholes to expose utility lines in the street as required by 5-1. Jacking or drilling pits shall be kept 0.6 m (2 feet) clear of the edge of any type of pavement wherever possible. Excessive use of water, such that pavement might

be undermined, or softened, will not be permitted. In no case shall any water used in the Work be allowed to enter any storm drain system.

Jacking pits adjacent to railroad tracks shall be constructed not less than 3.7 m (12 feet) from the centerline of track. When the jacking pit is left overnight, it shall be covered with substantial planking.

Conduit shall be bent without crimping or flattening, and shall have a radius of not less than six times the inside diameter of the conduit.

Spare conduit stubs from foundations shall extend at least 150 mm (6 inches) from the face and at least 350 mm (14 inches) below the top of foundation and shall be capped on each end.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made so that the ends will come together for the full circumference thereof. Slip joints or running threads shall not be used for coupling conduits.

All conduit fittings shall be galvanized steel. Couplings shall be securely tightened to provide a good electrical and mechanical connection throughout the entire length of the conduit run. When a standard coupling cannot be used, a threaded union coupling approved by the Engineer shall be used.

A No.12 AWG pull wire or equivalent strength cord shall be installed in all complete conduit runs that are to receive future conductors. At least 0.6 m (2 feet) of pull wire shall be extended beyond each end of the conduit run and secured.

All conduit ends shall be capped until the pulling of conductors is started. When caps are removed, the ends of metallic-type conduit shall be provided with threaded conduit bushings.

Conduit shall be blown clean with compressed air prior to installing conductors. In the presence of the Engineer, The Contractor may be required to pass a proper size-testing mandrel through all conduit.

Conduit terminating in street lighting standards shall not be transposed and shall terminate as near the door of the standard as possible with the end of the conduit below, but within 25 mm (1 inch) of the lower edge of the door. The prolongation of the conduit shall pass through the door opening.

Conduit terminating in traffic signal standards of pedestals shall extend vertically approximately 25 mm (1 inch) above the foundation cap and shall be centered within the bolt circle.

All conduit entering concrete pull boxes shall terminate within 50 to 100 mm (2 to 4 inches) inside the box wall and not be less than 50 mm (2 inches) above the bottom nor be less than 125 mm (5 inches) below the top. The prolongation of the conduit shall pass through the top of the box. Conduits shall enter from the direction of the run.

All conduit ends in pull boxes and standards shall be securely packed with an approved sealant after conductors are installed.

All conduit terminated without a pull box shall be capped and identified by chipping the standard "4" at least 75 mm (3 inches) in height on the curb.

**307-2.6 Wiring.** Wiring shall be done in conformance with 307-1.2, and the requirements of this subsection.

Connectors and terminals for use with aluminum utility power service conductors shall be aluminum and shall be greased with an approved inhibitor.

Where low-voltage conductors are run in standards containing high-voltage conductors, either the low-voltage or the high-voltage conductors shall be encased in flexible or rigid metallic conduit to a point where the two types of conductors are no longer in the same raceway.

Conductors shall be pulled by hand. Winches or other power-actuated pulling equipment shall not be used. Only approved lubricants may be used in placing conductors in conduit.

Splices shall be made only in pull boxes and standard bases. Conductors shall be joined by the use of a connector approved by the Engineer. The splice shall be capable of satisfactory operation under continuous submersion in water.

Conductor insulation shall be well-penciled, trimmed to conical shape, and roughened before applying splice insulation. Splice insulation shall consist of layers of vinyl chloride electrical insulating tape, conforming to ASTM D 2301, Type I, applied to a thickness equal to and well-lapped over the original insulation.

A total of 0.6 m (2 feet) of slack shall be left at each standard, and within each pull box sufficient slack shall be left to extend 450 mm (18 inches) above the top of pull box grade.

Small, permanent identification bands shall be marked as specified. The bands shall be securely attached to conductors in pull boxes and near the termination of each conductor. Where circuit and phase are clearly indicated by conductor insulation, bands need not be used. Permanent identification bands shall be embossed, 0.15 mm (6 mil), oil-resistant polyvinyl chloride tape with pressure-sensitive backing. Tape shall be of a type such that symbols contrast with the background color.

**307-2.7 Bonding and Grounding.** Metallic cable sheaths, metallic conduit, nonmetallic conduit grounding wire, ballast and transformer cases, service equipment, sign switches, anchor bolts, and metal standards that form a continuous system shall be effectively grounded. Bonding and grounding jumpers shall be copper wire or copper strap of the same cross-sectional area as No. 8 AWG for all systems, except where noted herein.

Grounding of metallic conduit, service equipment, and neutral conductors at service points shall be accomplished as required by the applicable code and the serving utility, except that grounding conductors shall be No.6 AWG copper wire.

For bonding purposes in all nonmetallic type conduit, a bare No.8 AWG copper wire shall be run continuously in all circuits.

Bonding of standards shall be accomplished by means of a No. 8 AWG bonding wire attached from a grounding bushing to a foundation bolt or a 4.5 mm (3/16 inch), or larger, brass or bronze bolt installed in the lower portion of the standard.

Bonding of metallic conduit in nonmetallic pull boxes shall be by means of copper strap or galvanized grounding bushing and bonding jumpers.

For Series Circuits the metallic conduit or bonding conductor system shall be securely grounded, at intervals not to exceed 150 m (500 feet), to one of the following:

- 1) A 25 mm (1 inch) galvanized pipe driven to a depth of 2.4 m (8 feet) and having its upper end not more than 75 mm (3 inches) above the conduit; or,
- 2) A minimum 13 mm by 2.4 m (1/2 inch by 8 foot) copper-coated (minimum thickness of rod coating 0.3 mm (0.01 inch) steel rod driven to a depth of 2.4 m (7 feet 9 inches); or,
- 3) A metal water service pipe on the street side of meter, with the approval of the owner. The water pipe shall be thoroughly scraped and cleaned prior to connection.

For Multiple Circuits, the metallic conduit or bonding conductor system shall be grounded at the service points.

On wood poles, all equipment mounted less than 2.4 m (8 feet) above ground surfaces shall be grounded.

**307-2.8 Service.** The Contractor shall furnish and install all material and equipment necessary to complete the electrical connection between the terminating point of the serving utility and the electrical system, as shown on the Plans. Prior to the expiration of the first 10 percent of the working days, the Contractor shall install the necessary facilities to receive utility service connection. The Engineer shall arrange with the serving utility to complete service connections.

### **307-3 STREET LIGHTING CONSTRUCTION.**

**307-3.1 General.** Street lighting construction shall conform to the requirements of 307-2 and 307-3.

**307-3.2 Pull Box Covers.** Pull box covers shall be inscribed "STREET LIGHTING" "HIGH VOLTAGE."

**307-3.3 Wiring.** For series-circuit lighting conductor splices, sufficient synthetic oil-resistant rubber tape, conforming to the requirements of ASTM D 119, shall be applied over the conductor to fill all voids before placing the vinyl chloride tape specified herein and then be well covered with a coating of approved insulating paint or similar material.

For multiple circuits, an approved fused disconnect splice connector shall be installed in each ungrounded conductor between the line and the ballast. The connector shall be installed in the base of the luminaire standard or in an adjacent pull box and be readily accessible.

**307-3.4 Service.** For series street lighting systems served from overhead circuits, a switch of 5,000-volt rating shall be connected to control each circuit. The switch shall be enclosed in a NEMA Type 3R, 450 mm x 600 mm x 150 mm (18 inch by 24 inch by 6 inch) terminal box. The terminal box shall be fitted with a cover permanently inscribed "DANGER - HIGH VOLTAGE." The cover shall be attached to the box to form a raintight plate and shall require tools for removal. The terminal box shall be installed not less than 3 m (10 feet) above the ground.

**307-3.5 Lamp Size and Identification.** Each lamp shall be identified with a target affixed to the underside of the horizontal luminaire or on the body facing oncoming traffic for upright luminaires. Existing tape targets shall be removed and disposed of or covered as directed by the Engineer. The target shall be made of noncorrosive material to provide a durable and legible surface that is designed to endure for the life of the luminaire. The target shall have a stable color background and black block numerals. The target shall be 7.62 cm (3 in.) square. The targets shall have the identification numbers and background color shown in Table 307-3.5A and Table 307-3.5B respectively. The identifying numerals shall be 5.08 cm (2 in.) high, minimum, and have a stroke width of 0.64 cm (1/4 in.).

TABLE NO. 307-3.5 (A)

Identifying Numeral	Lamp Wattage
1	18
3	35
5	50 or 55
7	70
9	90
10	100
13	135
15	150 – 55V
15H	150 – 100V
17	175
17B	175 Position Oriented
18	180
20	200
21	215
25	250
25B	250 Position Oriented
30	300
31	310
36	360
40	400
40B	400 Position Oriented
70	700
XI	1000

TABLE NO. 307-3.5 (B)

Background Color	Lamp Type
GOLD	High Pressure Sodium
GREEN	High Pressure Sodium/Mercury Ballast
LIGHT BLUE	Mercury
RED	Metal Halide
TAN	Low Pressure Sodium

### 307-4 TRAFFIC SIGNAL CONSTRUCTION.

**307-4.1 General.** Traffic signal construction shall conform to the requirements of 307-2 and 307-4.

**307-4.2 Temporary Signal Systems.** Temporary traffic signal heads shall provide a minimum of two clearly visible signal faces for traffic from each direction, one being adjacent to the left side of the traveled way and one being adjacent to the right side of the traveled way. If a mast arm is required, then a temporary mast arm shall be installed. The approved location and any additional signal faces shall be determined by the Engineer. All temporary signals shall be securely mounted at approximately a 3 m (10 foot) height on wood poles, platform standards, or semipermanent structures. Mast arms, where required, shall provide a minimum clearance of 5.2 m (17 feet) from the traveled way to the bottom of the signal. All primary and mast arm signals shall have backplates. All mast arm signals and arrow indications shall be 300 mm (12 inch) size and other signals shall be 200 mm (8 inch) size.

When traffic signal shutdown is permitted by the Engineer, it will be for a 2-hour period between 9 a.m. and 2 p.m. Work necessitating longer periods of time may be authorized by the Engineer. Preliminary work associated with the shutdown shall be done prior to the actual shutdown in order to minimize the amount of

time necessary for the completion of the work. Sufficient manpower and equipment shall be employed by the Contractor to minimize the shutdown period. Once a shutdown is effected, all work shall be diligently pursued without interruption until the signals are back in normal operation. Delays in effecting the shutdown by the Engineer shall not constitute shutdown time for the Contractor.

In all cases, shutdown, flashing operation, and turn-on must be requested at least 24 hours in advance and will be supervised or performed by the Engineer.

**307-4.3 Controller Cabinet Wiring Diagrams.** Prior to acceptance of the Work, the Contractor shall furnish five sets of traffic signal controller cabinet schematic wiring diagrams which shall have the same phase designations as shown on the Plans for the intersection. The diagrams shall show the location of the installation and shall list all equipment installed in each cabinet. In addition, for each signal installation, the Contractor shall furnish an intersection sketch showing standards, detectors, and phasing. One copy of the controller cabinet diagram and the intersection and phase diagram, as reviewed by the Engineer, shall be placed in a heavy-duty plastic envelope and attached to the inside of the door of each controller cabinet.

**307-4.4 Pull Box Covers.** Pull box covers to be installed in signal systems, or combined signal and low voltage lighting systems, shall be inscribed "TRAFFIC SIGNALS." Pull box covers for underground service points, where both traffic signals and street lighting jointly occupy the same box, shall be inscribed "TS-SL."

**307-4.5 Wiring.** Sufficient conductors shall be provided to perform the functional operation of the signal system and three spare No. 14 AWG conductors shall be provided throughout the signal light system. End of spare conductors shall be doubled back and taped. Traffic signal multiconductor cable may be utilized when approved by the Engineer.

The neutral for pedestrian push-button circuits shall be separate from the signal light circuit neutral.

Interconnect conductors shall be continuous from controller to controller unless splices are specifically authorized by the Engineer. Splices shall be made only in pull boxes.

Where telephone circuits are installed adjacent to other electrical circuits, the telephone conductors shall be encased in UL approved metallic conduit.

Wiring entering controller cabinets shall be neatly arranged, secured, and tagged.

All stranded conductors shall be terminated with approved terminal lugs.

**307-4.6 Signal Heads.** All new vehicle signal heads installed at any one intersection shall be of the same style and from the same manufacturer, except for programmed visibility heads.

All mast arm and arrow indications shall be a minimum of 300 mm (12 inch). All other signal indications shall be 200 mm (8 inch). Visors are required on all signal heads.

Backplates, of an approved type, shall be installed unless otherwise shown on the Plans. All pedestrian heads shall have a device approved by the Engineer to reduce sun glare.

Signal heads shall not be installed at any intersection until all other signal equipment, including the controller, is in place and ready for operation at that intersection, except that signal heads may be mounted if the faces are turned away from traffic or are covered.

Signal heads shall be located and aimed as shown on the Plans or as directed by the Engineer. Mounting and location on standards shall be as shown or as directed by the Engineer.

**307-4.7 Signal Head Mountings.** Heads shall be supported by assemblies of 38 mm (1-1/2 inch) standard steel pipes with malleable iron or bronze fittings. All assemblies shall be installed plumb or level, as applicable, shall be symmetrically arranged, and securely tightened. Top horizontal members

shall be approximately 300 mm (12 inches) in length. Construction shall be such that all conductors are concealed within standards or pipe assemblies.

Unless otherwise specified herein or on the Plans, heads shall be installed with terminal-compartment mountings. For top mounting of a one-way head and mast arm mountings, a slip-fitter without a terminal compartment shall be used. Clamp-type mounting may be used for installation of heads on existing concrete standards if inserts for terminal-compartment mounting have not been provided. The terminal compartment shall be mounted on the standard on the side away from traffic and parallel with the prolongation of the nearest curb face.

**307-4.8 Directional Louvers.** Where shown on the Plans or standard drawings, louvers shall be furnished and installed in the visors of the signal head sections designated.

#### **307-4.9 Vehicle Detectors.**

**307-4.9.1 General.** Vehicle detectors shall be of the type or types shown on the Plans. The location of each detector shall be as shown on the Plans or as directed by the Engineer.

**307-4.9.2 Sensor Units.** A minimum of at least one sensor unit shall be provided for each approach for each separately controlled phase of operation unless otherwise specified. Sensor units shall be housed in the controller cabinet unless otherwise specified.

**307-4.9.3 Inductive Loops.** The Contractor shall install and activate all detector loops within 14 days of the activation of the controller. Detector loops damaged during removal of pavement or other related work shall be replaced and reactivated within 7 days of the placement of permanent pavement. This Work shall be done at no additional cost to the agency. Detector loops shall conform to the following:

- 1) Detector loops, and their leads to the nearest pull box, shall be formed from a continuous conductor of No.12 AWG solid or seven-strand minimum tinned copper wire, having 600-volt Type USE cross-linked polyethylene insulation with a minimum thickness of 1.2 mm (3/64 inch).

The two leads for each loop shall be installed as a pair, twisted at a rate of 360° per 0.30 meters (one foot) in a common saw slot. The detector loop leads may share a common saw slot with leads from other detector loops. However, the detector loop leads shall not cross any loops and shall not be installed within 500 mm (20 inches) of any other loop. The lead-in cable shall consist of No.12 AWG-UF twisted pair and be continuous from the pull box where connections are made to the inductive detector loops to the cabinet containing the sensor units for the loops.

- 2) The Contractor shall make continuity and insulation resistance tests after installation on both inductive detector loops and lead-in cables, as specified in 307-5.2. The measurement shall be made using the conduit system as ground and with the shield (if any) of the lead-in grounded.

Slots 6 mm (1/4 inch) minimum width shall be cut in the pavement, blown clean, and dried before installing inductive loop detectors. Eighteen inch corner cutoffs shall be provided on all loops.

After conductors are installed in the slots cut in the pavement, the slots shall be filled with epoxy sealant, or hot melt adhesive. The epoxy sealant is the "Epoxy Sealant for Inductive Loops" and the hot melt adhesive is the "Hot Melt Bituminous Adhesive" specified in the CalTrans Standard Specifications. The sealant or hot melt adhesive shall fill the slots to within 3 mm (1/8 inch) of the pavement surface. The sealant or adhesive shall be at least 13 mm (1/2 inch) thick above the top conductor in the saw cut. Before

setting, surplus sealant or adhesive shall be removed from the adjacent road surfaces without the use of solvents.

The loops shall be joined in the pull box in combination of series and parallel so that optimum sensitivity is obtained at the sensor unit. Final splices between loops and lead-in cable shall not be made until the operation of the loops under actual traffic conditions is approved by the Engineer.

**307-4.9.4 Magnetometer Detectors.** All magnetometer detectors to be installed at a particular intersection shall be of the same make and type.

Where an existing system is being modified and existing magnetometer detectors are to remain in use, new detection equipment shall be the same make and type as the existing, or approved alternate.

A separate channel shall be provided for each lane. Separate control units shall be provided for each approach.

A separate cable shall be provided for each magnetometer sensing element placed in the pavement. The cable shall be run continuously (without splices) to the lead-in cable.

The sensing elements shall be placed in vertically cut holes in the roadway at locations shown on the plans. Each hole shall be of a diameter large enough to accept the particular type of sensing element being used, with adequate space for the lead-in conductor cable. Holes shall be cut to a depth sufficient to provide a mounting depth of the sensing element as recommended by the manufacturer of the unit provided.

Slots, 6 mm (1/4 inch) minimum width by 25 mm (1 inch) minimum depth, shall be cut in the pavement between the sensing element holes and the nearest pull box for the lead-in conductor cables.

Slots and holes cut in the pavement shall be blown clean and dried before installing lead-in conductor cables and sensing elements.

The sensing elements shall be placed in the bottom of the holes, in a vertical position, and the holes shall be filled with clean, dry sand to approximately 75 mm (3 inches) below the pavement surface.

The epoxy sealant for the slots and holes shall be as provided for in 307-4.9.3, except the top 75 mm (3 inches) of the holes shall be filled with the epoxy sealant.

**307-4.10 Pedestrian Push Buttons.** Pedestrian push buttons and signs shall be installed on the crosswalk side of the standard unless otherwise specified.

**307-4.11 Controller Slab.** In unpaved areas, a 100 mm (4 inch) thick portland cement concrete slab shall be constructed in front of each controller cabinet. The slab shall extend the full width of the cabinet foundation and extend out 1 m (3 feet) from the face of said foundation.

## **307-5 INSPECTION AND TESTING.**

**307-5.1 General.** Inspection or sampling of certain materials may be made at the factory or warehouse prior to delivery to the Work site, when required by the Engineer.

**307-5.2 Testing.** Prior to acceptance to the completed work, the Contractor shall cause the following tests to be made on all electrical circuits, in the presence of the Engineer.

**307-5.2.1 Continuity.** Each circuit shall be tested for continuity.

**307-5.2.2 Ground.** Each circuit shall be tested for unintentional ground.

**307-5.2.3 Megger.** A megger test at 500 volts DC shall be made on each circuit between the circuit and a ground. The insulation resistance shall be not less than 10 megohms on all circuits, except for inductive loop detector circuits which shall have an insulation resistance value of not less than 100 megohms.

**307-5.2.4 Functional.** A functional test shall be made in which it is demonstrated that each and every part of the system functions as specified or intended. The test may commence only with the approval of the Engineer.

The functional test for each new or modified electrical system shall consist of not less than 5 days of continuous, satisfactory operation. If unsatisfactory performance of the system develops, the condition shall be corrected and the test shall be repeated until the 5 days of continuous satisfactory operation are obtained.

Functional tests shall not start nor turn-ons be made on a Friday, or on the day preceding a legal holiday.

Shutdown caused by factors beyond the Contractor’s control shall not constitute discontinuity of the functional test.

**307-5.3 Faults.** Any material revealed by these tests to be faulty in any part of the installation shall be replaced or corrected by the Contractor at its expense in a manner permitted by the Engineer, and the same test shall be repeated until no fault is evident.

**307-6 PAINTING.** All painted equipment that has been relocated shall be repainted. All paint used on the Work site shall be provided in the original container identifying the grade, trade name, number, and manufacturer, and shall conform to the requirements of Section 210.

All paint shall be applied evenly and smoothly by skilled craftsmen by either hand brushing or approved spraying equipment, allowing no surplus to accumulate, except that no spraying shall be done at the worksite. The work shall be done in a neat and workmanlike manner, and the use of brushes for the application of paint shall be required when paint spraying proves to be unsatisfactory or otherwise objectionable.

The thickness of each paint coat (two required) shall be limited to that which will result in uniform drying throughout the paint film. Skips, “holidays”, thin areas, or other deficiencies in any one coat of paint shall be corrected before the succeeding coat is applied.

The final coat of paint shall present a smooth surface, uniform in color, free of runs, sags, or excessive brush marks.

**307-7 SALVAGE.** Unless otherwise specified, conductors, standards, electrical equipment, and foundations not to be reused shall become the property of the Contractor and shall be removed from the Work site. Any salvage value shall be reflected in the Bid. All conduit abandoned in place shall be terminated at least 125 mm (5 inches) below finished grade.

Care shall be exercised in removing equipment to be reused or salvaged so that it will remain in the condition existing prior to its removal. The Contractor will be required to replace, at its expense, any equipment that has been damaged or destroyed by its operations.

**307-8 PAYMENT.** Payment for street lighting or traffic signal work will be as shown in the Bid.

**SECTION 308 - LANDSCAPE AND IRRIGATION INSTALLATION**

**308 CROSS REFERENCE**

Landscape and Irrigation .....212

**308-1 GENERAL.** This section shall govern the preparation, planting, and irrigation system construction for landscape areas required by the Plans or Specifications.

Existing utilities and improvements not designated for removal shall be protected in place. Removals shall be performed in accordance with applicable provisions of 300-1.3.

Unless otherwise provided, walls, curbs, planter boxes, walks, irrigation systems, and similar improvements required by the Plans or Specifications shall be constructed following rough grading and before landscaping.

All work on the irrigation system, including hydrostatic and coverage tests, preliminary operational tests of the automatic control system, and the backfill and densification of trenches, and other excavations shall be performed after topsoil work and before planting.

### **308-2 EARTHWORK AND TOPSOIL PLACEMENT.**

**308-2.1 General.** Earthwork and topsoil placement shall include excavation and backfill for the irrigation system and the preparation for and the spreading, densification, cultivation, and raking of topsoil, including fertilization and conditioning.

Planting holes and backfill shall be in accordance with 308-4.

Preliminary rough grading and related work to prepare areas for landscaping work to within 30 mm (0.1 foot) of finish grade, or to subgrade for Class A or Class B topsoil, shall be completed in accordance with Section 300.

**308-2.2 Trench Excavation and Backfill.** Trenches and other excavations shall be sized to accommodate the irrigation system components, conduit, and other required facilities. Additional space shall be provided to assure proper installation and access for inspection.

Unless otherwise specified, the minimum depth of cover over pipelines and conduit shall be as follows:

- 1) Electrical conduit – 600 mm (24 inches) (900 mm (36 inches) under roadways).
- 2) Waterlines continuously pressurized – 600 mm (24 inches) (900 mm (36 inches) under roadways).
- 3) Lateral sprinkler lines – 300 mm (12 inches).

The bottom of trenches shall be true to grade and free of protruding stones, roots, or other matter which would prevent proper bedding of pipe or other facilities. Bedding of the pipe shall conform to 308-5.2.

Trenches and excavations shall be backfilled so that the specified thickness of topsoil is restored to the upper part of the trench. Backfill shall be flooded in accordance with 306-1.3.3.

### **308-2.3 Topsoil Preparation and Conditioning.**

**308-2.3.1 General.** The type and thickness of topsoil shall be shown on the Plans, or if not shown, shall be Class A, 150 mm (6 inches) thick. Planting areas shall be free of weeds and other extraneous materials to a depth of 300 mm (12 inches) below finish grade before topsoil work.

Soil shall not be worked when it is so wet or so dry as to cause excessive compaction or the forming of hard clods or dust.

The existing soil below subgrade for Class A topsoil shall be scarified to a depth of 150 mm (6 inches) prior to spreading topsoil.

Class C topsoil shall be scarified and cultivated to a finely divided condition to a depth of 200 mm (8 inches) minimum below finish grade. During this operation, all stones over 25 mm (1 inch) in greatest dimension shall be removed.

**308-2.3.2 Fertilizing and Conditioning Procedures.** The planting area shall be brought to finish grade before spreading the fertilizers or conditioning materials specified.

Fertilizing and conditioning materials shall be mechanically spread at a uniform rate. The quantities of materials necessary for the planting area shall be at the site and shall be verified by delivery tickets furnished to the Engineer before spreading.

After spreading, the fertilizing and conditioning materials shall be uniformly cultivated into the upper 150 mm (6 inches) of soil by suitable equipment operated in at least two directions approximately at right angles. The resulting soil shall be in a friable condition.

**308-2.4 Finish Grading.** The finish grade shall be smooth, uniform, and free of abrupt grade changes and depressions to ensure surface drainage.

The finish grade below adjacent paving, curbs or headers shall be 25 mm (1 inch) in lawn areas and 50 mm (2 inches) in shrub or groundcover areas.

After fertilizing and conditioning, the soil shall be watered and allowed to settle to provide a stable surface, not overly densified to the extent that it will prevent aeration and water infiltration. After the soil has dried out to a workable condition, the planting areas shall be regraded, raked, and smoothed to the required grades and contours. Finish surfaces shall be clean and suitable for planting.

**308-3 HEADER INSTALLATION.** Headers shall be installed at the locations and grades shown on the Plans prior to planting.

Stakes shall be located at splices, corners, and at intervals not to exceed 1.5 m (5 feet) and driven slightly below the top of the header. Splice plates shall be used at butt joints. Headers shall be nailed to stakes with two nails, clinched 13 mm (1/2 inch). Splice plates shall be centered on the joint and nailed to each header with four 10d box nails.

#### **308-4 PLANTING.**

**308-4.1 General.** The types, sizes, and quantities of plant materials shall be as called for in the Specifications.

All plants will be inspected prior to planting, including plants previously approved at the nursery. The Contractor shall be responsible for the condition of all plants, planted or otherwise, until acceptance.

Planting shall be performed with materials, equipment, and procedures favorable to the optimum growth of the plants and in compliance with these procedures.

Except as noted for specimen planting, all planting shall follow the completion of the irrigation system.

**308-4.2 Protection and Storage.** The Contractor shall keep all plant material delivered to the site in a healthy condition for planting. Plants shall not be allowed to dry out. Bare root stock shall be separated and "heeled in" moist earth or other suitable material. Balled and burlapped plants shall have the root ball covered with moist sawdust, wood chips, or other approved material.

**308-4.3 Layout and Plant Location.** Planting areas will be staked by the Engineer. Detailed layout within the planting areas shall be performed by the Contractor and approved by the Engineer prior to planting. Parkway trees will be located in the field by the Engineer before planting.

The first row of plants in areas designated for center-to-center spacing of plants shall be located at one-half of designated spacing from the edge of the area.

**308-4.4 Specimen Planting.** Plants in boxes 600 mm (24 inches) and larger shall be planted before installation of lateral irrigation lines.

Irrigation lines conflicting with specimen plant locations shall be rerouted to clear the root ball.

**308-4.5 Tree and Shrub Planting.** Planting holes shall be approximately square with vertical sides twice the depth and width of the plant container or ball, and shall be larger if necessary to permit

handling and planting without injury or breakage of the root ball or root system. Any plant with a broken or cracked root ball before or during planting shall not be planted.

Containers shall be opened and removed in such a manner that the root is not injured. Balled plant wrappings shall be loosened or cut back after plant is positioned in the planting hole.

The native soil at the bottom of planting holes shall be scarified to a depth of 150 mm (6 inches).

All planting holes shall be backfilled with a prepared soil mix. Soil shall consist of 50 percent of the specified topsoil and 50 percent Type 1, 2, or 3 organic soil amendment.

After planting, the plant shall be plumb, with the root crown at its natural growing depth with respect to finish grade. Planting shall be governed by the following requirements:

- 1) A layer of prepared soil mix shall be deposited in the planting hole.
- 2) The plant shall be set approximately at the center of the hole.
- 3) Prepared soil mix shall be deposited in the remainder of the hole to finish grade.
- 4) The backfill shall be thoroughly water-settled and additional prepared soil mix added to fill any remaining void below finish grade.
- 5) A circular watering basin slightly larger than the planting hole, 100 mm (4 inches) high for trees and 50 mm (2 inches) high for shrubs, shall be left around the plant. The bottom of the basin shall be at approximate finish grade or slightly lower. Type 1, 2, 3, or 4 mulch shall be spread at least 50 mm (2 inches) thick in the basin.
- 6) The plant shall be guyed and staked as specified in 308-4.6.
- 7) The area around plant shall be regraded to finish grade. The excess soil shall be disposed of by the Contractor.

#### **308-4.6 Plant Staking and Guying.**

**308-4.6.1 Method "A" Tree Staking.** The tree shall be staked with a 38 mm (1-1/2 inch) nominal diameter x 3 m (10 foot) long galvanized steel pipe, per 212-2.1.2, installed vertically, positioned at least 150 mm (6 inches) from the trunk at ground level, and 750 mm (30 inches) into the soil in a manner to avoid injury to the roots or breaking the root ball. The trunk shall be secured to the pipe with one tie just below the head of the tree. The tie shall be No. 12 BWG galvanized iron wire covered with garden hose, or other approved tie. The loop shall be 25 mm (1 inch) greater in diameter than the trunk. The tie shall be attached to the pipe through a hole drilled at the tie location described above. The wire ties shall be secured by twisting the ends.

**308-4.6.2 Method "B" Tree Staking.** The tree shall be staked with two No. 19M (No. 6) steel reinforcing bars 1.8 m (6 ft) long driven 600 mm (24 in) into the ground. The stakes shall be 450 mm (18 in) from each side of the tree trunk, and stakes and tree shall be in a plane parallel to the street centerline. Ties shall be made of 25 mm (1-in) or wider flexible plastic ribbon material having a minimum tensile strength of 2.2 kN (500 pounds). Four ties shall be used; two at 50 mm (2 in) from the top of each stake and two at 0.6 m (2 ft) above the ground. Ties shall be loops secured to the stake on one end and shall be long enough to provide for 75 mm (3 in) of slack to permit the tree trunk limited movement in any direction.

**308-4.6.3 Guying.** Trees and other plants, except specimen plants, to be guyed shall be designated in the Contract Documents.

Guying shall be done immediately after planting. Three guys per plant shall be installed in accordance with the following:

- 1) Each guy shall be secured to the appropriate main branch by a twisted loop of No. 12 BWG galvanized iron wire housed in garden hose.
- 2) Each guy shall be anchored to a driven stake located at a horizontal distance from the tree equal to the vertical distance from ground to the connection of guy wire on the tree branch.
- 3) Each guy shall be covered with highly visible garden hose or plastic tubing to a height of 1.8 m (6 feet) above grade.
- 4) Slack in each guy shall be removed by hand so as not to bend or twist the plant.

**308-4.7 Ground Cover and Vine Planting.** Soil preparation and fine grading shall be completed prior to ground cover planting.

Ground cover and vines shall be planted in moist soil and spaced as indicated on the Plans.

Each plant shall be planted with its proportionate amount of flat soil to minimize root disturbance. Soil moisture shall be such that the soil does not crumble when removing plants.

Following planting, ground cover and vine areas shall be regraded to restore smooth finish grade and to ensure proper surface drainage. A 25 mm (1 inch) layer of Type 1, 2, 3, or 4 mulch shall be spread over the planted areas. Watering shall begin immediately following mulching.

When necessary to prevent plant damage from pedestrian traffic during the initial growing stage, the Contractor shall erect temporary protective fencing to be removed at the end of the plant establishment period.

Vines shall be tied to walls, fences, etc., in the manner prescribed on the Plans. Temporary staking shall be removed at the end of the plant establishment period.

#### **308-4.8 Lawn Planting.**

**308-4.8.1 General.** Before planting lawn, all specified soil preparation and fine grading shall be completed.

**308-4.8.2 Seed.** Seed lawn planting may be accomplished by Method A (dry method) or Method B (hydraulic method). Seeding shall not be performed when the wind velocity exceeds 8 km/h (5 miles per hour), or is detrimental to the uniform distribution of the seed.

(a) **Method A.** The area to be seeded shall be lightly raked to provide a seed bed.

The required seed mixture shall be sown uniformly at the specified rate. Seeding shall be done in two operations with the spreader set to sow one-half the specified amount in each operation. The second sowing shall be at right angles to the first.

After sowing, the area shall be evenly covered to a depth of 6 mm to 13 mm (1/4 to 1/2 inch) with an approved mulch.

The lawn area shall be watered in a manner so as not to cause surface erosion.

Newly seeded surfaces shall be kept moist continuously throughout the germination period.

(b) **Method B.** The seed, fertilizer, fiber, and other materials in the slurry mixture shall be as specified. All materials shall be of such character that they will disperse into a uniform slurry when mixed with water. The mixture shall be such that an absorbent, porous mat will be formed.

All materials must be available for inspection prior to application. Weights and contents of containers shall be clearly identified. A green coloring additive shall be used in the slurry for visual inspection purposes.

The slurry shall be applied under pressure at the specified rates.

Areas to be planted by this method shall be moistened to a depth of 150 mm (6 inches) but shall not be surface wet at the time of application.

The slurry planted areas shall be kept moist during the germination period, but puddling shall be avoided.

**308-4.8.3 Sod.** The type and thickness of sod and the areas to be sodded shall be in accordance with the Contract Documents.

Subgrade for sod shall be the specified thickness of the sod below finish grades. Soil conditioning and fine grading shall be completed before sodding. No heavy equipment shall operate over the subgrade after grading is completed.

The subgrade shall be moist but not wet when sod is laid. Sod shall be laid with closely fitted joints, and the ends of the strips shall be staggered. Openings shall be plugged with sod or topsoil.

Within 2 hours after installing sod and before rolling, the sod shall be lightly irrigated. All seams and joints shall then be rolled until the sod is well bonded to the subgrade.

The area shall then be watered thoroughly to penetrate the subsoil at least 200 mm (8 inches). Watering shall be repeated as necessary to keep the sod moist until rooted into the subgrade. Sodded areas shall be protected against foot traffic until the sod is well established.

**308-4.8.4 Stolon.** Topsoil preparation and conditioning and finish grading shall be completed in accordance with 308-2.3 and 308-24 before stolon planting.

The area to be planted in stolons shall be thoroughly irrigated to a depth of at least 200 mm (8 inches). As soon as the soil can be worked, the specified commercial fertilizer shall be worked into the top 25 mm (1 inch) of soil.

At the time of planting, the top 50 mm (2 inches) of soil shall be friable and contain enough moisture to prevent stolons from drying out during the planting operation. The stolons shall be worked into the soil to a depth of 13 mm to 38 mm (1/2 to 1-1/2 inches) by a mechanical or hand planter, or broadcast by hand and covered with 6 mm (1/4 inch) of mulch.

When the area to be planted exceeds 1000 m<sup>2</sup> (10,000 square feet), a mechanical spreader shall be used; when less than 1000 m<sup>2</sup> (10,000 square feet) and more than 200 m<sup>2</sup> (2,000 square feet), the use of a hand planter or mechanical planter is optional; and when less than 200 m<sup>2</sup> (2,000 square feet), handplanting or broadcasting with mulch is optional.

The planted stolons shall not be allowed to dry out. Watering shall begin immediately after planting and the stolons kept moist at all times until the plants are well established.

When overseeding is required, the seed shall be spread in accordance with 308-4.8.2, Method A, immediately after planting stolons.

### **308-4.9 Erosion Control Planting.**

**308-4.9.1 General.** Erosion control planting shall be for slope protection. Topsoil preparation and conditioning shall be in accordance with 308-2.3.

**308-4.9.2 Straw Stabilization.** When straw stabilization is specified, Type 6 mulch shall be incorporated into the slope topsoil either by discing or with a steel plate studded roller. The steel plate studs shall be at least 150 mm (6 inches) long, not more than 150 mm (6 inches) wide, and approximately 25 mm (1 inch) thick, with rounded edges. The roller shall be capable of forcing the straw into the soil a sufficient depth to tie down the surface soils.

**308-4.9.3 Seeding and Mulching.** Seed, fertilizer, mulch, and other specified materials may be applied on slopes by Method A or Method B described in 308-4.8.2.

**308-4.9.4 Sprigging.** Sprigging shall consist of planting turf grasses, cut stems of plants, and plants with attached root system, but without adhering soil.

Sprigs shall normally be harvested and planted within a 24-hour period. Ice plant sprigs shall be harvested between 48 and 96 hours before planting so that a thin callus is formed over the cut surface of each sprig. Sprigs shall be shaded during callusing, but shall not be moistened.

Turf grasses shall be planted in accordance with 308-4.8.4.

Ice plant sprigs shall be planted in moist soil in holes or furrows 100 mm (4 inches) deep and the hole or furrow refilled with soil and made firm around the plant in such a manner that the plant is not damaged.

Sprigs shall be planted individually at specified spacing. When row sprigging is specified, planting shall be in furrows cut along the contour of the slope.

If mulching of sprigged areas is required, it shall immediately follow planting.

**308-4.9.5 Watering.** All seeded and planted areas shall be kept moist during the establishment period.

Areas containing ice plants shall be maintained in a barely moist condition to a depth of 25 mm (1 inch) below the planted root depth.

When a permanent irrigation system is not available, the Contractor shall provide whatever temporary system is necessary to provide adequate watering during the establishment period without erosion detrimental to the planting.

### **308-5 IRRIGATION SYSTEM INSTALLATION.**

**308-5.1 General.** The Contractor shall furnish all necessary materials, labor, and equipment required to complete the work of installing the irrigation system in accordance with the Specifications.

Large specimen plants shall be planted before installing the irrigation system, as required by 308-4.4.

Unless otherwise provided, the irrigation system layout shown on the Plans shall be considered schematic. With the Engineer's approval, the Contractor may make adjustments where necessary to conform to actual field conditions. The irrigation system shall be operational, with uniform and adequate coverage of the areas to be irrigated, prior to planting.

Service connections shall be as shown on the Plan or designated by the utility company and will be installed by others at no cost to the Contractor. The Contractor shall notify the Engineer at least 3 weeks prior to the time electrical and water services are required. The Contractor shall be responsible for furnishing the labor and materials to connect to the service connection.

Trenches through paved areas shall be resurfaced in accordance with 306-1.5.

After completing the irrigation system, the Contractor shall submit drawings showing the location of pipe, valves, tubing, wiring, controllers, and electrical services as constructed.

### **308-5.2 Irrigation Pipeline Installation.**

**308-5.2.1 General.** Trench excavation and backfill including the depth of cover over the pipeline shall be in accordance with requirements of 308-2.2.

Pipe fittings shall be installed in accordance with the manufacturer's recommendations and these specifications. When requested by the Engineer, the Contractor shall furnish the manufacturer's printed installation instructions before pipe installation.

Pipe shall be bedded in at least 50 mm (2 inches) of finely divided material to provide a firm, uniform bearing. After laying, the pipe shall be surrounded with additional finely divided material to at least 50 mm (2 inches) over the top of the pipe. Trench backfill, sufficient to anchor the pipe, may be deposited before the pipeline pressure testing, except that joints shall remain exposed until satisfactory completion of testing.

When two or more pipelines are installed in the same trench, they shall be separated by a minimum horizontal clear distance of 150 mm (6 inches) and they shall be installed so that each pipeline, valve, or other pipeline component may be serviced or replaced without disturbing the other.

All assemblies shall be assembled as specified and in accordance with the manufacturer's directions.

During installation of pipe, fittings, valves, and other pipeline components, foreign matter shall be prevented from entering the system. All open ends shall be temporarily capped or plugged during cessation of installation operations.

Changes in pipeline size shall be accomplished with reducer fittings.

**308-5.2.2 Steel Pipeline.** Ends of pipe shall be cut square and reamed to full size with a long taper reamer.

Threads shall be cut with clean, sharp dies and shall conform to American Standards Association Specification B2.

Joints shall be made with a nontoxic, nonhardening joint compound applied to the male threads only.

When wrapped pipe is specified, joints and any remaining unwrapped portion of the pipeline shall be similarly wrapped after pressure testing.

**308-5.2.3 Plastic Pipeline.** Plastic pipe shall be jointed by socket-type solvent-welded fittings, threaded fittings, rubber-ring fittings, or by other means specified. When plastic pipe is joined to steel pipe, the steel pipe shall be installed first.

Plastic pipe shall be cut square, externally chamfered approximately 10 to 15 degrees, and all burrs and fins removed.

Solvent welded joints shall be made in accordance with ASTM D 2855. The solvent recommended by the manufacturer shall be used.

Plastic pipe installation shall be in accordance ASTM D 2774 and the requirements herein.

Care shall be exercised in assembling a pipeline with solvent welded joints so that stress on previously made joints is avoided. Handling of the pipe following jointing, such as lowering the assembled pipeline into the trench, shall not occur prior to the set times specified in ASTM D 2855.

Solvent shall be applied to pipe ends in such a manner that no material is deposited on the interior surface of the pipe or extruded into the interior of the pipe during jointing. Excess cement on the exterior of the joint shall be wiped clean immediately after assembly.

Threads for plastic pipe shall be as specified in 308-5.2.2. A plug shall be installed in the bore of the pipe to prevent distortion prior to threading.

Threaded pipe joints shall be made using teflon tape or other approved jointing material. Solvent shall not be used with threaded joints.

Pipe shall be protected from tool damage during assembly. Vises shall have pleated jaws and strap wrenches shall be used for installation of fittings and nipples.

Plastic pipe which has been nicked, scarred, or otherwise damaged shall be removed and replaced. Plastic pipe shall be snaked from side to side in the trench to allow 1 meter (1 foot) of expansion and contraction per 100 meters (100 feet) of straight run.

The pipeline shall not be exposed to water for 24 hours after the last solvent welded joint is made.

**308-5.2.4 Copper Pipeline.** Copper pipeline shall be made with sweated solder joints.

Before jointing, the end of the pipe for the depth of the fitting, and the interior of the fitting shall be buffed to a bright finish and coated with solder flux. The assembled joint shall be made with a 50-50 tin-lead solder. A continuous solder bead shall show around the joint circumference after soldering.

Copper pipe shall be joined to steel or cast iron pipe with a dielectric union.

**308-5.3 Installation of Valves, Valve Boxes, and Special Equipment.** Valves, backflow preventers, pressure regulators, and related accessories shall be furnished and installed as specified.

All valves and other equipment shall be installed in a normal upright position unless otherwise recommended by the manufacturer, and shall be readily accessible for operation, maintenance, and replacement. Sectional control valves shall not be located within range of sprinklers they control.

Valves shall be same size as the pipeline in which they are installed.

Gate valves and sectional control valves shall be installed below ground. Gate valves shall be housed in a covered concrete box that will permit access for servicing. Sectional control valves shall be equipped with a sleeve and cap centered on the valve stem.

Quick-coupler valves and garden valves projecting above grade shall be installed 0.9 m (3 feet) from curbs, pavement, and walks. In lawn areas, such equipment shall be installed in a covered concrete box set to finish grade. In ground cover and shrubbery areas, quick-coupler valves shall be set 150 mm (6 inches) above finish grade, and garden valves shall be set between 300 mm and 375 mm (12 and 15 inches) above finish grade. Quick-coupler valves and garden valves shall be installed on a double-swing-joint riser assembly as described in 308-5.4.3 and secured to a driven No. 13M (No. 4) reinforcing steel rod as described in 308-5.4.3.

All valve boxes, pipe sleeves, and caps shall be set to finish grade, and valves shall be set at sufficient depth to provide clearance between the cover and the cap, valve handle, or key when the valve is in the fully open position.

Backflow preventers shall be provided with pipe supports and the accessories necessary to properly secure the assembly. All backflow preventers shall be assembled with pipe and fittings of galvanized steel.

**308-5.4 Sprinkler Head Installation and Adjustment.**

**308-5.4.1 General.** In accordance with the requirements of 308-5.6, all mains and laterals, including risers, shall be flushed and pressure tested before installing sprinkler heads, after which a water coverage test shall be performed.

**308-5.4.2 Location, Elevation, and Spacing.** Sprinkler head spacing shall not exceed the maximum shown on the drawings or recommended by the manufacturer.

In new lawn areas, sprinkler heads shall be installed 75 mm (3 inches) above grade and then reset flush with the finish surface just prior to the first mowing. Lawn sprinklers shall be installed 50 mm (2 inches) clear of adjacent walks, curbs, paving, headers, and similar improvements.

Sprinkler heads shall be installed 100 mm (4 inches) from adjacent vertical elements projecting above grade such as walks, planter boxes, curbs, and fences.

Shrub heads, bubbler heads, and oscillating sprinklers shall be installed 150 mm (6 inches) above finish grade.

Nozzle lines shall be installed at least 300 mm (12 inches) above finish grade. Sprinkler heads projecting above finish grade shall be at least 300 mm (12 inches) from adjacent curbs, walks, paving, and similar improvements.

**308-5.4.3 Riser and Nozzle Line Installation.** To obtain optimum coverage of the area, risers shall be oriented perpendicular to finish grade.

Risers for oscillating sprinklers and nozzle lines shall be galvanized steel pipe. All other risers may be galvanized steel of Schedule 80 PVC. All pipe between the connection to the lateral or main and the sprinkler head shall be threaded.

Sprinkler head riser assemblies shall be top outlet, single-swing joint, or double-swing joint as specified herein.

Sprinkler head risers and nozzle risers installed above grade within 600 mm (24 inches) of roadway paving, curbs, walks, and similar improvements shall be of the double-swing joint type.

A top outlet riser assembly shall consist of a pipe riser threaded into a top outlet ell or tee installed in the lateral supply line.

Double-swing joint and single-swing joint riser assemblies shall utilize a horizontal 150 mm (6 inch) pipe nipple threaded into a side outlet ell or tee installed in the lateral supply line. For a double-swing joint, three ells shall be used in the remaining assembly ahead of the vertical riser pipe. For a single-swing joint, one ell shall be used.

Risers for nozzle lines, oscillating sprinklers, and other sprinkler heads installed above grade within 600 mm (24 inches) of curbs, walks, roadways, and similar improvements shall be supported by a No. 13M (No. 4) reinforcing steel rod. The upper end of the rod shall be at finish grade and be of such length that it extends 600 mm (24 inches) below the lateral supply line.

Where nozzle lines cannot be supported on adjacent fences, guard rails and the like, they shall be supported on driven 13 mm (1/2 inch) pipe stakes, 1.2 m (4 feet) long at 2.4 m (8 foot) centers. The nozzle line shall be secured to the top of the stake with 9.5 mm (3/8 inch) anchor rings, 300 mm (12 inches) long.

**308-5.4.4 Sprinkler Head Adjustment.** When all sprinkler heads are installed and the irrigation system is operating, each section or unit shall be adjusted and balanced, with all section control valves fully open to obtain uniform and adequate coverage.

Sprinkler heads having adjustable pin nozzles or orifices shall have the pins adjusted to provide adequate distribution of water over the coverage pattern. The Contractor shall substitute larger or smaller nozzle cores in nonadjustable sprinkler heads as necessary.

If additional work other than the prescribed above is necessary to correct a deficiency in the system installed as specified, such work will be paid for in accordance with 3-2.

**308-5.5 Automatic Control System Installation.** The Contractor shall install a complete automatic irrigation control system including the automatic controller, remote control valves and wiring, and all necessary accessories and utility service connection.

The automatic controller shall be installed outside of the coverage pattern of the irrigation system at the location designated in the contract documents. The foundation for the controller shall be walk concrete, as specified in 201-1, of the size shown on the Plan or recommended by the manufacturer. The control components in the controller shall be fused and the chassis shall be grounded.

Remote control valves shall be compatible with the automatic controller. When the valve is to be housed in a concrete box, it shall be installed with at least a 150 mm (6 inch) clearance below the concrete cover. The box shall be set to finish grade on a 300 mm (12 inch) layer of 25 mm (1 inch) crushed rock.

All service wiring shall be installed at the minimum depth specified in 308-2.2 in galvanized steel conduit from the service point to the controller. The applicable provisions of 307-2.8 shall govern the locations of service points. A separate disconnect switch or combination meter socket, as required, shall be installed between the source of power and the controller. The minimum service wire shall be No.12 AWG copper, 600-volt, Type TW, THW, THWN, or larger as required by the Specifications or controller manufacturer. Wire splices shall be located only in specified pull boxes and shall be made with a packaged kit approved for underground use, or as specified in 307-2.6. Pull boxes shall be concrete, set to grade on a 300 mm (12 inch) layer of 25 mm (1 inch) crushed rock.

Control wiring or hydraulic control tubing shall be housed in conduit between the controller and a concrete pull box installed at least 300 mm (12 inches) outside the limits of the controller foundation, or the structure foundation where the controller is housed. All other wiring and hydraulic control tubing issuing from the pull box shall be direct burial installed in main or lateral waterline trenches wherever practicable. The wiring or tubing shall be bundled and secured to the lower quadrant of the irrigation pipeline at 3 m (10 foot) intervals with plastic electrical tape. Sufficient slack shall be left in the wiring or tubing to provide for expansion and contraction. When the control wiring or tubing cannot be installed in a pipe trench, it shall be installed a minimum of 450 mm (18 inches) below finish grade and a bright colored plastic ribbon with suitable markings shall be installed in the trench 150 mm (6 inches) below grade directly over the wire or tubing.

Control wiring shall be suitably color coded as necessary for identification. All common wire shall be the same color. Unless otherwise required, all control wiring shall be direct burial, Type UF, No. 14 AWG copper. Splices in control wire shall be made in accordance with the requirements for service wire. At least 0.6 m (2 feet) of slack shall be left at each splice and point of connection in pull boxes and valve boxes.

All wiring shall be tested for continuity, open circuits, and unintentional grounds prior to connecting to equipment. When tested for a period of 4 hours, the hydraulic control system shall maintain a constant test pattern of 860 kPa (125 psi).

Upon completion of the Work, the control system shall be in operating condition with an operational chart mounted within the controller cabinet.

### **308-5.6 Flushing and Testing.**

**308-5.6.1 General.** After completion and prior to the installation of any terminal fittings, the entire pipeline system shall be thoroughly flushed to remove dirt, scale, or other material. After flushing, the following tests shall be conducted in the sequence listed below. All equipment, materials, and labor necessary to perform the tests shall be furnished by the Contractor and all tests shall be conducted in the presence of the Engineer.

**308-5.6.2 Pipeline Pressure Test.** A water pressure test shall be performed on all pressure mains and laterals before any couplings, fittings, valves, and the like are concealed. All open ends shall be capped after the water is turned into the line in such a manner that all air will be expelled. Pressure mains shall be tested with all control valves to lateral lines closed. After the pressure main test, all valves shall be opened to test lateral lines. The constant test pressure and the duration of the test are as follows:

Mains.....6 hours at 860 kPa (125 psi)

Laterals....2 hours at 690 kPa (100 psi)

**308-5.6.3 Sprinkler Coverage Test.** The coverage test shall be performed after sprinkler heads have been installed and shall demonstrate that each section or unit in the irrigation system is balanced to provide uniform and adequate coverage of the areas serviced. The Contractor shall correct any deficiencies in the system in accordance with the requirements of 308-5.4.4.

**308-5.6.4 Operational Test.** The performance of all components of the automatic control system shall be evaluated for manual and automatic operation.

During the maintenance period and at least 15 days prior to final inspection, the Contractor shall set the controller on automatic operation and the system shall operate satisfactorily during such period. All necessary repairs, replacements, and adjustments shall be made until all equipment, electrical work, controls, and instrumentation are functioning in accordance with the Contract Documents.

**308-6 MAINTENANCE AND PLANT ESTABLISHMENT.** The Contractor shall maintain all planted areas on a continuous basis as they are completed during the progress of the work and during the establishment period, and shall continue to maintain them until final acceptance.

All planted areas shall be kept free of debris and shall be weeded and cultivated at intervals not to exceed 10 days. The first mowing of lawn areas shall be performed when the grass is 60 mm (2-1/2 inches) high and shall be repeated as often as necessary to maintain the lawn at a height of 50 mm (2 inches). In no case shall the lawn be cut lower than 38 mm (1-1/2 inches) in height.

Any required pruning of plants will be designated by the Engineer at the start of the plant establishment period and the Contractor shall perform the pruning as part of the plant establishment work.

The Contractor shall request a final inspection to begin the plant establishment period after all planting and related work have been completed in accordance with the Contract Documents.

After planting is completed, a field notification will be issued to the Contractor to establish the effective beginning date of the plant establishment period. The plant establishment period shall be for a period of 30 calendar days and shall be extended by the Engineer if the planted areas are improperly maintained, appreciable plant replacement is required, or other corrective work becomes necessary.

Upon completion of the plant establishment period, a final inspection for acceptance will be performed by the Engineer. If the plant establishment period is satisfactorily completed ahead of other work included in the Contract, the maintenance of planted areas shall be continued by the Contractor until all other work has been completed and accepted.

**308-7 GUARANTEE.** The entire irrigation control system shall be guaranteed against defects in materials and workmanship for a period of 1 year from the date of acceptance of the work. The Contractor shall furnish a faithful performance bond in the amount specified in the Contract Documents to cover the guarantee.

**308-8 PAYMENT.** The lump sum or unit prices shown in the Bid shall include full compensation to complete and maintain the landscape and irrigation work shown on the Plans or in the Specifications.

## SECTION 309 - MONUMENTS

**309-1 DESCRIPTION.** This work shall consist of furnishing and installing portland cement concrete right-of-way monuments and cast-in-place survey monuments at the locations shown on the Plans, in the Specifications, or as directed by the Engineer.

**309-2 MATERIALS.** The concrete portion of monuments shall be constructed in accordance with the provisions in 201-1 and Section 303.

Marker plates for survey monuments will be furnished by the Agency at the Work site.

**309-3 CONSTRUCTION.** Survey monuments shall be cast-in-place in neat holes without the use of forms. The exposed surface of the finished monuments shall be uniform, of even texture, and shall be free of holes, cracks, and chipped edges.

Marker plates or copper bars shall be placed in survey monuments before the concrete has acquired its initial set and shall be firmly bedded in the concrete. The concrete shall be so located that when the plate is inserted, the reference point will fall within a 25 mm (1 inch) circle in the center of the plate.

Monuments shall be set firmly and vertically in the ground to a depth of at least 0.9 m (3 feet).

The tops of survey monument covers shall be set flush with the groundline or pavement surface, whichever applies.

**309-4 PAYMENT.** The unit price paid for any survey monuments shall include full compensation for doing all the work involved in constructing the survey monuments, including necessary excavation and backfill as shown on the Plans or directed by the Engineer.

## SECTION 310 - PAINTING

### 310-1 GENERAL.

**310-1.1 Weather Conditions.** Paint shall be applied only on thoroughly dry surfaces and during periods of favorable weather. Except as provided herein, painting will not be permitted when weather conditions are such that the atmospheric temperature is at or below 2°C (35°F), or when freshly painted surfaces may become damaged by rain, fog, or condensation, or when it can be anticipated that the atmospheric temperature will drop below 2°C (35°F) during the drying period. If fresh paint is damaged by the elements, it shall be replaced by the Contractor at its expense.

Subject to the approval of the Engineer, the Contractor may provide suitable enclosures to permit painting during inclement weather. Provisions must be made to artificially control atmospheric conditions within limits suitable for painting inside the enclosure throughout the painting operation. The cost of providing and maintaining such enclosures shall be considered as included in the prices paid for the various items of work and no additional payment will be made therefore.

**310-1.2 Application.** Painting shall be done in a neat and workmanlike manner. Unless otherwise specified, paint shall be applied by brush, roller, or spray methods.

If brushes are used, they shall have sufficient body and length of bristle to spread the paint in a uniform coat. In general, the primary movement of the brush shall be such as to fill thoroughly all irregularities in the surface, after which the coating shall be smoothed by a series of parallel strokes. Paint shall be evenly spread and thoroughly brushed out. The paint will be considered to have been improperly applied if an inordinate amount of residual brush marks remain. If rollers are used, they shall be of a type that do not leave a stippled texture in the paint film.

On all surfaces which are inaccessible for brushing, the paint shall be applied by spray or by sheepskin daubers especially constructed for the purpose, or by other means approved by the Engineer.

If spray methods are used, the operator shall be thoroughly experienced. Runs, sags, thin areas in the paint coat, or skips and holidays shall be considered as evidence the work is unsatisfactory and the Contractor may be required to apply the remainder of the paint by brush.

A water trap acceptable to the Engineer shall be furnished and installed on all equipment used in spray painting.

Mechanical mixers shall be used to mix the paint a sufficient length of time prior to use to thoroughly mix the pigment and vehicle. To keep the pigment in suspension, paint shall be kept thoroughly mixed while being applied.

**310-1.3 Thinning Paint.** Paints specified are formulated ready for application and no thinning will be permitted. If the paint becomes thick in cool weather, it shall be heated by immersing the container in hot water.

**310-1.4 Protection of Work.** The Contractor shall protect all parts of the structure against disfigurement as a result of its painting operations. The Contractor shall be responsible for any damage caused by its operations to vehicles, persons, or property, and shall provide at its expense protective means to guard against such damage.

Paint stains on adjacent improvements which result in an unsightly appearance shall be removed by the Contractor at its expense.

When ordered by the Engineer to abate a dust nuisance and to protect the wet paint film, the Contractor shall dampen the adjacent roadbed and shoulders with water at its expense on each side of the location where painting is in progress. The Contractor shall furnish and post at its expense DRIVE SLOWLY signs and take other precautions necessary to prevent dust and dirt from accumulating on freshly painted surfaces.

## **310-2 SURFACE PREPARATION FOR PAINTING STEEL STRUCTURES\***

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**310-2.1 General.** The following methods of surface preparation apply to steel surfaces unless another method is specified.

**310-2.2 Hand Cleaning.** Hand cleaning is a method of preparing metal surfaces for painting by removing loose mill scale, loose rust, dirt, and loose paint by hand brushing, hand sanding, hand scraping, hand chipping, with other hand impact tools, or by a combination of these methods. It is not intended that all mill scale, rust, and paint be removed by this process, but loose mill scale, rust paint, and other detrimental foreign matter present shall be removed.

Oil, grease, or salts shall first be removed by the methods prescribed in 310-2.3. Other detrimental foreign matter shall be removed by the following operations:

- 1) Stratified rust (rust scale) shall be removed by hand hammering, hand chipping, other hand impact tools, or a combination thereof.
- 2) All loose mill scale and all loose or nonadherent rust shall be removed by hand wire brushing, hand sanding, hand scraping, or by a combination of these methods. Rust and mill scale are classified as "loose mill scale" and "loose or nonadherent rust" if they can be removed from a steel surface by vigorous hand brushing with a new, commercially acceptable wire brush, of suitable type, at a rate of 0.2 m<sup>2</sup> (2 square feet) per minute. This test shall be conducted on an area not previously brushed, scraped, or sanded, but from which all detrimental stratified rust (rust scale), oil, and grease (if present) have been removed. This test establishes a standard for surface preparation and shall not be considered as establishing the production rate by cleaning. Regardless of the methods used for cleaning under this specification, the surface shall be cleaned at least as well as the surface resulting from this test.

In preparing surfaces for repainting, all loose or nonadherent paint shall be removed. Edges of remaining old paint shall be feathered so that the repainted surface will have a smooth appearance. The remaining old paint shall have sufficient adhesion so that it cannot be lifted as a layer by inserting the blade of a dull putty knife under it. All accessible weld flux and spatter shall be removed by hand

scraping or by hand impact tools followed by wire brushing. The accessible portions of all partially enclosed steel members shall be cleaned. On new work, areas which will be inaccessible after assembly shall be cleaned before assembly.

All rivets, welds, corners, joints, and openings shall be properly cleaned. The steel wire of the wire brushes shall have sufficient rigidity to clean the surface, shall be kept free of excess foreign matter, and shall be discarded when they are no longer effective. Hand scrapers shall be made of suitable material and shall be kept sharp enough to be effective. The tools shall be operated in such a manner that no burrs or sharp ridges are left on the surface and no sharp cuts made into the steel.

After hand cleaning is completed, dust and other loose matter shall be removed from the surface. If detrimental amounts of grease or oil are still present, these areas shall be spot cleaned with solvent. The pretreatment (if any is specified) or prime coat of paint shall be applied as soon as possible after cleaning and before further deterioration of the surface occurs.

**310-2.3 Solvent Cleaning.** Solvent cleaning is a procedure for removing detrimental foreign matter such as oil, grease, soil, drawing and cutting compounds, and other contaminants from steel surfaces by the use of solvents, emulsions, cleaning compounds, steam cleaning, or other materials and methods which may not involve a solvent action. It is intended that solvent cleaning, if specified, shall be used prior to the application of paint and with other specified surface preparations for the removal of rust, mill scale, or paint.

Soil, cement spatter, drawing compounds, salts, or other foreign matter (other than grease or oil) shall be removed by brushing with stiff-fiber or wire brushes, by scraping, or by cleaning with solutions of alkaline cleaners provided such cleaners are followed by a fresh water rinse, or by a combination of these methods. When specified, the fresh water rinse shall be followed with a passivating dichromate or dilute chromic acid wash.

Oil or grease shall be removed by any of the following methods:

- 1) Wiping or scrubbing the surface with rags or brushes wetted with solvent. The final wiping shall be done with clean solvent and clean rags or brushes.
- 2) Spraying of the surface with solvent. The final spraying shall be done with clean solvent.
- 3) Complete immersion in a tank or tanks of solvent. Solvent for the last immersion shall not contain detrimental amounts of contaminant.

Emulsion cleaners may be used in lieu of the methods in this subsection provided that after treatment the surface shall be washed to remove detrimental residue.

Steam cleaning, using detergents or cleaners if specified, may be used in place of the methods in this subsection provided that the surface shall finally be steamed or washed to remove detrimental residues.

If chemical paint strippers are used for the removal of paint, all wax from the stripper remaining on the surface shall be removed by the use of suitable solvents. All alkaline residues from the paint strippers shall be removed by washing the surface with fresh water. All detrimental paint residue or stripping agent residue shall be removed.

Regardless of the method used to clean oil, grease, or contaminants from a surface, there shall be no detrimental residue left on the surface.

Solvent-cleaned surfaces shall be primed or prepared as specified before any detrimental corrosion or recontamination occurs.

**310-2.4 Power Tool Cleaning.** Power tool cleaning is a method of preparing metal surfaces for painting by removing loose mill scale, loose rust, and loose paint with power wire brushes, power impact tools, power grinders, power sanders, or by a combination of these methods. It is not intended that all mill scale, rust, and paint be removed by this process; but loose mill scale, rust, paint, and other detrimental foreign matter present shall be removed.

Oil, grease, and salts shall first be removed by the methods prescribed in 310-2.3. Other detrimental foreign matter will be removed as described below.

Stratified rust (rust scale) shall be removed by power impact tools. If minor quantities of stratified rust are present, they may be removed as outlined in 310-2.2.

Large areas of tight, well-adhered paint, even though they may be removable, shall be removed only if specified. All loose mill scale and all loose or nonadherent rust and all loose paint, as defined below, shall be removed by one or more of the following methods:

- 1) Power wire brushing using rotary, radial, or cup brushes of suitable size, entering all accessible openings, angles, joints, and corners. The steel wire of such brushes have sufficient rigidity to clean the surface, shall be kept free of excess foreign matter, and shall be discarded when they are no longer effective. The surface shall be cleaned, but not burnished to a detrimental degree.
- 2) Power impact tool cleaning using power driven chipping or scaling hammers, rotary scalers, single- or multiple-piston scalers, or other similar impact cleaning tools. Cutting edges of such tools shall be kept in effective condition.
- 3) Power grinding using abrasive wheels or power sanding using abrasive materials. Sanding or abrasive materials shall be discarded when they become ineffective.

Mill scale, rust, and paint are classified as "loose mill scale," "loose and nonadherent rust," and "loose" or "removable paint" if they can be removed from a steel surface by power wire brushing using a commercial electric or air wire brushing machine operated at a speed under load of 3,450 rpm and equipped with a 150 mm (6 inch) diameter cup brush of double-row, knotted construction, made of No. 20 gage music wire. The brush shall be held against the steel surface with a force of 71 N (16 pounds), and the rate of cleaning shall be 0.2 m<sup>2</sup> (2 square feet) of surface per minute. This test must be conducted on an area not previously brushed, scraped, or sanded, but from which all detrimental stratified rust (rust scale), oil, and grease, if present, have been removed. This test establishes a standard for surface preparation and shall not be considered as establishing the production rate of cleaning. Regardless of the method used for cleaning under this specification, the surface shall be cleaned at least as well as the surface resulting from this test.

In preparing surfaces for repainting, all loose paint shall be removed. Thick edges of remaining old paint shall be feathered so that the repainted surface will have a smooth appearance. The remaining old paint shall have sufficient adhesion so that it cannot be lifted as a layer by inserting the blade of a dull putty knife under it. All accessible weld flux and spatter shall be removed by power tools. The accessible portions of all partially enclosed steel members shall be cleaned. On new work, areas which will be inaccessible after assembly shall be cleaned before assembly.

Rivet heads, cracks, crevices, lap joints, fillet welds, and re-entrant angles shall be cleaned by the use of power wire brushing, sharp chisels used in chipping, scaling hammers, rotary grinders, sanders, or by a combination of such tools. All tools shall be operated in such a manner that no burrs or sharp ridges are left on the surface and no sharp cuts are made into the steel. Areas inaccessible for cleaning by power tools but accessible for hand cleaning shall be cleaned by methods outlined in 310-2.2.

After these cleaning operations are completed, dust and other loose matter shall be removed from the surface. If detrimental amounts of grease or oil are still present, these areas shall be spot cleaned with solvent. The pretreatment (if any), or the prime coat of paint shall be applied as soon as possible after cleaning and before further deterioration of the surface occurs.

### 310-2.5 Blast Cleaning.

#### 310-2.5.1 General.

(a) **Definition.** Blast cleaning is a method of preparing metal surfaces for painting by removing mill scale, rust, rust scale, paint, or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels, to obtain one of the degrees of surface cleanliness described below.

(b) **White metal.** A white metal blast-cleaned surface finish is defined as a surface with a gray-white, uniform metallic color, slightly roughened to form a suitable anchor pattern for coatings. The surface, when viewed without magnification, shall be free of all oil, grease, dirt, visible mill scale, rust, corrosion products, oxides, paint, or any other foreign matter. The color of the clean surface may be affected by the particular abrasive medium used.

(c) **Near-White.** A near-white blast-cleaned surface finish is defined as one from which all oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint, or other foreign matter have been completely removed from the surface except for very light shadows, very slight streaks, or slight discolorations caused by rust stain, mill scale oxides, or slight, tight residues of paint or coating that may remain.

At least 95 percent of each square inch of surface area shall be free of all visible residues, and the remainder shall be limited to light discoloration mentioned above.

(d) **Commercial.** A commercial blast-cleaned surface finish is defined as one from which all oil, grease, dirt, rust scale, and foreign matter have been completely removed from the surface and all rust, mill scale, and old paint have been completely removed except for slight shadows, streaks, or discolorations caused by rust stain, mill scale oxides, or slight, tight residues of paint or coating that may remain; if the surface is pitted, slight residues of rust or paint may be found in the bottom of pits; at least two-thirds of each 645 mm<sup>2</sup> (square inch) of surface area shall be free of all visible residues and the remainder shall be limited to the light discoloration, slight staining or light residues mentioned above.

(e) **Brush-off.** A brush-off blast-cleaned surface finish is defined as one from which all oil, grease, dirt, rust-scale, loose mill scale, loose rust, and loose paint or coatings are removed completely, but tight mill scale and tight-adhered rust, paint, and coating are permitted to remain provided that all mill scale and rust have been exposed to the abrasive blast pattern sufficient to expose numerous flecks of the underlying metal fairly uniformly distributed over the entire surface.

Heavy deposits of oil or grease shall be removed by the methods prescribed in 310-2.3.

Small quantities of oil or grease may be removed by the blast-cleaning operation.

Excessive rust scale shall preferably be removed by impact tools, as prescribed in 310-2.2 and 310-2.4.

**310-2.5.2 Methods.** The surface of the metal may be blast-cleaned by one of the following methods:

- 1) Dry sandblasting using compressed air blast nozzles and dry sand of a maximum particle size no larger than that passing through a 1.18 mm (No. 16) mesh screen, U.S. sieve series.
- 2) Wet or water-vapor sandblasting using compressed air blast nozzles, water, and sand of a maximum particle size no larger than that passing through a 1.18 mm (No. 16) mesh screen, U.S. sieve series.
- 3) Grit blasting using compressed air blast nozzles and crushed grit made of cast iron, malleable iron, steel, or synthetic grits other than sand. The largest commercial grade of metal grit permitted by this specification shall be SAE Grit No. G25 abrasive material.
- 4) Shot blasting using compressed air nozzles and cast iron, malleable iron, steel, or synthetic shot. The largest commercial grade shot permitted by this specification shall be SAE Shot No. S330.
- 5) Closed, re-circulating nozzle blasting using compressed air, vacuum, and any of the preceding abrasives.
- 6) Grit blasting using centrifugal wheels and crushed grit made of cast iron, malleable iron, steel, or synthetic grits. The largest commercial grade permitted by this specification shall be SAE Shot No. S330.

The surface, if dry blasted, shall be brushed with clean brushes made of hair, bristle, or fiber, blown off with compressed air (from which detrimental oil and water have been removed), or cleaned by vacuum, for the purpose of removing any traces of blast products from the surface, and also for the removal of abrasive from pockets and corners.

The surface, if wet sandblasted, shall be cleaned by rinsing with fresh water to which sufficient corrosion inhibitor has been added to prevent rusting, or with fresh water followed immediately by an inhibitive treatment. This cleaning shall be supplemented by brushing, if necessary, to remove any residue.

The compressed air used for nozzle blasting shall be free of detrimental amounts of condensed water or oil. Adequate separators and traps shall be provided. Blast cleaning operations shall be done in such a manner that no damage is done to partially or entirely completed portions of the work.

The blast-cleaned surface shall be further treated, or primed, as specified, within 8 hours after blasting when practicable, but in any event not later than 24 hours after blasting and also before any visible or detrimental rusting occurs. Surfaces which rust before painting is accomplished shall be recleaned by the Contractor at its expense.

### **310-3 SURFACE PREPARATION FOR PAINTING GALVANIZED SURFACES.**

**310-3.1 Hand Cleaning.** Concrete spatter, heavy grease, and other foreign matter shall be removed from galvanized surfaces by hand scraping or wire brushing.

**310-3.2 Solvent Cleaning.** After hand cleaning, all galvanized surfaces shall be cleaned by the solvent cleaning procedures prescribed in 310-2.3 herein to remove oil, grease, and other detrimental foreign matter. After washing, all areas shall be roughened by abrasive blasting using an abrasive that is no larger than 600 $\mu$ m (30 mesh). Galvanizing shall not be removed by this operation.

**310-4 SURFACE PREPARATION FOR PAINTING WOOD SURFACES.** Wood surfaces shall be prepared for painting by removing all cracked or peeled paint, loose chalky paint, dirt, and other foreign matter by wire brushing, scraping, sanding, or other approved means immediately prior to painting. All surfaces shall be wiped or dry brushed to remove any dust or chalky residue that may result from cleaning operations. All wood designated to be painted shall be thoroughly dry before paint is applied.

## 310-5 PAINTING VARIOUS SURFACES.

### 310-5.1 Painting Structural Steel.

**310-5.1.1 Paint.** Unless otherwise specified, paints shall consist of a primer (applied in not less than two coats), a pre-treatment, and two finish coats. The total dry film thickness of the primer shall not be less than 80  $\mu\text{m}$  (3 mils), and the total dry film thickness of two finish coats shall be not less than 50  $\mu\text{m}$  (2 mils). The dry film thickness of the paint will be measured in place with a calibrated magnetic film thickness gage. Pre-treatment thickness shall be sufficient to completely coat the underlying primer.

Excessively thick coats of paint will not be permitted. The thickness of each coat shall be limited to that which will result in uniform drying throughout the paint film.

Paint shall conform to 210-1. Succeeding coats of paint, not otherwise materially different in color, shall have carbon black mixed into the paint 30 g/L (0.25 lbs. per gallon) lamp black, Federal Specification TT-P-00350) or slightly varying pigments to produce a shade contrasting with the paint being covered. Such changes shall be in undercoats, and the final finish coat shall be the specified finish color.

**310-5.1.2 Cleaning.** Unless otherwise specified, after erection and riveting or welding, all surfaces of structural steel which will be exposed to air in the completed structure, shall be commercially blast-cleaned as prescribed by 310-2.5 prior to painting.

In repainting existing steel structures where partial cleaning is required, the method of cleaning will be as specified.

Any damage to sound paint on areas not designated for treatment, which results from the Contractor's operations, shall be repaired as directed by the Engineer.

**310-5.1.3 Application of Paint.** Painting of finish coats of structural steel, except for sections which will be inaccessible after erection as described herein, shall be done after erection unless otherwise specified. Requests to do any painting other than undercoats prior to erection shall be submitted by the Contractor and approved by the Engineer in writing before such work is started. Any deficiencies in the first coat of paint shall be corrected prior to the application of succeeding coats of paint.

Surfaces exposed to the atmosphere which would be inaccessible for painting after erection shall be painted the full number of coats prior to erection.

All previous coats of paint shall be dry and fully cured and the surface of the paint coat being covered shall be free from moisture, dust, grease, or any other deleterious material which would prevent the bond of the succeeding paint coats. In spot painting, any old paint which lifts after application of the first spot coat, shall be removed by scraping and the area repainted before application of the next coat.

The application of finish coats will not be permitted until the repaired total film thickness of the undercoats of paint, as described in 310-5.1.1, is obtained.

Open seams at contact surfaces of stiffeners and built-up members which would retain moisture shall be caulked with non-sag polysulphide material conforming to Federal Specification TT-S-230, Type 2, or other approved material before applying the second coat of primer.

Except for anchor bolt assemblies, steel surfaces embedded in concrete need not be painted. Ungalvanized anchor bolt assemblies shall be painted or dipped with one coat of zinc-rich primer prior to installation.

The bottom surfaces of masonry plates and surfaces of structural steel to be in contact with elastomeric bearing pad or preformed fabric pads shall be cleaned and painted with the full number of specified coats prior to erection.

With the exception of abutting chord and columns splices and column and truss shoe bases, machine finished surfaces shall be coated with a rust inhibitor which can be easily removed. Surfaces of iron and steel castings which have been machine finished shall be painted with a coat of shop paint.

Zinc-rich primer shall be applied by spray methods. On areas inaccessible to spray application, the paint may be applied by brush or daubers. Mechanical mixers shall be used in mixing the primer. After mixing, the primer shall be strained through a metal 600  $\mu\text{m}$  to 250  $\mu\text{m}$  (30-60) mesh screen or a double layer of cheesecloth immediately prior to or during pouring into the spray pot. An agitating spray pot shall be used in all spray application of primer. The agitator or stirring rod shall reach within 50 mm (2 inches) of the bottom of the spray pot and shall be in motion at all times during primer application. Such motion shall be sufficient to keep the primer well mixed. Whenever painting operations are interrupted, the primer remaining in the fluid hose shall be expelled from the hose. Primer shall be free from dust, dirt, salt, or other deleterious deposits and thoroughly dry before applying pre-treatment vinyl wash primer.

The wash primer shall not be applied more than 72 hours before application of finish coats. The vinyl wash primer wash shall be applied by spraying to produce a uniform wet film completely coating the underlying surface.

**310-5.1.4 Payment.** Full compensation for preparing surfaces and for painting shall be considered as included in the prices for the various contract items of work involving structural steel and no separate payment for such work will be made.

**310-5.2 Painting Machinery.** Prior to installation, all surfaces of machinery exposed to the atmosphere, which are subject to corrosion and are normally painted, shall be painted with two coats of paint. Unless otherwise specified, after installation of the machinery, such surfaces shall be painted with a finish coat. All coats shall be as specified for structural steel. Full compensation for painting machinery shall be considered as included in the price paid for the machinery or in the item of which the machinery is part.

**310-5.3 Painting Galvanized Surfaces.** Unless otherwise specified, galvanized surfaces shall be left unpainted. When required to be painted, the surfaces shall be prepared as specified in 310-3 and then painted in accordance with 210-1, one coat of zinc dust-zinc oxide primer. The primer shall be applied by spraying to produce a complete covering of the galvanized surface. After the primer is applied, one coat of pre-treatment vinyl wash primer shall be applied. One finish coat shall be applied the same day as the wash primer is applied.

Full compensation for painting such surfaces shall be included in the price paid for the various contract items involving galvanized metal objects and no separate payment for such painting will be made.

**310-5.4 Painting Metal Guard Rails.** Metal guard rails, when required to be painted, shall be painted with three coats of paint of the type specified for metal guard rails in 210-1.5. Full compensation for painting guard rails shall be considered as included in the price paid for the guardrails and no separate payment for such painting will be made.

#### **310-5.5 Painting Lumber.**

**310-5.5.1 Paint.** Unless otherwise specified, all new lumber requiring painting shall consist of a primer and two finish coats as prescribed in 210-1.5 for wood structures, or as specified by the Engineer.

On all lumber previously painted the number of coats and types of paint will be as specified.

**310-5.5.2 Preparation of Surfaces.** Wood surfaces designated to be painted shall be cleaned in accordance with 310-4.

**310-5.5.3 Application of Paint.** When permitted by the Engineer, the first coat of paint may be applied prior to erection.

After the first coat has dried and the lumber is in place, all cracks, checks, nail holes, etc., shall be puttied flush with the surface and allowed to dry before the second coat is applied.

Skips, holidays, thin areas, or other deficiencies in any one coat of paint shall be corrected before the succeeding coat is applied.

The surface of any paint coat being covered shall be free of deleterious material before additional paint is applied.

**310-5.5.4 Payment.** Full compensation for preparing surfaces and for painting lumber shall be considered as included in the prices paid for the various contract items of work involving lumber and no separate payment for such work will be made.

### **310-5.6 Painting Traffic Striping, Pavement Markings, and Curb Markings.**

**310-5.6.1 General.** The Contractor shall apply all traffic striping, marking, and all other directional information on the surfaces of highways, streets, detour roads, parking lots, median strips, and curbing only when required by the Contract Documents.

Should the Contractor elect to alter the existing traffic stripes and markings, or to divert the flow of traffic on construction projects for its convenience and there are no specific pavement markings or lane delineations shown on the Plans or in the Specifications, it shall provide the necessary temporary striping in accordance with the State Traffic Manual unless otherwise directed by the Engineer.

When not otherwise shown on the Plans, detour transitional traffic line striping shall have a minimum taper of 1:20 for temporary striping and 1:30 for permanent striping. Temporary traffic lanes shall be at least 3 m (10 feet) wide and no lane shall encroach within 1.5 m (5 feet) of an open excavation or within 0.6 m (2 feet) of a longitudinal curb.

All traffic stripes (except black stripes) shall be beaded on the final finish coat in accordance with 210-1.6.5.

The Contractor shall furnish all equipment, materials, labor, and supervision necessary for painting traffic lanes, directional arrows, guidelines, curbs, parking lines, crosswalks, and other designated markings in accordance with the Plans, or for approved temporary detours essential for safe control of traffic through and around the construction site. The Contractor shall remove by wet sandblasting (or by other approved methods) all existing or temporary traffic markings and lines that may confuse the public. When temporary detour striping or markings are no longer required, they shall be removed prior to painting the new traffic stripes or markings.

**310-5.6.2 Weather Conditions.** All paint shall be applied within the temperature range specified in Section 210, in referenced State Specifications, or as recommended by the paint manufacturer.

Paint shall be applied only when the pavement surface is dry and clean, when air temperature is above 5°C (40°F), and when the weather is not windy, foggy, or humid.

**310-5.6.3 Equipment.** All equipment required to perform the work shall be approved in advance by the Engineer, and shall include such apparatus as brushes, brooms, compressors, air blowers to properly clean the pavement surface, a mechanical marking machine, a suitable device for heating the paint to the specified temperatures, a bead dispensing device, auxiliary hand spray painting equipment, paint rollers, or other equipment as may be necessary to satisfactorily complete the work.

The striping machine shall be an approved spray-type marking machine suitable for applying traffic paint. It shall have sufficient paint capacity for each color with adequate air pressure to perform the work satisfactorily without excessive stopping. The machine shall produce a uniform film thickness and cross section at the required coverage and shall produce markings with clean-cut edges without running or spattering. It must be capable of being guided within the straightness tolerances set forth in these specifications. The machine shall have suitable adjustments for painting the line width specified and when required, shall be equipped with an automatic cycling device to produce intermittent (skip) lines in

accordance with 310-5.6.5. However, the machine shall be equipped to produce a variable skip pattern, including simultaneous painting of a broken line on one side and a solid line on the other side of a multiple stripe. An acceptable tolerance in the skip pattern is plus or minus 0.3 m (1 foot).

The striping machine shall be capable of three-gun application consisting of one black and two yellow spray guns operating simultaneously or individually. The equipment shall also be capable of operating two white guns simultaneously.

The striping machine shall have a wheelbase of sufficient length to produce a straight line to meet the straightness tolerance specified in 310-5.6.7. The machine must also be capable of producing curved lines without abrupt breaks, in accordance with approved layouts.

Provision shall be made for a dispenser capable of applying glass beads at the required rate.

Equipment for applying molten thermoplastic material shall readily extrude the material between 200°C (400°F) and 220°C (425°F) to produce a continuous line 3.2 mm (1/8 inch) to 4.8 mm (3/16 inch) thick, of uniform cross section, and having clear, sharp dimensions.

Thermoplastic material may also be applied by an approved machine that flame sprays the material on to clean road surfaces. This machine shall be capable of applying a coating 250 µm (10 mils) thick which will dry to “no pick-up” in accordance with ASTM D 711. The equipment shall produce a smooth, continuous line having clear sharp dimensions.

Word markings, letters, numerals, and symbols shall be applied using suitable spray equipment together with stencils and templates.

The Contractor shall provide a wet sandblasting machine with sufficient sand, water, and air capacity to completely remove all existing or temporary traffic striping or markings that may be confusing to the public. This machine shall meet all requirements of the air pollution control district having jurisdiction. All sand used in wet sandblasting shall be removed from the pavement without delay as the sandblasting operation progresses. Removal of striping by high velocity water jet may be permitted when approved by the Engineer.

**310-5.6.4 Geometry, Stripes, and Traffic Lanes.** Permanent and temporary striping and marking shall be in accordance with 310-5.6.1.

Longitudinal pavement markings shall conform to the following:

- 1) Yellow lines separate traffic flow in opposing directions.
- 2) White lines separate traffic flow in the same direction.
- 3) Broken lines are permissive.
- 4) Solid lines are restrictive.
- 5) Line widths indicate degree of emphasis.
- 6) Double lines indicate maximum restriction.

Centerlines shall be used to separate opposing traffic, and need not be at the geometric center of the roadway. Permanent lane widths shall be 3.6 m (12 feet) unless otherwise designated. Traffic stripes shall normally not project into or across a street intersection.

Lane lines shall be used to separate traffic traveling in the same direction on all multiple-lane highways and in congested locations where the roadway will accommodate more lanes of traffic with striping than it would without.

Standard word markings, letters, numerals, and symbols shall be as shown on the Plan. In the absence of such information, all stencils and templates shall be identical with those used by the Agency. The Contractor shall obtain stencils for all required legends.

## 310-5.6.5 Traffic Stripes and Markings.

TABLE 310-5.6.5 (A)

Line Color	Type	Suggested Use	Width mm (Inches)	Wet Film <sup>6, 8</sup> Thickness $\mu\text{m}$ (Mils)	Reflectorized
1 White	Broken <sup>2, 4</sup>	Lane	100 (4)	380 (15)	X
2 White	Solid	Lane extension	100 (4)	380 (15)	X
3 White	Solid	Parking stalls—T's	100 (4)	380 (15)	X <sup>8</sup>
4 White	Solid	Shoulder	50-100 (2-4)	380 (15)	X
5 White	Solid	Lane	200 (8)	380 (15)	X
6 White	Solid	Channelizing lane	200 (8)	380 (15)	X
7 White	Extra wide	Diagonals, limit bar	300-600 (12-24)	380 (15)	X
8 White	Extra wide	R.R. and stop lines	300-600 (12-24)	380 (15)	X
9 White	Solid	Crosswalks as shown on Plan or as directed by the Engineer	300-600 (12-24)	380 (15)	X
10 White	Solid	Words and symbols R.R.	As shown on Plan	380 (15)	X
11 Yellow	Solid	Centerline	100 (4)	380 (15)	X
12 Yellow	Broken <sup>2, 4</sup> Fig. 1A	Centerline	100 (4)	380 (15)	X
13 Yellow	Double yellow (broken yellow-solid yellow) (black separation line <sup>1</sup> ) Fig. 1C	Centerline—passing permissible when broken yellow in driver's lane	Yellow 100 (4) <sup>1</sup> Black 75(3)	380 (15) 180 (7)	X
14 Yellow	Double yellow (2 solid yellow) (black separation line <sup>1</sup> ) Fig. 1B	Centerline—no passing left edge of pavement two-way left turn lane	Yellow 100 (4) <sup>1</sup> Black 75(3)	380 (15) 180 (7)	X
15 Yellow	2 Double yellow 2 Solid yellow (Black separation <sup>1</sup> ) Fig. 1B	Median island on pavement or edge of median island	Yellow 100 (4) Black <sup>1</sup> 75 (3) Each Double-yellow separated by 600mm (24 in) min spacing	380 (15) 180 (7)	X X
16 Yellow	Solid	Crosswalks (near schools in accordance with Subsection 21,368 Motor Vehicle Code)	300-600 (12-24) 300 (12) standard w/approved words & symbols as required	380 (15)	X
17 Yellow	Double broken Skip cycle as shown on plan or as ordered by Engineer	Reversible centerline separates opposing flow, reversible lane	Yellow 100 (4) <sup>1</sup> Black 75(3)	380 (15) 180 (7)	X X
18 Yellow	Double yellow (broken yellow-solid yellow) (Black separation line <sup>1</sup> ) Fig. 1D	Centerline—traversable median	Yellow 100 (4) <sup>1</sup> Black 75(3)	380 (15) 180 (7)	X X
19 Red	Traffic zone curb marking	No stopping	Top and side of curb length per Plan	150 (6)	X <sup>8</sup>
20 Green	Curb marking	Limited time parking Commercial loading zone	Top and side of curb length per Plan	150 (6)	X <sup>8</sup>
21 Yellow	Curb marking	Limited time loading zone—commercial vehicle	Top and side of curb length per Plan	150 (6)	X <sup>8</sup>
22 White	Curb marking	Limited time loading	Top and side of curb length per Plan	150 (6)	X <sup>8</sup>
23 White or Yellow	Words and symbols	Guiding, warning and regulating	Per Plan	200 (8)	X
24 White or Yellow	Broken or solid	Extension of line through intersection	600 (24) stripes 1200 (48) gaps	380 (15)	X

## NOTES TO TABLE 310-5.6.5 (A)

- Black paint is used with other colors when the pavement itself does not provides sufficient contrast. Black paint shall not be beaded.
- A broken lane line (white) or center line (yellow) is formed by segments and gaps. Normal segments for roadways with prevailing speed of 64 km/h (40 mph) or less are 2.1m (7 ft) and gaps are 5.2m (17 ft). When the prevailing speed is 72 km/h (45 mph) or more, segments are 3.7m (12 ft) and gaps are 11m (36 ft).
- Curb markings will be reflectorized only when specified.
- Broken lines shall have become a solid yellow or white line approximately 15m (50 ft) from all intersections.
- All lines shall have a wet film thickness of 380  $\mu\text{m}$  (15 mils) when using "Regular Dry" cold applied paint. Black paint used for contrast shall have a wet film thickness of 180  $\mu\text{m}$  (7 mils).
- When using "Rapid Dry" hot applied paint, the wet film thickness shall be 300  $\mu\text{m}$  (12 mils). Dry film thickness of the finish stripe shall be 200 to 250  $\mu\text{m}$  (8 to 10 mils). Rapid dry black paint shall have a wet film thickness of 150  $\mu\text{m}$  (6 mils) and a dry film thickness of 80  $\mu\text{m}$  to 130  $\mu\text{m}$  (3 to 5 mils).
- The following paint application rates shall be used:
- Reflectorization is not required for off-street parking.

TABLE 310-5.6.5 (B)

Line Description White or Yellow	Wet Film Thickness	
	Regular Dry 380 µm (15 mils)	Rapid Dry 300 µm (12 mils)
100 mm (4 in) single solid line	38.8 L/km (16.5 gals/mile)	9.2 L/km (13.2 gals/mile)
175 mm (7 in) single solid line, 2.1m (7 ft) painted, 5.1 m (17 ft) unpainted	11.3 L/km (4.8 gals/mile)	9.2 L/km (3.9 gals/mile)
100 mm (4 in) single broken line, 3.7 m (12 ft) painted, 11m (36 ft) unpainted	9.6 L/km (4.1 gals/mile)	7.8 L/km (3.3 gals/mile)

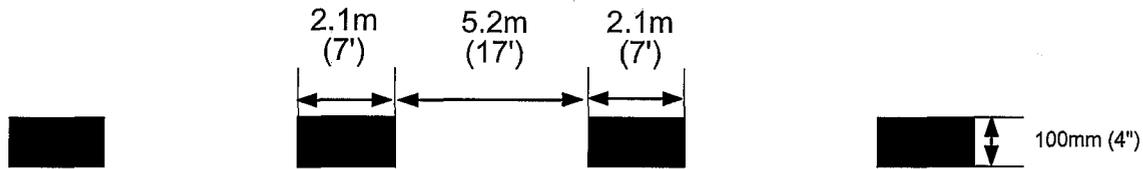
Line Description Black	Wet Film Thickness	
	0.18 mm (7 mils)	0.15 mm (6 mils)
75 mm (3 in) single solid line	13.6 L/km (5.8 gals/mile)	11.5 L/km (4.9 gals/mile)

Legends Words and Symbols ..... 0.4 L/m<sup>2</sup> (1 gal/100 feet<sup>2</sup>)  
 Curbs ..... 0.4 L/m<sup>2</sup> (1 gal/100 feet<sup>2</sup>)

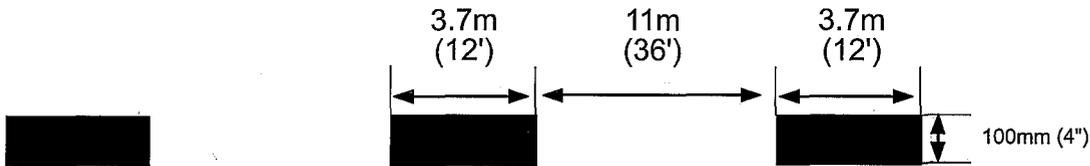
**STANDARD TRAFFIC STRIPE**

**A. SINGLE TRAFFIC STRIPE**

1. PREVAILING SPEED OF 64 KM/H (40 MPH) OR LESS



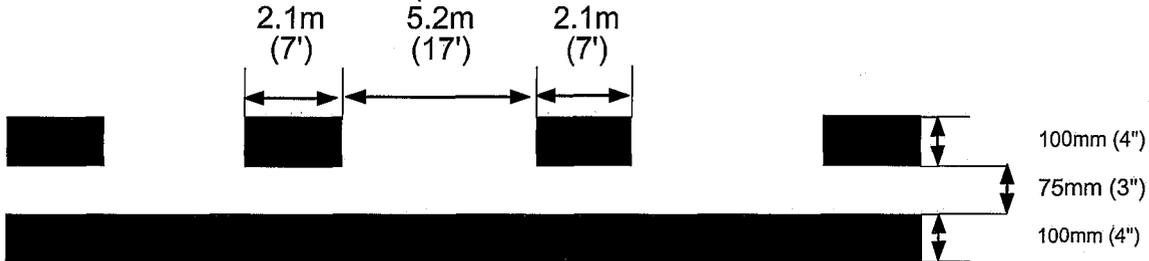
2. PREVAILING SPEED OF 72 KM/H (45 MPH) OR MORE



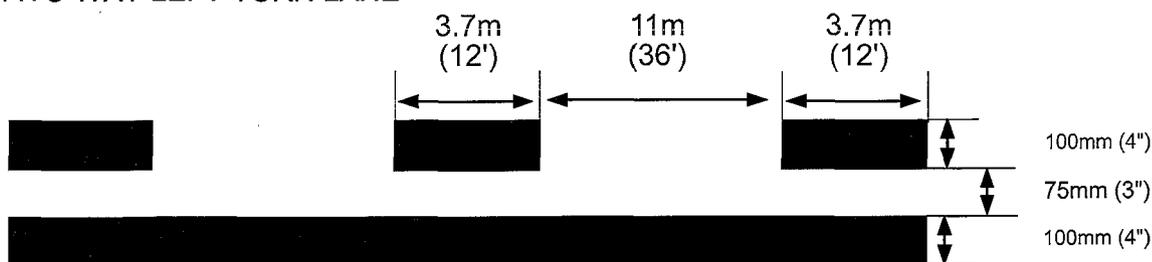
**B. TWO-WAY BARRIER STRIPE (NO PASSING IN EITHER DIRECTION)**



**C. ONE-WAY BARRIER STRIPE (FOR PASSING WHEN BROKEN LINE IS IN DRIVER'S LANE)**



## D. TWO WAY LEFT TURN LANE



FOR ALL OF THE ABOVE: THE SKIP CYCLE SHALL BE AS SHOWN ON THE PLAN OR AS ORDERED BY ENGINEER.

**310-5.6.6 Preparation of Existing Surfaces.** Existing markings and striping, either permanent or temporary, which are to be abandoned or obliterated shall be removed by wet sandblasting or other approved methods. Dry sandblasting may be used in selected areas only with the permission of the Engineer and with approval of the air pollution control authority having jurisdiction over the area in which the work will be performed. Alternate methods of paint removal require prior approval of the Engineer. Obliteration of traffic striping with black paint or light emulsion oil shall be done only with the prior approval of the Engineer.

Before applying paint, the existing pavement surface shall be cleaned by washing, sweeping, blowing, or vacuuming as necessary to remove moisture, dirt, grease, oils, acids, laitance, or other foreign matter which would reduce the bond between the paint and the pavement. Areas which cannot be satisfactorily cleaned shall be scrubbed with a water solution of tri-sodium phosphate (10 percent  $\text{Na}_3\text{PO}_4$  by weight) or other approved cleaning solution. After cleaning, the surface shall be rinsed with water and dried before painting.

**310-5.6.7 Layout, Alignment, and Spotting.** When necessary, the Engineer will furnish the necessary control points for all required pavement striping and markings. The Contractor shall establish all traffic striping between these points by stringline or other method to provide striping that will vary less than 80 mm per 100 m (1/2 inch in 50 feet) from the specified alignment.

When no previously applied figures, markings, or traffic striping are available to serve as a guide, suitable layouts shall be spotted in advance of the permanent paint application. Traffic lines may be spotted by using a rope as a guide for marking spots every 1.5 m (5 feet), by using a marking wheel mounted on a vehicle, or by any other means satisfactory to the Engineer.

The Contractor shall mark or otherwise delineate the traffic lanes in the new roadway or portion of roadway, or detour before opening it to traffic.

The Contractor shall provide an experienced technician to supervise the location, alignment, layout, dimensions, and application of the paint.

**310-5.6.8 Application of Paint.** Traffic striping and marking shall be applied at locations and to the dimensions and spacing indicated on the approved Plans or as provided in the Specifications. Where temporary traffic striping and marking is required, it shall not be applied until the layouts, alignments, sequencing, and condition of the existing surface have been approved.

Paint shall be mixed in accordance with the manufacturer's instructions. It shall be mixed thoroughly and applied to the surface at the proper temperature, at its original consistency without the addition of any paint thinner. If the paint is applied in two coats, the first coat shall be thoroughly dry before the second coat is applied. Before applying thermoplastic paint on concrete surfaces, there shall be a prime

coat consisting of either a two-component epoxy or a 10 percent solution of buna N rubber in methylethyl ketone applied 1/2 hour before application of the thermoplastic paint.

Traffic striping shall be applied in one application.

Ten days shall elapse between the application of a bituminous seal coat and the permanent traffic marking. The paint shall not bleed, curl or discolor when applied to bituminous surfaces. If bleeding or discoloring occurs, the unsatisfactory areas shall be given an additional coat of paint. This additional painting will be paid for in accordance with Section 3.

Straight stripes deviating more than 80 mm per 100 mm (1/2 inch in 50 feet) shall be obliterated by sandblasting, and the markings corrected. The width of markings shall be as designated, within tolerance of 4 percent. When existing striping and markings are to be repainted, they shall be repainted to completely cover the old markings within 6 mm (1/4 inch). Stripe repainting shall be retraced within a longitudinal tolerance of  $\pm 150$  mm (6 inches) at the end of each stripe. Abrupt breaks in striping alignment will not be allowed. The striping shall be a continuous operation except where crossovers are required to complete painted medians.

All painting shall be performed by competent and experienced equipment operators and painters using proper equipment, tools, stencils, templates, and shields in a workmanlike manner.

Difficulties normally experienced in cool weather shall be minimized by heating the traffic paint to provide for a uniform flow of material.

Reflective material shall be applied to traffic stripes and markings, in accordance with 210-1.6.5.

Temporary striping and marking shall be renewed when the stripes and markings have lost 50 percent of their original visual effectiveness.

All paint materials shall be tested before application to verify that they meet the specification requirements. The Engineer shall be notified upon delivery of the paint to permit inspection and sampling. When required by the Engineer, the Contractor shall furnish a notarized certificate signed by either an authorized employee of the manufacturer or test laboratory or both stating that the paint conforms to the specified requirements. This certificate shall not be interpreted as final approval of the paint.

**310-5.6.9 Protection of Work, Workers, and the Public.** The Contractor shall use proper and sufficient directional signs, warning devices, barricades, pedestals, lights, traffic cones, flagpersons, or such other devices to protect the Work, workers, and the public.

All markings and striping shall be protected from injury and damage of any kind while the paint is drying. All adjacent surfaces shall be protected from disfiguration by spatter, splashes, spillage, and dripping of paint or other material.

In areas of high traffic volume, the Contractor shall schedule work to paint traffic lines and markings in off-peak traffic hours or on weekends.

**310-5.6.10 Measurement and Payment.** The quantity of traffic striping and marking shall be measured by one or more of the following methods: linear meter (foot), the area in square meter (square feet), or one lump sum item complete in place.

All costs for temporary pavement painting for the convenience of the Contractor, including costs for sandblasting of existing lines and markings, shall be at its expense.

## SECTION 311 - SPECIAL PROTECTIVE MATERIALS

### 311-1 PLASTIC LINER INSTALLATION.

**311-1.1 General.** The installation of all plastic liner shall be done in accordance with Plans and Specifications.

Liner shall be applied and secured to the forms, inspected, and approved by the Engineer prior to the placement of reinforcing steel. Forms in contact with plastic liner shall not be oiled. Forms in contact with rigid plastic liner may be lubricated with a biodegradable lubricating material approved by the Engineer.

Liner sheet, weld strip, other liner accessory items, adhesive products, and cleansers to be used in conjunction with the installation of the liner shall conform to 210-2.

### 311-1.2 Installer Qualifications.

**311-1.2.1 Applicators.** The application of plastic liner to forms and other surfaces is considered to be specialized work. Personnel performing such work shall be adequately trained in the methods of liner installation and shall demonstrate their ability to the Engineer prior to commencing work.

**311-1.2.2 Welders.** Each welder shall pass a qualification welding test before doing any welding. Requalification may be required at any time it is deemed necessary by the Engineer. All test welds shall be made in the presence of the Agency's representative and shall consist of the following:

- 1) Two pieces of liner at least 380 mm (15 in) long and 230 mm (9 in) wide, shall be lapped 40 mm (1-1/2 in) and held in a vertical position.
- 2) A welding strip shall be positioned over the edge of the lap and welded to both pieces of liner. Each end of the welding strip shall extend at least 50 mm (2 inches) beyond the liner to provide tabs.

The weld specimen will be tested by the Engineer as follows:

- 1) Each welding strip tab, tested separately, shall be subjected to a 45 N (10-pound) pull normal to the face of the liner with the liner secured firmly in place. There shall be no separation between the welding strip and liner.
- 2) Three test specimens shall be cut from the welded sample and tested in tension across the welds.
  - a) If none of these specimens fails when tested as indicated in 210-2.3.5, the weld will be considered as satisfactory.
  - b) If one specimen fails to pass the tension test, a retest will be permitted. The retest shall consist of testing three additional specimens cut from the original welded sample. If all three of the retest specimens pass the test, the weld will be considered satisfactory.
  - c) If two of three specimens fail, the welder will be considered to be an unqualified welder and shall be disqualified.

A disqualified welder may submit a new welding sample when he has had sufficient off-the-job training or experience to warrant re-examination.

### 311-1.3 Placing Liner.

**311-1.3.1 Coverage.** The circumferential coverage shown on the Plan for the liner is the minimum limit of coverage permitted.

After pipe is installed, the offset of each longitudinal terminal edge of sheet on adjoining pipe shall not be greater than 38 mm (1-1/2 inches). In cast-in-place structures, no such offset of the lower terminal edge shall be permitted.

At any location as shown on the Plans, where there is a difference in, and the longitudinal terminal edges of liner downstream from said location are lower than those upstream, the terminal edges of the liner installed in the section of pipe or structure immediately upstream from the station shall be sloped uniformly for the entire length of the section of pipe or structure from the limits of the smaller coverage to those of the greater coverage. Wherever the longitudinal terminal edges of liner downstream from the station are higher than those upstream, the slope shall be accomplished uniformly throughout the length of the section of pipe or structure immediately downstream from the station. An approved locking extension shall be provided along all sloping lower terminal edges of liner plate.

**311-1.3.2 Positioning Liner.** All liner installed in pipe shall be positioned so that the locking extensions are parallel to the axis of the pipe.

Liner shall be centered within the form with respect to the "T" of the pipe when the inner form is in position. Liner shall be set flush with the inner edge of the socket end of a pipe section and shall extend either to the spigot end or beyond the spigot end, as required for the type of liner joint to be made with the adjoining pipe.

Rigid liner shall be set flush with the inner edge of the socket-and-spigot end of pipe or structure. Rigid liner may be set back from the edge of the pipe up to 13 mm (1/2 inch) to facilitate manufacturing.

Liner installed in cast-in-place structure shall normally be positioned with locking extensions placed in the vertical direction. Horizontal placement may be utilized with the approval of the Engineer.

Liner shall be closely fitted to inner forms. Sheets shall be cut to fit curved and warped surfaces using a minimum number of separate pieces.

Prior to installation, the Contractor shall indicate to the Engineer the proposed layout of liner sheets for cast-in-place structures, including the location and type of all field welds.

The Engineer may require field sketches or the use of patterns or the marking of sheet layouts directly on the forms where complicated or warped surfaces are involved.

At transverse joints between sheets of liner used in cast-in-place structures and at all pipe joints, the space between ends of locking extensions, measured longitudinally, shall not exceed 100 mm (4 inches). Where sheets are cut and joined for the purpose of fitting irregular surfaces, this space shall not exceed 50 mm (2 inches).

**311-1.3.3 Securing Liner in Place.** Liner shall be held snugly in place against inner forms. For pipes and similar circular sections, light steel banding straps, prefabricated tubes, or other approved means shall be used. If used, banding straps shall be placed in strap channels. Any method of banding other than in strap channels shall require prior approval by the Engineer. Where form ties or form stabilizing rods pass through the liner, provisions shall be made to maintain the liner in close contact with the forms during concrete placement.

Concrete shall be prevented from flowing around the edges of sheets at joints by welding a weld strip or applying a waterproof tape over the back of the joint.

**311-1.3.4 Flexible Liner Weep Channels.** At each pipe joint and at transverse joints in cast-in-place structures, a gap not less than 50 mm (2 inches) nor greater than 100 mm (4 inches) shall be left in all locking extension to provide a transverse weep channel. If locking extensions are removed to provide a weep channel at joints, the base of the extension left on the sheet shall not exceed 0.80 mm (0.032 inch).

Intermediate weep channels shall be provided as required by the Plans or Specifications. Intermediate weep channels shall not be less than 60 mm (2.5 inches) nor greater than 100 mm (4 inches) in width. If locking extensions are removed to provide intermediate weep channels, the base of the extension left on the sheet shall not exceed 1.60 mm (0.063 inch). Weep channels are not required on pipe containing a steel cylinder or pipe having 360 degree liner coverage

Any area behind liner, which is not properly served by regular weep channels, shall have additional weep channels 50 mm (2 inches) wide provided by cutting away locking extensions. Provisions shall be made to permit any water accumulated behind the liner of concrete manhole shafts to drain into the weep channels of the lined structure.

An additional transverse weep channel shall be provided approximately 300 mm (12 inches) away from each liner return where surfaces lined with plastic liner join surfaces which are not lined, and at the terminal edge of the weep channel for reinforcement.

As a part of the work of installing liner, outlets of all weep channels shall be cleared of obstructions which would interfere with their proper function.

Where required by the Plans or Specifications, a 300 mm (12 inch) long weld strip, 25 mm (1 inch) wide, shall be centered over each terminal edge of the weep channel for reinforcement.

**311-1.3.5 Liner Returns.** A liner return with integral weep channels shall be installed where shown on the Plans and wherever surfaces lined with plastic liner join surfaces which are not so lined (such as brick, unlined concrete pipe, clay pipe, cast iron pipe, manhole frames, and metal or clay tile gate guides).

Unless otherwise indicated by the Plans, the Specifications, or the Standard Plans showing liner installation methods, returns shall be made as follows:

- 1) Each liner return shall be a separate strip of liner at least 75 mm (3 inches) wide joined at right angles to the main liner by means of approved corner strips.
- 2) Flexible corner strips shall continuously heat-welded to the return and to the main liner. Rigid corner strips shall be nonflammable solvent welded.

Each liner return shall be sealed to the adjacent construction with which it is in contact by means of a compound approved by the Engineer. If the joint space is too wide or the joint surface too rough to permit the use of the compound, the joint space shall be filled with 50 mm (2 inches) of densely caulked cement mortar, lead wool, or other caulking material approved by the Engineer, and finish coated with a minimum of 25 mm (1 inch) of an approved corrosion-resistant material.

#### **311-1.4 Concrete Casting Operations.**

**311-1.4.1 Concrete Placement.** During concrete placement, shall be continuously vibrated to avoid damage to the liner and produce dense concrete securely anchoring the locking extensions into the concrete.

**311-1.4.2 Removing Forms.** When removing forms, care shall be taken to protect liner from damage. Sharp instruments shall not be used to pry forms from lined surfaces. When forms are removed, any nails that remain in the liner plate shall be pulled and the resulting holes clearly marked. Form tie holes shall be marked before ties are broken off and all areas of abrasion of the liner shall be marked.

Following completion of form removal, liner in pipe and structures shall be cleaned for inspection at the direction of the Engineer. Repairs to the liner in pipe and structures shall be completed and approved by the Engineer prior to shipment of the pipe.

Banding straps used in securing liner to forms shall be removed within the limits of the unlined invert. Voids left in the invert at the edge of the liner shall be filled with cement mortar or other material approved by the Engineer.

### 311-1.5 Field Jointing of Liner.

**311-1.5.1 General.** No field joint shall be made in liner until the lined pipe or structure has been backfilled and 7 days have elapsed after the flooding, jetting, or other means of compaction has been completed. Where groundwater is encountered, the joint shall not be made until pumping of groundwater has been discontinued for at least 7 days and no visible leakage is evident at the joint. The liner at the joints shall be free of all mortar and other foreign material and shall be clean and dry before joints are made.

Heated joint compound shall not be brought in contact with liner.

No coating of any kind shall be applied over any joint, corner, or welding strip, except where nonskid coating is applied to liner surfaces.

**311-1.5.2 Field Joints in Pipe Installation.** Field joints in liner plate at pipe joints shall be performed by utilizing one of the following types:

- 1) Flexible liner Type P-1 joint shall consist of a 100 mm (4 inch) joint strip, centered over the mortared pipe joint and secured along each edge to adjacent liner by means of a welding strip.
- 2) Flexible liner Type P-2 joint shall be made with an integral joint flap with locking extensions removed per 210-2.4.6, extending a minimum of 75 mm (3 inches) beyond the spigot end of the pipe. The flap shall overlap and be welded to the adjacent lined pipe section using a weld strip. Care shall be taken to protect the flap from damage. Excessive tension and distortion while bending the flap back to facilitate laying and joint mortaring shall be avoided.

Any flap which has been bent back and held shall be allowed to return to its original shape and flatness well in advance of making the liner joint.

- 3) Rigid liner Type CJ-1 shall consist of a co-extruded 185 mm (7-1/4 inch) wide joint strip, centered over the mortared pipe joint, and secured along each edge to the adjacent liner by means of solvent welding. The nonflammable solvent shall be approved by the Engineer prior to its use.
- 4) Field joints in rigid liner at manhole joints shall use and shall consist of a 38 mm (1-1/2 inch) by 38 mm (1-1/2 inch) factory-installed L-angle. When manholes are installed in the field, polyurethane compound, approved by the Engineer, shall be applied between L-angles for sealing purposes.

Field joints in liner at pipe joints shall not be made until the mortar in the pipe joint has been allowed to cure for at least 48 hours.

All joints between flexible-lined pipe and flexible-lined cast-in-place structures shall be either Type C-1 or Type C-2 specified herein.

**311-1.5.3 Field Joints in Cast-in-Place Structures.** Field joints in liner on cast-in-place structures shall be one of the following types:

(a) **Flexible Liner.**

- 1) Type C-1 joint shall be made in the same manner as a Type P-1 joint. The width of space between adjacent sheets of liner in a Type C-1 joint shall not exceed 13 mm (1/2 inch). This is the only type of joint permitted at transverse expansion and contraction joints in concrete. Its only other use is for joints between pipes and cast-in-place structures.
- 2) Type C-2 joints shall be made by overlapping sheets not less than 38 mm (1-1/2 inches) and securing the overlap to the adjacent liner by means of a welding strip. The upstream sheet shall overlap the downstream sheet. The length of that part of the overlapping sheet not having locking extensions shall not exceed 100 mm (4 inches).

A welding strip shall be applied to the back of the joint. The C-2 joint may be used at any transverse liner joint other than those at transverse expansion and contraction joints in concrete and shall be used for liner joints made at longitudinal joints in concrete.

- 3) Type C-3 joint shall be made by butting sheets of liner together and applying a welding strip over the back of the joint before concrete is placed. After the concrete is in place, apply a welding strip over the front of the joint. A Type C-3 joint is not permitted at a transverse joint which extends to a lower terminal edge of liner or at any joint where the gap between adjoining sheets of liner exceeds 3 mm (1/8 in).

**(b) Rigid Liner.**

- 1) Type CJ-1 shall be used where flexible joints are required. The solvent-welded joint shall be held in place by applying continuous pressure over the entire width and circumferential length of the solvent-welded joint for a minimum of 6 hours.
- 2) Type CJ-2 shall be used as a liner return as described in 311-2.3.5.
- 3) Type CJ-3 shall be used for internal and external 90-degree corners.
- 4) Type CJ-4 shall be used for internal external 135-degree corners.
- 5) Type CJ-5 shall be used for applications where custom panel widths are required. It may also be used where custom angles are required.
- 6) Type CJ-6 shall be used for custom or compound angle requirements.

**311-1.5.4 Installation of Welding Strips for Flexible Liner.** Welding strips shall be fusion welded to joint strips and liner by welders approved by the Engineer using only approved methods and techniques. The welding operation of any joint shall be continuous until that joint has been completed.

Adequate ventilation shall be maintained during all welding operations.

Hot air welding tools shall provide clean effluent air at constant pressure to the surfaces to be joined within a temperature range between 260°C and 315°C (500°F and 600°F).

For lap welds, the welding strip shall be offset so that approximately 1/3 of the width is placed on the high side of the lap and properly fused. A small gap in fusion, not to exceed 3 mm (1/8 inch) in width at the lap, is acceptable.

For butt welds, the welding strip shall be centered over the cleaned surfaces to be joined and fused across its entire width. Incomplete fusion, charred, or blistered welds will be rejected.

After repairs have been made, repaired welds shall be reinspected, tested, and approved by the Engineer.

**311-1.5.5 Joint Reinforcement.** A 300 mm (12 inch) long welding strip shall be applied as a reinforcement across each transverse joint, weep channel, or return which extends to the lower terminal edge of liner. These reinforcement strips shall be centered over the joint being reinforced and located as close to the lower edge of liner as practicable. They shall be welded in place after the transverse welding strips have been installed.

**311-1.6 Application of Liner to Concrete Surfaces.** Application of liner plate to concrete surfaces by means of approved adhesive shall be accomplished by the following steps:

- 1) The concrete surface shall be etched by sandblasting to develop a slightly granular surface. When permitted by the Engineer, the concrete surface may be acid etched and neutralized in lieu of being sandblasting.
- 2) After sandblasting, the concrete surface shall be thoroughly cleaned of dust. Surfaces etched with acid shall be thoroughly washed with clean water and completely dried before applying primer. Application of primer, adhesive, and liner shall be in accordance with manufacturer's recommendations as approved by the Engineer.

**311-1.7 Non-Skid Surfaces.** All surfaces of the liner, shown on the Plans to be non-skid, shall be treated as follows prior to installation:

- 1) The liner shall be cleaned, dried, and sprayed with an adhesive coating recommended by the manufacturer of the liner plate.
- 2) Immediately after the adhesive is applied to the liner, the surface shall then be liberally sprinkled with clean, dry, well-graded sand, passing a 600  $\mu\text{m}$  (No. 30) sieve but be retained on a 212  $\mu\text{m}$  (No. 70) sieve.  
After the sanded surface has thoroughly dried, all excess sand shall be brushed away and a seal coat of the adhesive coating shall be sprayed over the sand in sufficient quantity to coat and bond the sand to the liner plate.
- 3) The coated sand surface shall be allowed to dry thoroughly before handling.

**311-1.8 Application of Liner to Steel.** All fabrication and welding of steel to be lined with plastic liner shall be completed before the liner is installed except for field welding.

All steel surfaces to which plastic liner is to be applied shall be sandblasted, leaving surfaces free of all mill scale, rust, grease, moisture, and other deleterious substances. All interior weld metal shall be ground smooth and all weld spatter removed. After welds are ground, weld metal shall not project more than 1.5 mm (1/16 inch) above the pipe surface. In the event that field welding is required, the plastic liner shall not be installed closer than 300 mm (12 inches) to the weld. Plastic liner shall be installed in the weld area after welding on the steel has been completed.

The application of primer, adhesive, activator, and liner to steel surfaces shall conform to the requirements set forth herein for bonding of liner plate to concrete surfaces with adhesive. All field joints shall be tight-fitting butt joints. After the liner has been applied to steel surfaces, corner strips or welding strips shall be applied over all joints and welded in place.

**311-1.9 Protection and Repair of Liner.** All necessary measures and precautions shall be taken to prevent damage to liner from equipment and materials used in, or taken through the work. Any damage to installed liner plate shall be repaired by the Contractor in accordance with the requirements set forth herein for the repair of liner at no additional cost to the Agency.

For flexible liner, all nail and tie holes and all cut, torn, and seriously abraded areas in the liner plate shall be patched. Patches made entirely with welding strip shall be fused to the liner over the entire patch. The use of this method is limited to patches which can be made with a single welding strip. The use of parallel, overlapping, or adjoining welding strips will not be permitted. Large patches may consist of smooth liner over the damaged area, with edges covered with welding strips fused to the patch and to the liner adjoining the damaged area. The size of a single patch of the latter type shall be limited only as to its width, which shall not exceed 100 mm (4 inches).

For rigid liner, all nail and tie holes, and all cut, torn, and seriously abraded areas in the liner plate shall be patched. Patches are available in three standard sizes: 50 mm (2 inch), 75 mm (3 inch), and 100 mm (4 inch) diameter disks with a thickness of 1.98 mm (0.078 inch). Patches shall be solvent welded to the liner plate.

Whenever liner is not properly anchored to concrete, or wherever patches larger than those permitted above are necessary, the repair of liner and the restoration of anchorage shall be as directed by the Engineer.

**311-1.10 Field Tests.** Upon completion of the installation, the surface of liner shall be cleaned to permit visual inspection and spark testing by the Engineer, using a spark-type detector complying with the requirements of 210-2.3.7. All areas of liner plate failing to meet the field test shall be properly repaired and retested. In addition to the visual inspection and prior to spark testing, all welds shall be tested for adhesion by probing with an instrument, such as a putty knife, to assure proper fusion of the weld strip and liner plate without damage to the weld strip or liner.

The Contractor shall assist in the inspection and spark testing by providing adequate ventilation, ladders for access, barricades, or other traffic control devices, and shall be responsible for opening and closing entrances and exits.

Any spark testing of liner by the Contractor for its purposes shall be done with a detector complying with 210-2.3.7.

**311-1.11 Payment.** Payment for plastic liner materials and their installation shall be included in the price bid for the pipe or structure to which they are applied.

## **SECTION 312 - PAVEMENT MARKER PLACEMENT AND REMOVAL**

**312-1 PLACEMENT.** Except as provided herein, markers shall be cemented to the pavement with Rapid Set Epoxy Adhesive conforming to 214-6.2.1 or with Bituminous Adhesive conforming to 214-7. In areas of new construction where the markers are protected from all traffic, including the Contractor's vehicles, Standard Set Epoxy Adhesive conforming to 214-6.2.2 may be used. Said protection from all traffic shall be for at least 3 hours after marker placement when the average ambient temperature is 13°C (55°F) or above, at least 24 hours when said temperature is between 5°C and 13°C (40°F and 55°F), and at least 48 hours when the temperature is 5°C (40°F) or below.

The Engineer will be the judge as to when Rapid Set Epoxy or Bituminous Adhesives have set sufficiently to bear traffic.

Regardless of the type of adhesive used, markers shall not be placed under the following conditions:

- 1) When either the pavement or the air temperature is 0°C (32°F) or less.
- 2) If the relative humidity of the air is greater than 80 percent.
- 3) If the pavement is not surface dry.

The portion of the highway surface to which the marker is to be bonded by the adhesive shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint, and any other material which would adversely affect the bond of the adhesive. Cleaning shall be done by blast cleaning on all surfaces regardless of age or type. The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been pressed in place. The marker shall be placed in position and pressure applied until firm contact is made with the pavement. Excess adhesive around the edge of the marker, excess adhesive on the pavement, and adhesive on the exposed surfaces of the markers shall be immediately removed. Soft rags moistened with mineral spirits conforming to Federal Specification TT-T-291 or kerosene may be used, if necessary, to remove adhesive from exposed faces of pavement markers. No other solvent shall be used. The marker shall be protected against impact until the adhesive has hardened to the degree designated by the Engineer.

Epoxy adhesives require that the mixing operation and placing of the markers be done rapidly. When hand mixing the standard-set epoxy adhesive, not more than 1 liter (1 quart) shall be mixed at one time, and the markers shall be aligned and pressed into place within 5 minutes after mixing operations are started. Any mixed batch which becomes so viscous that the adhesive cannot be readily extruded from under the marker on application of slight pressure shall not be used. Rapid-set epoxy adhesive shall not be mixed by hand.

Just before use, Components A and B shall be mixed in a one-to-one ratio by volume. When automatic proportioning and mixing machine is used, the temperature of the components shall be maintained by indirect heating or cooling, so that the adhesive will meter, mix, and extrude properly.

The maximum temperature shall be such that after proper mixing there shall be no excess flow of adhesive from under the marker other than that specified above.

The rapid-set epoxy adhesive shall be mixed by a two-component type automatic mixing and extrusion apparatus. When machine mixing the standard-set or the rapid-set epoxy adhesives, the markers shall be placed within 60 seconds after the adhesive has been mixed and extruded and no further movement of the markers will be allowed. In addition, no more than 90 seconds shall be permitted between the time the adhesive is pumped into the mixing head and the time this adhesive is in place on the roadway and not subject to further movement. The mixed adhesive shall not remain in the mixing head for more than 45 seconds. Adhesive remaining in the mixing head longer than this period shall be wasted before resuming the operation.

Automatic mixing equipment for the epoxy adhesive shall use positive displacement pumps and shall properly meter the two components in the specified ratio,  $\pm 5$  percent volume of either components. At the beginning of each day and at any other time ordered by the Engineer, the ratio shall be checked by the Contractor in the presence of the Engineer. This check shall be made by disconnecting the mixing heads, or using suitable bypass valves, and filling two suitable containers with the unmixed components. The mixing head shall properly mix the two components so that there is no trace of black or white streaks in the mixed material.

Voids in a cured, undisturbed sample of the mixed adhesive obtained from the extrusion nozzle shall not exceed 4 percent.

The bituminous adhesive shall be indirectly heated in an applicator with continuous agitation. The adhesive shall be applied when at a temperature of between 200°C and 220°C (400°F and 425°F). Markers shall be placed immediately after application of the adhesive.

**312-2 GEOMETRY.** All details and dimensions for raised pavement markers shall conform to the *CalTrans Traffic Manual* or as directed by the Engineer.

All markers shall be placed to the line established by the Engineer. Reflective markers shall be placed in such manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. All additional work necessary to establish satisfactory lines for markers shall be performed by the Contractor.

No pavement markers shall be placed over longitudinal or transverse joints of the pavement surface.

**312-3 REMOVAL.** Pavement markers shall be removed by such methods that will cause the least possible damage to the pavement or surfacing. Any damage to the pavement or surfacing caused by pavement marker removal shall be repaired by the Contractor at its expense by methods acceptable to the Engineer.

During the removal of ceramic type pavement markers, screens or other protective devices shall be furnished to contain any fragments.

All fragments resulting from the removal of pavement markers shall be removed from the pavement surface before the lane or lanes are opened to public traffic.

**312-4 MEASUREMENT AND PAYMENT.** The quantity of reflective and nonreflective pavement markers placed or removed will be measured as units determined from actual count in place or one lump sum item complete in place.

Except as called for otherwise, payment will be made at the Contract Unit Prices for reflective and nonreflective markers. Payment shall include full compensation for doing all the work involved in furnishing and placing or removing pavement markers, including adhesives and pavement repair, as shown on the Plans or in the Specifications and as directed by the Engineer.

## PART 4

### SECTION 400 - ALTERNATE ROCK PRODUCTS, ASPHALT CONCRETE, PORTLAND CEMENT CONCRETE AND UNTREATED BASE MATERIAL

(This subsection shall apply only when Alternate Rock Material-Type S is specified)

#### 400-1 ROCK PRODUCTS.

##### 400-1.1 General.

**400-1.1.1 General.** The following specifications set forth the requirements for aggregates for asphalt concrete, portland cement concrete, and untreated base material.

All rock products shall be clean, hard, sound, durable, uniform in quality, and free of any detrimental quantity of soft, friable, thin, elongated or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

The weight loss, as determined by ASTM C 131, shall not exceed 15 percent during 100 revolutions nor 52 percent during 500 revolutions.

Specified gradations represent the limits which determine the suitability of aggregate for use. Actual gradations shall be uniformly graded from coarse through fine, remaining proportionately distant from these limits.

Coarse aggregate is material retained on the 4.75 mm (No. 4) sieve and fine aggregate is material passing the 4.75 mm (No. 4) sieve.

The Contractor, at its expense, shall provide safe and satisfactory facilities for obtaining representative samples.

Materials may be sampled at any time until final formal acceptance of the Work.

**400-1.1.2 Source.** Before beginning portland cement concrete and asphalt concrete work, the Contractor shall submit the name of the supplier to the Agency. The supplier shall have on file with the Agency mix designs for portland cement concrete and asphalt concrete when required by the Specifications.

The Contractor or supplier shall resubmit required information when any change is made.

**400-1.1.3 Statistical Testing.** Statistical testing shall conform to the following:

Whenever both individual test results and moving average requirements are specified, materials shall meet both requirements.

Individual samples tested prior to the first use of aggregates from each source, or prior to the first use of aggregates after appreciable changes have been made in aggregate processing procedures, shall conform to the limits specified for the moving average.

Whenever the results of an individual test for any property of a material, other than concrete compressive strength, does not comply with the limits specified for an individual test and if the moving average would not comply with the limit specified for the moving average should the next test be of the same value as that of the test being considered, the production of that material shall be suspended until corrective changes have been made by the Contractor and tests indicate that the quality of the next material to be used in the work complies with that specified for the moving average.

Moving average shall be computed as follows:

Moving average shall be rounded to the same number of significant figures as are reported for individual test results. When the figure to be dropped is less than five, round down, if greater than five, round up, and if it is five, round up or down to the even number.

Moving averages shall be continuous for the batch plant. In determining a moving average for a material property, all of the individual tests results that represent material actually used in the work shall be used in the calculation. The test results shall enter the calculation sequence in the chronological order that the work is preformed. The first individual test result shall start a moving average and shall meet the moving average requirements. Until more than four test results are available, the moving average shall be the numerical average of the individual test results. When more than four test results are available the moving average shall be determined by multiplying the last moving average by four, adding the new result to this product and then dividing this sum by five.

In computing moving average, whenever an upper calculation limit value for an individual test is stated in the Specifications, the upper calculation limit value shall be used in the calculation in lieu of any actual individual test results which exceed said upper calculation limit value.

#### **400-2 UNTREATED BASE MATERIALS.**

##### **400-2.1 General.**

**400-2.1.1 Requirements.** All requirements of 200-2 shall apply except as hereafter provided. When base material without further qualification is specified, the Contractor shall supply processed miscellaneous base.

**400-2.2 Disintegrated Granite.** Disintegrated granite shall conform to 200-2.7

**400-3 PORTLAND CEMENT CONCRETE.** Provisions of 201-1 shall apply except that gradings A, B, and C may be used interchangeably. When no class is specified, Class 330-C-23 (560-C-3250) shall be used.

The concrete ball penetration test, California Test 533, may be used at the discretion of the Engineer if it is calibrated to the slump test for a given mix.

**400-3.1 Coarse Aggregate.** Coarse aggregate shall meet the requirements of 200-1.4 with the following modifications:

- 1) The soundness loss, when tested by California Test 214 shall not exceed 10 percent.
- 2) The minimum specific gravity of the 4.75 mm (No. 4) material shall be 2.56.
- 3) The specific gravity requirement may be waived if the material is stockpiled and approved by the Engineer before use.

The grading requirements for course aggregate are shown in Table 400-3.3.1 (A) for each aggregate size.

**TABLE 400-3.1.1 (A)**  
**PERCENTAGE PASSING**

Sieve Sizes	Number 2		Number 3		Number 4
	Individual Test Results	Moving Average	Individual Test Results	Moving Average	Combined Average
50 mm (2 in)	100	100	—	—	—
37.5 mm (1-1/2 in)	89-100	91-100	100	100	—
25 mm (1 in.)	X ± 18	X ± 12	89-100	91-100	—
19 mm (3/4 in.)	0-16	0-14	X ± 18	X ± 12	100
9.5 mm (3/8 in.)	0-5	0-4	X ± 18	X ± 12	90-100
4.73 mm (No. 4)	—	—	0-16	0-14	0-30
2.36 mm (No. 8)	—	—	0-5	0-4	0-10

In the above table the symbol X is the gradation that the Contractor proposes to furnish for the specific sieve size. The X value shall meet the gradation limits of Table 200-1.4 (B).

**400-3.2 Fine Aggregate.** The fine aggregate shall meet the requirements in 200-1.5. The relative mortar strength shall not be less than 95 percent. Fine aggregate for mortar and plaster shall conform to the gradation for mortar sand in 200-1.5.5.

Fine aggregate shall be graded within the following limits:

**TABLE 400-3.2.1 (A)**  
**PERCENTAGE PASSING**

Sieve Sizes	Individual Test Results	Moving Average
9.5 mm (3/8 in.)	100	100
4.75 mm (No. 4)	95 - 100	96 - 100
2.36 mm (No. 8)	61 - 99	66 - 94
1.18 mm (No. 16)	X ± 11	X ± 8
600 μm (No. 30)	X ± 8	X ± 7
300 μm (No. 50)	X ± 6	X ± 4
150 μm (No. 100)	1 - 11	3 - 9
75 μm (No. 200)	0 - 5	0 - 4

In the above table, the symbol X is the gradation that the Contractor proposes to furnish for the specific sieve size. The X value shall meet the gradation limits of Table 200-1.5.5 (A).

#### **400-4 ASPHALT CONCRETE.**

**400-4.1 General.** Asphalt concrete shall be a mixture of mineral aggregate and paving, or liquid asphalt mixed at a central mixing plant.

This material will be designated by the type of asphalt concrete, class of aggregate grading, and grade of asphalt, i.e., "III-B2-AR-4000" and shall conform to the requirements in this section. Unless otherwise specified, III-B3-AR-4000 shall be used.

**400-4.2 Materials.**

**400-4.2.1 Asphalt.** The asphalt to be mixed with the mineral aggregate shall be asphalt binder conforming to 203-1 or 203-2.

**400-4.2.2 Aggregate.** Coarse and fine aggregate shall consist of any one or a mixture of the following materials:

- 1) Broken or crushed stone, or crushed gravel.
- 2) Natural material having sufficient roughness to meet the specified stabilometer requirements when confined within the limits specified for grading in 400-4.3.

Each type of aggregate shall be fed to the dryer at a rate within 10 percent of the amount set. Adequate means shall be provided for controlling and checking the accuracy of the feeder. The aggregate shall conform to the requirements of 400-1.1.

The percentage of crushed particles will be determined by California Test 205.

**400-4.2.3 Coarse Aggregate.** Coarse aggregate shall consist of material of which at least 25 percent by weight shall be crushed particles.

**400-4.2.4 Fine Aggregate.** Fine aggregate shall consist of material containing not less than 20 percent by weight of crushed particles in the portion passing the 4.75 mm (No. 4) sieve and retained on the 2.36 mm (No. 8) sieve. The remainder may consist of natural fine aggregate.

If the fine aggregate is deficient in material passing the 75  $\mu\text{m}$  (No. 200 sieve), a mineral filler conforming to the requirements of 203-6.3.3 shall be added to meet the combined grading.

**400-4.3 Combined Aggregates.**

The combined aggregate for asphalt concrete sampled after completion of all processing except adding of asphalt and mineral filler shall conform to Table 400-4.3 (A).

**TABLE 400-4.3 (A)**

Tests	California Test	Requirements
Both Kc and Kf-Factors (obtained from Centrifuge Kerosene Equivalent Test)	303	1.7 Max.
Sand Equivalent	217	45

The combined aggregate for asphalt concrete shall also conform to Table 400-4.3 (B) when mixed with the amount of asphalt determined to be optimum by California Test 367, which shall in no case be less than the minimum asphalt percentage specified in Table 400-4.3 (C) for the class specified.

**TABLE 400-4.3 (B)**

Tests	California Test	Requirements
Stabilometer Value*	366	35 Min.
Moisture Vapor Susceptibility (Stabilometer Value)	307	25 Min.
Swell	305	0.76 mm (0.030 in Max.)

\* S-values shall be as set forth in Section 203-6.2, Section 203-6.4.1, and Table 203-6.4.3 (A)

The grading of the combined aggregates shall conform to one of the gradings shown in Table 400-4.3 (C).

**TABLE 400-4.3 (C)**  
**TYPE III ASPHALT CONCRETE**

CLASS		B2		B3	
Sieve Size		Individual Test Result	Moving Average	Individual Test Result	Moving Average
25.0 mm	(1 in)	100	100	100	100
19.0 mm	(3/4 in)	87 - 100	90 - 100	90 - 100	95 - 100
9.5 mm	(3/8 in)	50 - 80	60 - 75	60 - 84	65 - 80
4.75 mm	(No. 4)	30 - 60	40 - 55	40 - 60	45 - 60
2.36 mm	(No. 8)	22 - 44	27 - 40	24 - 50	30 - 45
600 µm	(No. 30)	8 - 26	12 - 22	11 - 29	15 - 25
75 µm	(No. 200)	1 - 8	3 - 6	1 - 9	3 - 7
Asphalt %		4.6 - 6.0		4.6 - 6.0	

CLASS		C2		C3	
Sieve Size		Individual Test Result	Moving Average	Individual Test Result	Moving Average
19.0 mm	(3/4 in)	100	100	100	100
12.5 mm	(1/2 in)	89 - 100	95 - 100	89 - 100	95 - 100
9.5 mm	(3/8 in)	70 - 94	75 - 90	74 - 100	80 - 95
4.75 mm	(No. 4)	44 - 72	50 - 67	50 - 78	55 - 72
2.36 mm	(No. 8)	30 - 54	35 - 50	32 - 60	38 - 55
600 µm	(No. 30)	10 - 34	15 - 30	14 - 38	18 - 33
75 µm	(No. 200)	2 - 10	4 - 7	2 - 10	4 - 8
Asphalt %		4.8 - 6.5		4.6 - 7.0	

CLASS		D	F
Sieve Sizes		Combined Average	Combined Average
12.5 mm	(1/2 in)	100	-
9.5 mm	(3/8 in)	95 - 100	100
4.75 mm	(No. 4)	65 - 85	95 - 100
2.36 mm	(No. 8)	50 - 70	70 - 80
600 µm	(No. 30)	28 - 40	35 - 50
75 µm	(No. 200)	5 - 14	7 - 16
Asphalt %		6.0 - 8.0	8.0 - 10.0

The statistics, the basis of which will be the long term record of the plant, will be kept for each batch plant. Evaluation of gradation test results shall conform to the provisions of 400-1.1.3.

**400-4.4 Storing, Drying, and Screening Aggregates.** Storing, drying, and screening aggregates shall conform to 203-6.5.

**400-4.5 Proportioning, Mixing, Asphalt Concrete Storage, and Miscellaneous Requirements.** Proportioning shall conform to the provisions of 203-6.6. Mixing shall conform to the provisions of 203-6.7. Asphalt concrete storage shall conform to 203-6.8. Miscellaneous requirements shall conform to 203-6.9.



# PART 5

## SYSTEM REHABILITATION

### SECTION 500 - PIPELINE

#### 500-1 PIPELINE REHABILITATION.

##### 500-1.1 Requirements.

**500-1.1.1 General.** This subsection provides information about various pipeline system rehabilitation.

Section 500 does not address the structural capacity of any of the rehabilitation systems described herein nor their structural requirements. The method shall be capable of bridging cracks, holes, and joint displacements that have been determined not to require point repair. The type of rehabilitation materials and methods for a given project will be designated on the Plans and in the Specifications. Unless otherwise provided for in the Special Provisions, proof of meeting the Chemical Resistance and Physical Testing shall be submitted to the Engineer for approval in accordance with 2-5.3 as a submittal. The Agency may require testing of the materials and methods prior to job commencement to verify manufacturing compliance with required quality control standards and that no damage occurred to the materials during shipment to the job site. At the time of installation, materials shall not be more than 6 months old from the date of manufacture. Material safety data sheets (MSDS) shall be available at the project site.

**500-1.1.2 Submittals.** Prior to rehabilitation, the Contractor shall submit shop drawings of construction details and all other submittals per 2-5.3. The shop drawings shall include the location, method of rehabilitation and, when applicable, any bypass locations with sufficient detail to assure that the work can be accomplished without sewage spill. All submittals required by these specifications shall meet the requirements as shown on the Plans and in the Specifications.

**500-1.1.3 Storage and Handling.** Liner pipes and rehabilitation materials shall be properly stored and handled to prevent damage in accordance with the manufacturer's recommendations and as approved by the Engineer. Damage is described as, but is not limited to, gouging, abrasion, flattening, cutting, puncturing, or ultra-violet (UV) degradation. Thorough inspection of the liner pipes and rehabilitation materials shall be performed prior to installation. Criteria for acceptance/rejection shall be per 500-1.1.8.

**500-1.1.4 Cleaning and Preliminary Inspection.** Pipeline cleaning shall be performed prior to closed circuit television (CCTV) inspection and rehabilitation. The Contractor shall protect the manholes to withstand forces generated by equipment, water, and air pressure. After cleaning, the Contractor shall also confirm the inside minimum and maximum size (diameter and/or configuration) of the pipeline. The Contractor shall be responsible for the removal of debris from the pipeline and restore the pipeline to a minimum of 95 percent of the original diameter or area, as shown on the Plans or in the Specifications. Pipeline debris is described as, but is not limited to, sludge, dirt, sand, rocks, grease, roots, and other solid or semisolid materials. Refer to 500-1.2, Pipeline Point Repairs, for the removal of obstructions.

Some pipeline cleaning methods available are listed herein. When utilizing high-velocity hydraulic cleaning equipment independently or in combination with other cleaning methods, it is recommended that a minimum of two passes with the hydraulic nozzle be done. Additionally, root cutters and porcupines can be attached to the winches for effective root removal. The Contractor shall be responsible for conducting a site inspection of each pipeline prior to rehabilitation to determine which

cleaning methods are to be used. These methods shall be submitted to the Engineer for approval in conformance with 2-5.3.

(a) **Hydraulically Propelled Equipment.** The equipment shall be a movable-dam type and be constructed in such a way that a portion of the dam may be collapsed at any time during the cleaning operation to prevent flooding of the sewer. The movable dam shall be equal in size to the pipeline being cleaned and provide a flexible scraper around the outer periphery to ensure removal of grease and other debris. If sewer cleaning balls or other equipment which cannot be collapsed are used, special precautions to prevent flooding of the sewers and public or private property shall be taken.

(b) **High-Velocity Hydraulic (Hydro-Cleaning) Equipment.** All high-velocity hydraulic cleaning equipment shall carry a water tank, auxiliary engines, pumps, and a hydraulically driven hose reel. The equipment shall have a selection of two or more high velocity nozzles capable of producing a scouring action from 15 to 45 degrees in all size lines designated to be cleaned. The cleaning units shall have high-velocity nozzles for washing and scouring manhole walls and floors. The nozzles shall be capable of producing flows from a fine spray to a solid stream.

(c) **Mechanically Powered Equipment.** Bucket machines shall be used in pairs with sufficient power to perform the work in an efficient manner. Machines shall be belt operated or have an overload shutoff device. Machines with a direct drive that could cause damage to the pipe will not be allowed. Bucket machines shall not be used on any host or rehabilitated pipeline that is lined with a plastic pipe or material. A power rodding machine shall be either a sectional or continuous-rod type capable of holding a minimum of 230 m (750 feet) of rod. The machine shall be fully enclosed and have an automatic safety clutch or relief valve.

For segmented liner systems 675 mm (27 in) and larger, a standard test section of liner pipe or mandrel shall be inserted prior to sliplining. The mandrel shall have a segment length equal to that of the liner pipe. The outside diameter of the mandrel shall be a minimum of one percent greater than the outside diameter of the liner pipe but shall not exceed 13 mm (1/2 in) without prior approval of the Engineer. The equipment used by the Contractor to insert the test section or mandrel shall conform to Table 500-1.1.4 (A). A baffle plate shall be attached to the test section with adequate height to guarantee removal of any debris which could be present.

If cleaning cannot be completed from one manhole, the equipment shall be moved and set up on the other manhole and cleaning shall be re-attempted. If successful cleaning still cannot be performed or the equipment fails to traverse the entire pipeline section, it shall be assumed that a major blockage exists. Efforts to clean the lines shall be temporarily suspended and the Contractor shall notify the Engineer. Upon removal of the obstruction, the Contractor shall complete the cleaning operation.

The Contractor shall dispose of all debris removed from the pipeline, in accordance with current applicable regulations. Any hazardous waste material encountered during the project shall be considered as a changed condition. Refer to 3-4.

**TABLE 500-1.1.4 (A)**

Nominal ID of Liner Pipe, mm (in)	Minimum Equipment Insertion Force, kN (Tons) <sup>1</sup>
675 (27) to and including 1500 (60)	220 (25)
Over 1500 (60) to and including 2100 (84)	290 (32.5)
Over 2100 (84)	440 (50)

1. The equipment at the insertion pit shall be capable of withdrawing the test section or mandrel, if necessary.

**500-1.1.5 Television Inspection.** Closed circuit television (CCTV) inspection will be required prior to rehabilitation to document the condition of the host pipeline and to verify that it was cleaned per 500-1.1.4. A post-installation CCTV inspection shall be performed to determine if the work was completed per the Contract Documents and that all service connections have been re-instated, as required. All video inspections shall be recorded on a four-head VCR in VHS format, standard play mode. All original videotapes, log sheets, and reports shall be submitted to the Engineer and will become property of the Agency.

CCTV equipment shall include television cameras, a television monitor, cables, power sources, and other equipment. Focal distance shall be adjustable through a range from 150 mm (6 inches) to infinity. The remote-reading footage counter shall be accurate to less than 1 percent error over the length of the particular section of pipeline being inspected. This distance is measured from the centerline of the manhole to the centerline of the next manhole. The camera and television monitor shall produce a minimum 14 lines per mm (350-lines-per inch) resolution. Telephones, radios, or other suitable means of communication shall be set up to ensure that adequate communication exists between members of the crew. The CCTV inspection system to be utilized on the project shall be approved by the Engineer prior to the work being performed. CCTV inspection for re-instating service connections shall be performed utilizing system 2) or 3).

CCTV inspection shall be performed utilizing one of the following video camera systems:

- 1) Remote-focus stationary lens cameras;
- 2) Rotating-lens cameras; or
- 3) Pan-and-tilt cameras.

The video camera shall be mounted on a skid, floatable raft system, or transporter based on the conditions of the pipeline to be televised.

The Contractor shall televise the pipeline during optimum low-flow level conditions, as pre-approved by the Engineer. The television camera utilized shall be specifically designed and constructed for sewer inspection. The camera shall be operative in 100 percent humidity conditions. Lighting for the camera shall minimize reflective glare. Lighting and picture quality shall be suitable to provide a clear, in-focus picture of the entire periphery of the pipeline for all conditions encountered during the work.

The camera shall be moved through the pipeline in a downstream direction at a uniform rate, stopping when necessary to ensure proper documentation of the sewer's condition, but in no case shall the television camera be pulled at a speed greater than 9 m/min. (30 feet per minute). A clear picture shall be provided looking into each service connection for both the pre-lining and post-lining tapes. During the pre-rehabilitation video inspection, if the television camera will not pass through the entire pipeline section, the Contractor shall reset the equipment at the downstream manhole and attempt to inspect the section of pipe from the opposite direction. If the camera fails to pass through the entire section, it shall be assumed that an obstruction exists. Efforts to televise that section of pipe shall be temporarily suspended and the Contractor shall notify the Engineer. Upon removal of the obstruction, the Contractor shall complete the CCTV inspection.

If an obstruction is encountered during the post-rehabilitation or post-installation video inspection, the Contractor shall remove the obstruction by excavation, repair, or other means approved by the Engineer at the Contractor's expense, in order that television inspection may continue.

Documentation shall consist of a color, VHS-format videotape, log sheets, and a written report detailing the post-rehabilitation or post-installation condition of the pipeline and lateral connections/openings. The report shall note the time and date of video inspection, street name, upstream and downstream manhole, direction of view, direction of flow, surface material, pipeline length, pipe

section length, pipe size, pipe material, lateral connections, video tape number, counter number, and a detailed logging of defects encountered. Any rejected work shall be repaired, then re-televised. If the quality of the video tape is deemed to be unacceptable by the Engineer, the pipeline shall be re-televised at no additional cost to the Agency. Additional Agency requirements for performing CCTV inspection will be noted on the Plans or in the Specifications.

**500-1.1.6 Sampling, Testing, and Installation.** All materials shall be sampled and tested in accordance with 4-1. Rehabilitation materials shall be tested in accordance with the requirements of 211-2 and conform to the requirements for the specified material, unless otherwise specified in the following subsection. Test methods, specifications, standards, and the required quality control procedures for testing and installation are listed in each subsection. The Contractor shall install only those pipeline rehabilitation system materials that specifically meet the criteria in the following subsections.

**500-1.1.7 Miscellaneous.**

(a) **Service Connections.** The Contractor shall be responsible for locating all service connections and cleanouts. The Contractor shall provide written notification of work activities to all local users and provide interim sewer service, as specified by the Agency. Cleanup and dust control shall comply with 7-8.

Service connections shall be re-established as quickly as possible, not to exceed 24 hours, after completion of each liner pipe installation. Services requiring bypasses to be provided by the Contractor will be identified in the Specifications. When the service connection is re-established, the invert of the service connection shall match the bottom of the reinstated service opening. The service opening shall be reinstated from a minimum of 95 percent to a maximum of 100 percent of the original service connection. The new edge shall be smooth and crack free with no loose or abraded material.

If the service connection is to be re-established by a remote control device, the Contractor shall have a fully operational backup device on site. If for any reason the Contractor is unable to remotely re-establish the service connections, the Contractor shall immediately re-establish each service connection by open excavation at no additional cost to the Agency.

(b) **Segmented Liner Pipes.** The Rehabilitation processes discussed in 500-1.8, 500-1.11 and 500-1.12 may be accomplished while flow exists in the host pipeline, without diverting the flow or bypass pumping. The Contractor shall consider the effects of varying floor levels on the buoyancy calculations in accordance with 2.5.3. Obstructions, including, but not limited to, roots, large offset joints, rocks, or other debris that could prevent passage or cause damage to the liner sections shall be removed. For variable exterior profile wall liner pipe, the Contractor shall consider the inside surface smoothness of the host pipe to minimize damage to the liner. The existing pipe joints shall be repaired prior to installing the liner pipes. Liner pipes shall be inserted one section at a time through an access/insertion pit constructed above the existing sewer. When segmented liner pipe sections are inserted from two locations to a common point, a coupling device shall be provided that is pre-approved by the Engineer. The top of the existing host pipe exposed in the pit shall be evenly removed down to the springline level. Liner pipe sections shall be inserted spigot end first with the bell end trailing and a pushing force shall be applied to the pipe wall and to the inside of the bell, unless otherwise approved by the Engineer.

Before insertion of the segmented liner pipe 675 mm (27 in) and larger, a standard test section of liner pipe or an approved mandrel shall be pushed/pulled through the section of pipe being rehabilitated in accordance with 500-1.1.4 to ensure that it has been properly cleaned and all obstructions removed. A jacking or pulling ring shall be used to distribute the push/pull forces

uniformly against the bell end perimeter of the liner pipe. The calculated forces shall include the frictional forces of the liner pipe against the invert of the host pipe or the soffit of the host pipe when buoyant forces cause the liner pipe to float. A load-measuring device, approved by the Engineer, shall be used to measure the loads exerted on the liner pipe, so that the manufacturer's approved maximum loads specified in 500-1.8, 500-1.11 and 500-1.12 will not be exceeded.

(c) **Access/Insertion Pits.** Upon completion of the rehabilitation process, and/or as directed by the Engineer, the access/insertion pit area shall be restored in accordance with shop drawings approved by the Engineer in accordance with 2-5.3 and 7-9.

(d) **Manhole Protection.** During the rehabilitation process, the Contractor shall protect the manholes to withstand the forces generated by equipment, water, and air pressures used while completing the rehabilitation installation.

**500-1.1.8 Rejection.** If the Contractor has used any material or method that has not been approved by the Engineer, the Contractor shall, at its sole expense, remove the entire rehabilitated pipe and replace it with new pipe as directed by the Engineer. All damaged rehabilitation materials and pipe rejected by the Agency shall be promptly removed from the project site at the Contractor's expense and disposed of in accordance with current applicable regulations.

**500-1.1.9 Measurement and Payment.** Pipeline cleaning and inspection, including CCTV inspection, will be paid for at the Contract Unit Price, in accordance with 9-3. The unit price shall be considered full compensation for furnishing all labor, materials, tools, equipment, apparatus, and incidentals for doing all the work required. If a separate bid item is not included, then full compensation shall be considered to be included in the bid price for the liner pipe and/or the pipeline point repair/replacement pipe.

Pipeline point repair/replacement and rehabilitation shall be measured along the longitudinal axis between the ends of the pipeline, as shown on the Plans, and shall not include the inside dimensions of structures.

The price per linear meter (foot) or lump sum for pipeline point repair/replacement and rehabilitation shall be considered full compensation for furnishing and installing all fittings, connections, seals, and special work shown on the Plans and in the Specifications. Additionally, the unit price shall include all labor, materials, and equipment required; removal of interfering portions of existing sewers, storm drains, and other improvements; closing or removing of abandoned pipelines and structures, if required CCTV inspection and/or leak testing; excavation of the trench and/or access/insertion pits; control of ground and surface waters; preparation of the subgrade; placing and joining of pipe, including any necessary annular space grouting; backfilling of the trench and/or access/insertion pits; temporary and/or permanent resurfacing; and all other work necessary for pipeline point repair/replacement and rehabilitation, complete and in place.

#### **500-1.2 Pipeline Point Repair/Replacement.**

**500-1.2.1 General.** This subsection specifies the point repair and/or replacement of host pipelines. The Contractor shall be responsible for repairing the pipeline where point repairs are identified on the Plans or in the Specifications prior to any rehabilitation. If this is not shown, it will constitute extra work when approved by the Engineer.

The work shall include verifying the location of the point repair and/or replacement through CCTV or person-entry inspection of the pipeline, locating all interfering utilities, excavation, dewatering, pipe repairs or replacement, backfilling, surface restoration, temporary flow bypassing, sewer dewatering, and traffic control.

**500-1.2.2 Materials.** The pipe and repair materials shall be the same as the host pipeline unless otherwise indicated, and shall comply with Section 207 for type and class required.

**500-1.2.3 Excavation.** All trenching and excavation shall conform to Section 306.

**500-1.2.4 Sewer Bypassing and Dewatering.** When required by the Contract Documents or the process, the Contractor shall bypass the sewer flow around the work and dewater the work area, all in conformance with 7-8.4 and 306-3.3.

**500-1.2.5 Notification of Work.** The Contractor shall notify the Engineer a minimum of 48 hours in advance of the planned time to begin pipeline point repair work/replacement at a particular location.

**500-1.2.6 Installation and Field Inspection.** The installation of the replacement pipe and/or repair work shall conform to Section 306. Prior to the demobilization of the contractor performing open-excavation repairs, the post-cleaning video tape(s) shall be submitted to the engineer. The results of the post-cleaning video tape(s) may indicate the need for additional excavation and repair prior to lining. The contractor shall review all the post-cleaning tape(s) and identify any additional point repair, which impacts the placement of the liner and the reinstatement of the service connection(s) and shall provide these locations in writing to the engineer. All pipeline point repairs/replacement shall be inspected and measured by the Engineer prior to any backfilling and compaction and leak testing/CCTV inspection prior to placing of permanent resurfacing.

**500-1.3 High-Density Polyethylene (HDPE) Solid-Wall Pipe Liner.**

**500-1.3.1 General.** HDPE solid-wall liner pipe for use in sanitary sewers, storm drains, and house connection sewers shall comply with ASTM D 3350 and ASTM F 714. Fittings shall comply with ASTM D 2683 or D 3261. Fittings fabricated by mitered, butt fusions are also permitted.

**500-1.3.2 Material Composition.** Pipe and fittings shall be made from HDPE compounds conforming with ASTM D 3350, Cell Classification 345434C, D, and E and shall also meet the requirements of 207-19.2.

**500-1.3.3 Liner Pipe Acceptance.** Liner pipe acceptance shall conform to 207-19.3.

**500-1.3.4 Marking.** Liner pipe marking shall conform to 207-19.4.

**500-1.3.5 Chemical Resistance and Physical Testing.** The HDPE liner pipe shall conform to 207-19.5.

**500-1.3.6 Installation and Field Inspection.** The HDPE liner pipe shall conform to 500-1.1 for the cleaning and inspection of the host pipeline; preparation of entry points as needed; and the storage, handling, and joining of HDPE pipe. A proofing pig shall be pulled through the host pipeline prior to liner insertion to verify adequate clearances.

**500-1.3.7 Annular Space Grouting.** Refer to 500-3, Annular Space Grouting. The entire annular space shall be fully grouted. The maximum safe annular grouting pressure in psig for single-stage or multi-stage grouting shall not exceed the values shown in Table 500-1.3.7 (A).

**TABLE 500-1.3.7 (A)**  
**DIFFERENTIAL-PRESSURE (VACUUM OR EXTERNAL FLUID)**  
**CAPABILITY FOR UNSUPPORTED PIPE AT 23 °C (73.4 °F)<sup>1</sup>**

SDR	kPa	PSI
32.5	28	(4)
26	55	(8)
21	110	(21)
19	145	(28)
17	193	(28)
15.5	248	(36)

1. Safety factor not included.

**500-1.3.8 Service Connections.** The Contractor shall be responsible for locating all service laterals and cleanouts. Service connections shall not be made until the liner pipe has stabilized, which is normally accomplished after a 24-hour waiting period. Service laterals shall be connected to the liner pipe by use of a heat-fused saddle or mechanical saddle as approved by the Engineer. Refer to 500-1.1.7.

**500-1.3.9 Repair and Rejection.** Liner pipe may be repaired for minor superficial pipe damage. Damaged liner pipe which has been penetrated over 10 percent of the wall thickness at either the inner or outer wall surface, shall be repaired by cutting out the damaged section and replacing it with new pipe. All repair methods shall be submitted to the Engineer for prior approval in accordance with 2-5.3. The remaining liner pipe sections shall be a minimum of 2.4 m (8 feet) in length. Liner pipes shall be inspected for damage immediately prior to installation. If liner pipe is found to be superficially damaged, the Engineer may allow the pipe to be repaired or may reject it. Rejected liner pipe shall be replaced with a new section of liner pipe. Refer to 500-1.1.8.

#### **500-1.4 Cured-In-Place Pipe Liner (CIPP) Liner.**

**500-1.4.1 General.** CIPP liner for the rehabilitation of pipelines shall be either the Type A - inversion process in compliance with ASTM F 1216 or the Type B - pull-in-place process in compliance with ASTM F 1743 for installation using heated-water cure. The CIPP liner shall use an approved epoxy or epoxy-vinyl ester-resin-impregnated flexible fabric tube. The tube is installed by an inversion method using a hydrostatic head or by pulling it through an existing pipe and inflating by inverting a membrane using a hydrostatic head.

**500-1.4.2 Material Composition and Testing.** The fabric tube shall consist of one or more layers of flexible, needled felt or an equivalent nonwoven material and have plastic coating(s). The material shall be compatible with and capable of carrying epoxy or epoxy-vinyl-ester resin, be able to withstand installation pressures and curing temperatures, and be compatible with the approved resins used. The approved epoxy or epoxy-vinyl-ester resin shall be compatible with the application and pipeline environment and be able to cure in the presence of water. The initiation temperature for cure shall be as recommended by the resin manufacturer and approved by the Engineer. The CIPP liner shall comply with ASTM D 5813 and shall have, as a minimum, the initial structural properties per Table 500-1.4.2 (A).

**TABLE 500-1.4.2 (A)**

<b>Property</b>	<b>ASTM Test Method<sup>1</sup></b>	<b>Initial MPa (psi)</b>
Flexural Strength	D 790	34.5 (5,000)
Flexural Modulus	D 790	2068 (300,000)
Tensile Strength	D 638	27.6 (4,000)
Tensile Modulus	D 638	1724 (250,000)

1. The initial values are determined by ASTM D 638 and D 790.

The Contractor shall provide field-cured samples as directed by the Engineer. The physical properties of the finished CIPP shall be verified through a field-sampling procedure in accordance with ASTM F 1216 or ASTM F 1743 and in accordance with ASTM D 5813.

**500-1.4.3 Resin and Tube Acceptance.** At the time of resin impregnation, the entire fabric tube shall be inspected for defects. The resin shall not contain fillers, except those required for viscosity control, fire retardance, or extension of pot life. Thixotropic agents that do not interfere with visual inspection may be added for viscosity control. Also, the opacity of the plastic coating shall not interfere with visual inspection. Resins may contain pigments, dyes, or colors that do not interfere with visual

inspection of the CIPP liner or its required properties. Additives may be incorporated that enhance the physical and/or chemical resistance.

**500-1.4.4 Chemical Resistance.** The CIPP liner system furnished shall include an epoxy or epoxy-vinyl resin and shall be tested in accordance with the requirements of 211-2 and conform to the weight change requirements of Table 210-2.4.1(A). Proof of meeting these requirements shall be provided with the Bid.

**500-1.4.5 Installation.** The host pipeline shall be cleaned and televised in accordance with 500-1.1.4 and 500-1.1.5. The OD of the tube being installed shall be properly sized to allow for expansion so that the CIPP can fit tightly against the existing pipe.

The CIPP shall be installed in accordance with ASTM F 1216 or ASTM F 1743 and the Contractor's recommendations as approved by the Engineer. Immediately prior to installation, the CIPP liner tube shall be saturated with resin (on or off the job site) and stored/transported at a cool temperature as recommended by the resin manufacturer.

**500-1.4.6 Curing.** After tube placement is completed, a suitable heat source and distribution equipment shall be provided by the Contractor to distribute or recirculate hot water throughout the installed CIPP liner tube. Temperature shall be maintained during the curing period as recommended by the resin manufacturer and approved by the Engineer. After the tube is cured, a cool-down period shall be used prior to opening the downstream end, reconnection of services, and returning normal flow back into the system. Heat curing of the resin shall occur within the manufacturer's approved recommended time frame (pot life). The water in the CIPP shall be cooled to below 38°C (100°F) before discharge.

**500-1.4.7 Service Connections.** After the curing is complete, existing service connections shall be re-established. This may be done without excavation by means of a remote-control cutting device operating within small diameter pipe. A CCTV camera shall be attached to the cutting device for precise location of service connections and inspection of the CIPP liner. Refer to 500-1.1.7.

**500-1.4.8 Repair and Rejection.** Internal and external repairs may be made to CIPP liner pipe in accordance with the manufacturer's recommendations and approval by the Engineer. Internal repairs may be made with approved fabric and epoxy or epoxy-vinyl-ester resins to restore strength and integrity. External repairs may be made by using standard plastic pipe repair techniques, including replacement of the damaged section using PVC pipe coupled to the CIPP liner, as approved by the Engineer. Refer to 500-1.1.8.

#### **500-1.5 Polyvinyl Chloride (PVC) Pipe Lining System.**

**500-1.5.1 General.** PVC profile extrusions with annular space grouting shall be installed for use in sanitary sewers and storm drains. This applies to the rehabilitation of small-diameter pipe and person-entry pipe (900 mm (36 inches) and larger) or conduits in terms of materials and installations.

**500-1.5.2 Material Composition.** The material shall be made from unplasticized PVC compounds conforming to 207-17, having a cell classification of 12334, 12454, or 13354 as defined in ASTM 1784.

**500-1.5.3 Material and Equipment Acceptance.** At the time of manufacture, each lot of plastic strips shall be inspected for defects and the physical properties certified in accordance with the ASTM Standards listed in this subsection, or as indicated in the Specifications. There are two strips of PVC used in this process. The former strip is a ribbed panel which varies in width and height as a function of pipe diameter. The joiner strip is a "U"-shaped strip of PVC which is used to lock together the former strip edges as the PVC strips or panels are being spirally wound upon themselves. The minimum thickness of the strips and panels shall be per Table 500-1.5.3 (A).

TABLE 500-1.5.3 (A)

Nominal ID of Original Pipe mm (inches)		Minimum Thickness				Minimum Profile Height mm (inches)	
		Former Strip		Joiner Strip			
mm	(inches)	mm	(inches)	mm	(inches)	mm	(inches)
200 to 300	(8 to 12)	0.64	(0.025)	0.64	(0.025)	4.88	(0.192)
375 to 400	(15 to 18)	0.75	(0.030)	0.79	(0.031)	6.15	(0.242)
600 to 900	(24 to 36)	1.15	(0.045)	1.48	(0.058)	12.20	(0.480)
750 to 1800	(30 to 72) <sup>1</sup>	1.53	(0.060)	-		12.40	(0.488)

1. In some lining applications for pipes and conduits 750 to 900 mm (30 to 36 inches) in diameter, it may be determined to use person-entry techniques.

The initial stiffness factor shall conform to Table 500-1.5.3 (B).

TABLE 500-1.5.3 (B)

Nominal ID of Original Pipe <sup>1</sup>		Stiffness Factor (EI) <sup>(2)</sup>	
mm	(inches)	Pa · m <sup>3</sup>	(in <sup>3</sup> · lbf/in <sup>2</sup> )
200	(8)	14	(120)
250	(10)	14	(120)
250	(10)	27	(240)
300	(12)	27	(240)
375	(15)	27	(240)
375	(15)	68	(600)
450	(18)	68	(600)
600	(24)	68	(600)
600	(24)	181	(1600)
750	(30)	181	(1600)
900	(36)	181	(1600)

1. For ID's larger than 900 mm (36 inches), see Plans or Special Provisions.

2. Stiffness factors shall be determined in accordance with ASTM D 2412. EI = 0.149R<sup>3</sup> (PS).

At the time of delivery, the strips shall be homogeneous throughout, uniform in color, and free of cracks, holes, foreign materials, blisters, or other deleterious faults. For testing purposes, a lot is defined as production during an 8-hour shift, while a batch is defined as each 60 linear meters (200 linear feet) of PVC product. Testing shall be performed every 2 hours and records kept on file in conformance with 500-1.5.4. The Contractor shall furnish and maintain in good condition all necessary equipment required for the proper execution and inspection of the work.

**500-1.5.4 Marking.** Each PVC continuous strip on each reel shall be distinctively marked on its inside surface end with a coded number which identifies the manufacturer, strip thickness, minimum profile height, size, material, machine, date, and shift on which the material was extruded. These markings shall also appear on the PVC strips with a maximum distance between markings of 1.5 m (5 feet), and shall be visible from inside the completed liner.

**500-1.5.5 Chemical Resistance.** PVC and cured sealant/adhesive shall be tested in accordance with the requirements of 211-2 and conform to the weight change requirements of Table 207-17.5(A).

**500-1.5.6 Installation and Field Inspection.** The host pipeline shall be cleaned of any obstructions and televised per 500-1.1.4 and 500-1.1.5. The condition shall be approved by the Engineer prior to insertion of the liner. The plastic strips or panels shall be handled with care to ensure that the plastic is not kinked, gouged, or otherwise damaged.

The former and joiner strips shall be engaged and an approved sealant/adhesive shall be injected onto the engaged locks. The Contractor shall ensure that the joiner strip is continuously engaged.

For person-entry pipe, the PVC panels shall be cut and trimmed to fit as near as practical to the internal perimeter of the existing conduit. A bead of approved sealant adhesive shall be applied to the female locking edge of the former strip. End joints shall be made with the plasticized end section, which shall overlap the joint by not less than 100 mm (4 inches). End joints shall be staggered and shall remain below the normal flowline of the sewer.

**500-1.5.7 Annular Space Grouting.** For small-diameter pipe, the annular space between the outside of the liner and the inside of the existing pipe shall be grouted. Grouting of the annular space shall be performed in such a manner to prevent damage or collapse of the liner. Grout shall be pumped into the annular space at manholes, service connections, and wherever the liner is exposed.

Grout shall conform to 500-1.3.7.

For person-entry pipe, the grout shall be injected behind the liner by tubes placed on top of the liner or holes drilled through the liner. Any holes in the plastic shall be covered with a patch of similar material as approved by the Engineer.

**500-1.5.8 Service Connections.** Service lateral connections shall be re-established with the liner in accordance with manufacturer's recommendations as approved by the Engineer. Refer to 500-1.1.7.

**500-1.5.9 Repair and Rejection.** Prior to installation, the PVC shall be inspected for flaws such as cracks, blisters, scratches, blemishes, and other faults. Material rejected for any reason shall be replaced prior to installation. If after installation, flaws of a deleterious nature are detected, they shall be corrected in a manner suitable to the supplier and approved by the Engineer. If flaws are correctable by approved splicing or patching methods, that work shall be completed promptly. If approved corrections cannot be made, lining shall be removed from the pipe utilizing new PVC pipe. Refer to 500-1.1.8.

**500-1.6 (Not Used).**

**500-1.7 Deformed/Re-formed HDPE Pipe Liner.**

**500-1.7.1 General.** Deformed HDPE extrusions for rehabilitating sanitary sewers and storm drains without excavation shall comply with ASTM D 3350 and ASTM F 714. This method applies to the rehabilitation of 100 through 450 mm (4 through 18 inch) diameter pipe. Unless otherwise indicated, liner for pipe shall have a minimum SDR of 32.5. This rehabilitation system may be capable of expanding up to 10 percent. Pipe stiffness shall conform to Table 500-1.7.1 (A).

**TABLE 500-1.7.1 (A)<sup>1</sup>**

Pipe Size (Inches)	Pipe Stiffness <sup>2</sup>		
	SDR 21	SDR 26	SDR 32.5
100 (4)	61	31	16
150 (6)	61	31	16
200 (8)	61	31	16
250 (10)	61	31	16
300 (12)	61	31	16
375 (15)	61	31	16
400 (18)	61	31	16

1. Minimum pipe stiffness (PS) when tested in accordance with ASTM 2412.

2. PS values are from ASTM F 174 Table X1.1

**500-1.7.2 Material Composition.** Pipe shall be made from HDPE compound complying with ASTM D 3350, cell classification 345434C, D, or E and shall also meet the requirements of 207-19.2, except that titanium dioxide pigment may be substituted for the 2 percent carbon black.

The Contractor shall provide the manufacturer's certified test results to the Engineer for approval, stating that the material conforms with the applicable requirements, including crystallization temperatures.

**500-1.7.3 Material and Equipment Acceptance.** Material and equipment acceptance shall conform to 207-19.3.

**500-1.7.4 Marking.** Marking shall conform to 207-19.4, except that the material shall be designated by HDPE cell classification.

**500-1.7.5 Chemical Resistance and Physical Testing.** HDPE pipe specimens shall be tested in accordance with the requirements of 211-2 and conform to 207-19.5, except the requirements shall be met with samples from pipes that have been subjected to the deformation and reforming process.

**500-1.7.6 Installation and Field Inspection.** HDPE pipe shall be installed as follows:

- 1) The existing pipeline shall be cleaned and televised per 500-1.1.4 and 500-1.1.5, and the condition approved by the Engineer prior to the insertion of the deformed pipe.
- 2) A cable shall be strung through the host pipe to be rehabilitated and attached to the deformed pipe through an existing manhole or access point. The pipe shall be pulled through the existing conduit by this cable. Pulling forces shall not exceed the axial strain limits of the deformed pipe. The measured pulling operation limits the pulling force to an allowable tensile stress (10.3 MPa (1,500 psi) or 50 percent of the yield) times the pipe wall cross-sectional area. Care shall be taken not to damage the deformed pipe during installation. Appropriate sleeves and rollers shall be used to protect the pipe. Calculations for pulling force limits shall be submitted to the Engineer in accordance with 2-5.3.
- 3) When the deformed pipe is in place, the pipe shall be cut and the processing manifolds (pipe end-closing assembly used for heat and pressure control within liner) shall be inserted and secured at both pipe ends. The temperature and pressure measuring instruments shall be attached to the deformed pipe at both ends.
- 4) After the deformed HDPE liner is outfitted with temperature and pressure instruments, steam shall be introduced into the system until a minimum temperature of 108°C (226°F) to a maximum temperature of 118°C (244°F) is reached and shall not exceed the melting temperature of 127°C (260°F). The minimum outside pipe temperature at the terminating end of the pipe shall be 85°C (185°F). This temperature shall be held for a minimum of 20 minutes. The deformed pipe shall be pressurized up to 100 kPa (gage) (14.5 psig), maximum, while the termination point valves are kept open to provide heat flow. The pressure shall then be increased in increments up to a maximum of 179 kPa (gage) (26 psig).
- 5) The Contractor shall cool the re-formed pipe according to the approved manufacturer recommendations. When the temperature reduces to 38°C (100°F), the Contractor shall then slowly raise the pressure to approximately 228 kPa (gage) (33 psig), while applying air or water for continued cooling. The equipment shall be disconnected after ambient temperature is attained.
- 6) Temperatures and pressures shall be monitored and recorded throughout the installation process to ensure that each phase of the process is achieved at the approved manufacturer's recommended temperature and pressure levels.
- 7) If the testing of the installed HDPE liner pipe is required in the Specifications the physical properties of the installed HDPE liner pipe shall be verified through field sampling and laboratory testing, all as approved by the Engineer. Unless the Specifications call for more than one sample, a sample shall be cut from a section of reformed/rerounded HDPE

liner pipe at the upstream, downstream, or an intermediate manhole/access pit that has been inserted through a same diameter pipe acting as a mold. HDPE liner pipe samples shall be submitted to a certified laboratory which has been pre-approved by the Engineer and tested in accordance with ASTM D 638 and ASTM D 790 to confirm that the liner pipe conforms to the minimum tensile and elongation requirements per 500-1.7.2. All costs incurred for this testing shall be borne by the Contractor.

**500-1.7.7 End Seals.** The beginning and end of the new HDPE pipe shall be sealed to the rehabilitated host pipeline. If sealing material is required, it shall be compatible with the HDPE pipe and shall provide a watertight seal.

**500-1.7.8 Service Connections.** Existing service connections shall be reinstated through the use of a remote control unit or excavation. Refer to 500-1.1.7 (a).

**500-1.7.9 Repair and Rejection.** The Contractor shall provide an evaluation and repair specification to the Engineer for approval for liner pipe found to be damaged during or after installation. Any liner pipe damaged in transit or on the project site prior to installation will be rejected and shall be immediately removed from the project site. Refer to 500-1.1.8.

### **500-1.8 Centrifugally Cast Fiberglass Reinforced Plastic Mortar (CCFRPM) Liner Pipe.**

**500-1.8.1 General.** CCFRPM liner for use in lining sanitary sewers shall comply with ASTM D 3262. Unless otherwise indicated, the minimum pipe stiffness shall be 124 kPa (18 psi), or greater, as tested in accordance with ASTM D 2412.

**500-1.8.2 Material Composition.** The amount, location, and orientation of the chopped glass-fiber reinforcement shall be specifically designed for each application. The glass shall be a commercial grade of E-Type glass fibers with a finish compatible with the resin used. The sand shall be a minimum 98 percent silica kiln-dried and graded. The polyester wall resin shall be an isophthalic, orthophthalic or other approved resin with a minimum tensile elongation of 2 percent. A vinyl ester liner resin shall be used to meet the chemical resistance requirements of 211-2 and conform to 207-20.5. Designation per ASTM D 3262 shall be Type 1, Liner 2, Grade 3, and a minimum pipe stiffness of 124 kPa (18 psi), unless a higher value is indicated on the Plans or in the Specifications. Elastomeric sealing gaskets shall conform to the requirements of ASTM F 477.

**500-1.8.3 Liner Pipe Acceptance.** The liner pipe shall be free of cracks, holes, delaminations, foreign inclusions, blisters or other defects that would, due to their nature, degree, or extent, have a deleterious effect on the pipe performance as determined by the Engineer. Prior to installation, damaged pipe shall be either repaired or field cut to remove the damaged portion as approved by the Engineer.

For testing purposes, a production lot shall consist of all liner pipes having the same lot marking number, but shall not exceed a total of 50 pipes. Pipe length, wall thickness, joint dimensions, pipe stiffness, and deflection characteristics shall be verified by testing for each lot in accordance with ASTM D 3262.

**500-1.8.4 Marking.** Each pipe section shall be marked on the inside and every 1.5 m (5 feet) on the outside, to show the manufacturer's name, manufacturing number (identifies factory location, date, shift, and sequence), nominal diameter, pipe stiffness, ASTM D 3262 and designation, and lot number.

**500-1.8.5 Chemical Resistance and Physical Testing.** Pipe liners and gaskets shall be tested in accordance with 211-2 and conform to 208-4 and 207-20.5 respectively. Verification shall be provided that physical testing of the product confirms conformance to ASTM D 3262 (qualification test only) and ASTM D 2412.

**500-1.8.6 Installation and Field Inspection.** The existing sewer shall be maintained in operation during the relining process. The existing host pipeline shall be cleaned of any obstructions and televised

per 500-1.1.4 and 500-1.1.5. Liner pipes shall be inserted one section at a time through an access pit constructed above the existing sewer. The top of the existing sewer exposed in the pit should be removed down to springline level (halfway). Liner pipes shall be inserted in accordance with 500-1.1.7 (b). The pushing force shall be applied to the pipe wall end inside of the bell. Maximum jacking load shall not exceed Table 500-1.8.6 (A).

The pipe installation shall conform to 500-1.1.7 (b). Maximum jacking loads shall not exceed the values noted in Table 500-1.8.6 (A).

TABLE 500-1.8.6 (A)

Nominal Diameter		SAFE AXIAL COMPRESSIVE LOAD kN (Tons) <sup>1</sup>			
		124 kPa (18 psi) Pipe Stiffness		249 kPa (36 psi) Pipe Stiffness	
mm	(in)	kN	(Tons)	kN	(Tons)
450	(18)	—	—	151	(17)
500	(20)	—	—	169	(19)
600	(24)	205	(23)	276	(31)
750	(30)	320	(36)	463	(52)
900	(36)	463	(52)	587	(66)
1050	(42)	632	(71)	845	(95)
1200	(48)	827	(93)	1157	(130)
1350	(54)	1094	(123)	1521	(171)
1500	(60)	1379	(155)	1886	(212)
1650	(66)	1557	(175)	2135	(240)
1800	(72)	1859	(209)	2598	(292)
1950	(78)	2242	(252)	3123	(351)
2100	(84)	2731	(307)	3754	(422)
2250	(90)	3176	(357)	4315	(485)
2400	(96)	3656	(411)	4982	(560)
2550	(102)	4181	(470)	5694	(640)

1. Factor of safety of 2:1 is included for longitudinal compressive load.

**500-1.8.7 Annular Space Grouting.** The entire annular space between the outside of the liner and the inside of the host pipe shall be grouted, in accordance with 500-3. The minimum radial annular space shall not be less than 25 mm (1 inch) unless approved by the Engineer. In accordance with 2-5.3, the grout mix and placement procedure shall be submitted to the Engineer for approval. Grouting of the annular space shall be done in such a manner to prevent damage or collapse of the liner. Maximum safe grouting pressure is equal to the pipe stiffness divided by 3.

**500-1.8.8 Service Connections.** Service laterals shall be connected to the liner pipe by use of a saddle approved by the Engineer. Refer to 500-1.1.7 (a).

**500-1.8.9 Repair and Rejection.** Prior to installation, damaged pipe shall be field cut to remove the damaged portion and rejoined by approved methods. Superficial damage may be repaired without field cutting. Liner pipe gouges deeper than 50 percent of the vinyl ester lining shall be field cut and removed per 500-1.1.8.

#### 500-1.9 External In-Place Wrap.

**500-1.9.1 General.** Existing sewer pipes experiencing crown corrosion may be rehabilitated utilizing a wrap of plastic liner with integral locking extensions followed by a cap of reinforcing steel and concrete.

Plastic liner sheet, weld strip, adhesive products and cleaners shall conform to 210-2. Prior to the plastic liner installation, the existing line shall be uncovered and the pipe exposed to accommodate the coverage shown on the Plans or stated in the Specifications. Liner shall be applied and secured to the host pipe and inspected and approved by the Engineer prior to placement of reinforcing steel and concrete.

**500-1.9.2 Installer Qualifications.** Applicators and welders shall be qualified in accordance with 311-1.2.

**500-1.9.3 Preparation of Existing Pipe for Installation of Plastic Liner.** The concrete surface shall be etched by sandblasting to develop a slightly granular surface. When permitted by the Engineer, the concrete surface may be acid etched in lieu of sandblasting. After sandblasting, the concrete surface shall be thoroughly cleaned of dust. Surfaces etched with acid shall be neutralized with clean water.

(a) **Coverage.** The circumferential coverage shall be the upper 270 degrees unless otherwise indicated on the Plans or in the Specifications.

(b) **Positioning Liner.** Liner installed on the existing pipe shall be positioned with the locking extensions outward and aligned with or perpendicular to the longitudinal axis of the pipe.

Liner shall be centered with respect to the field top centerline of the pipe. Liner shall be set to fit over the existing pipe joints with the field welded seams located away from the joint portion of the pipes. Liner shall be closely fitted to the existing pipe. Sheets shall be cut to fit curved and warped surfaces using the minimum number of separate pieces.

Prior to installation, the Contractor shall indicate to the Engineer the proposed layout of liner sheets, including the location and type of all field welds.

The Engineer may require shop drawings per 2-5.3, the use of patterns, or the marking of sheet layouts directly on the existing pipe where complex or warped surfaces are involved.

At transverse joints between sheets of liner used along the pipeline, the space between ends or edges of locking extensions, measured longitudinally, shall not exceed 100 mm (4 inches).

(c) **Securing Liner in Place.** Liner shall be held snugly in place against the existing pipe by use of adhesive materials, in accordance with the liner manufacturer's written recommendations as approved by the Engineer.

Liner shall be bonded to the existing pipe a minimum of 150 mm (6 inches) along both longitudinal bottom edges. This shall be accomplished by the application of an approved adhesive system.

#### **500-1.9.4 Field Joining of Liner.**

(a) **General.** Liner joints shall be free of all foreign material and shall be clean and dry before joints are made. All field joints are to be made and tested prior to placement of reinforcing steel and concrete.

(b) **Field Joints in Pipe Rehabilitation Installation.** Field joints in the liner plate shall be Type R-2 unless Type R-1 or R-3 is approved by the Engineer.

- 1) Type R-1 joint shall consist of a 50 mm (2 inch) wide weld strip, centered over the 25 mm (1 inch) maximum gap between sheets and securely welded along each edge of adjacent liner.
- 2) Type R-2 joints shall be made with an integral joint flap with locking extensions removed per 210-2.4.6, extending 38 mm  $\pm$  6 mm (1-1/2 inches  $\pm$  1/4 inch) beyond the end of the sheet. The sheet shall be overlapped not less than 13 mm (1/2 inch) and the overlap secured to the adjacent liner by means of a 25 mm (1 inch) welding strip. The downstream sheet shall overlap the upstream sheet.
- 3) Type R-3 joint shall consist of a 25 mm (1 inch) wide weld strip centered over a 6 mm (1/4 inch) maximum gap between sheets and secured along each edge of adjacent liner by means of a 25 mm (1 inch) welding strip.

(c) **Installation of Welding Strips.** Installation of welding strips shall be in accordance with 311-1.5.4.

**500-1.9.5 Protection and Repair of Liner.** Protection and repair of liner shall be in accordance with 311-1.9.5.

**500-1.9.6 Field Testing.** Field testing shall be in accordance with 311-1.10.

**500-1.9.7 Steel Reinforcement.** Before placing reinforcing steel, the Contractor shall submit a reinforcing steel placing plan in accordance with 2-5.3, Shop Drawings.

Reinforcing bars shall conform to 210-2 and be placed in accordance with 303-1.7. They shall be held in position by the use of concrete or plastic chairs. Metal chairs will not be allowed.

Caution shall be taken when installing reinforcing steel to ensure against puncturing or damaging the liner.

**500-1.9.8 Concreting Operations.**

(a) **General Placement.** Concrete placed against the liner shall be carefully conveyed, deposited, and consolidated to avoid damage to the liner and to produce dense concrete, securely anchoring the locking extensions into the concrete. Vibrators shall be used to consolidate concrete with particular attention along the bottom edge of the liner.

(b) **Forms.** The trench walls may serve as the outer form for the new concrete encasement. When outer forms are required, they shall be in accordance with 303-1.3.

**500-1.10 Folded and Re-formed PVC Pipe Liner.**

**500-1.10.1 General.** Folded and re-formed PVC liner pipe shall be inserted into sanitary sewers, force mains, and storm drains in order to rehabilitate the existing pipeline system without excavation.

**500-1.10.2 Type A Folded and Re-formed PVC Pipe Liner.**

(a) This method applies to the rehabilitation of 100 mm through 375 mm (4-through 15 inch) diameter pipe. The standard dimension ratio shall be SDR 35, 41, or 50 as specified by the Engineer. This rehabilitation system may be capable of expanding up to 10 percent. The initial pipe stiffness factor shall conform to Table 500-1.10.2 (A):

**TABLE 500-1.10.2 (A)<sup>2</sup>**

Nominal ID of Original Pipe mm (inches)	SDR	Stiffness Factor (EI) <sup>1</sup>	
		Pa · m <sup>3</sup>	(in <sup>3</sup> · lbf/in <sup>2</sup> )
100 (4)	35	4.5	(40)
150 (6)	35	15	(133)
200 (8)	50	12	(109)
	41	22	(198)
	35	36	(320)
250 (10)	50	24	(213)
	41	44	(388)
	35	70	(624)
300 (12)	50	42	(369)
	41	76	(671)
	35	122	(1076)
375 (15)	50	81	(720)
	41	148	(1307)
	35	238	(2105)

1. Pipe Stiffness (PS) shall be determined in accordance with ASTM D 2412. Stiffness factor is  $EI = 0.149r^3$  (PS). The stiffness factors listed in the table are typical values for gravity flow conditions. For pressure applications the stiffness factors are usually higher.

2. Effects of ovality and safety factor are not included.

(b) **Material Composition.** The folded pipe shall be made from unplasticized PVC compounds having a cell classification of 13223, as defined in ASTM D 1784.

(c) **Material and Equipment Acceptance.** At the time of manufacture, the extruded materials shall be inspected for defects and physical properties in accordance with ASTM F 1504, to show compliance with 500-1.10.2 (b), or as indicated in the Specifications. Testing shall be performed once per shift, change in material batch or coil. Certification shall be supplied per 4-1.5.

At the time of installation, the material shall be homogeneous and free of defects, cracks, holes, blisters, foreign materials, or other deleterious faults.

The Contractor shall furnish and maintain in good condition all equipment necessary for proper execution and inspection of the work.

(d) **Marking.** Marking shall conform to 207-17.2.1, except that under Item 3, there is no ASTM manufacturing specification for this product.

(e) **Chemical Resistance and Physical Testing.** The PVC material shall be tested in accordance with 211-2 and conform to Table 500-1.10.2 (B). The various requirements shall be met with samples taken from pipe that has experienced the folding and re-forming process.

**TABLE 500-1.10.2 (B)**

Property	ASTM Test Method	Initial Values	Values After 112 Days Exposure
Tensile Strength MPa (psi)	D 638	34.5 (5,000) min.	34.5 (5,000) min.
Impact Strength J/m (ft-lbs/in)	D 256 Method A Size 12.7 mm x 3.175 mm x 63.5 mm (1/2 in x 1/8 in x 2-1/2 in)	80 (1.5) of notch, min.	80 (1.5) of notch, min.
Weight Change % Unconditioned Conditioned	D 543	—	+ 1.5% max. + 1.0% max.

**(f) Installation and Field Inspection.**

- 1) The existing pipeline shall be cleaned of any obstacles and televised per 500-1.1.4 and 500-1.1.5, and the host pipe condition shall be satisfactory to the Engineer prior to the insertion of the folded pipe.
- 2) If necessary, a flexible heat containment tube shall be permanently placed inside the existing pipe for retention of heat necessary to soften the folded pipe. A cable shall be strung through the heat containment tube.
- 3) Steam shall be applied to the folded pipe until pliable for a minimum of 15 minutes prior to insertion into the existing pipe. Once the material has become pliable, the cable shall be attached to the folded pipe. Using a winch at the termination point, the folded pipe shall then be inserted into the existing pipe through a manhole or access point. Pulling force shall not exceed 8.9 kN (2,000 pounds).
- 4) After the folded PVC pipe is inserted into the existing pipe, it shall be cut off at the starting point and restrained at the terminating point. Thermocouples shall be placed on the exterior of the liner pipe at both the upstream and downstream ends for monitoring of the re-forming and cool-down process. Steam shall be introduced at the insertion end of the folded pipe until a minimum temperature of 66°C (150°F) is attained at the terminating end. This temperature shall be held for a minimum of 5 minutes and shall not exceed 115°C (240°F).

- 5) After the material has reached the required temperature, a specifically designed pressure driven rounding device shall be used to progressively round the folded PVC at a maximum rate of 1.5 meters per second (5 feet per second) using steam at 34 to 55 kPa (gage) (5 to 8 psig). The rounding process shall not cause any scraping, tearing, abrasion, movement, or other damage to the liner.
- 6) When the rounding process is complete, the steam shall be converted to air, maintaining an internal pressure of 34 to 83 kPa (gage) (5 to 12 psig). After the conversion to air pressure, water may be introduced until the system is completely filled. A minimum of 55 kPa (gage) (8 psig) air or water pressure shall be maintained until the system is cooled to at least 49°C (120°F) at both ends. At this point, the pressure shall be relieved and both ends shall be cut off in the manholes.
- 7) If testing of the installed PVC liner pipe is required in the Special Provisions, the physical properties of the installed PVC liner shall be verified through field sampling and laboratory testing as approved by the Engineer. Unless the Special Provisions call for more than one sample, a sample shall be cut from a section of reformed/re-rounded PVC liner pipe at the upstream, downstream, or an intermediate manhole/access pit that has been inserted through a same diameter pipe acting as a mold. PVC liner pipe samples shall be submitted to a certified laboratory, which has been pre-approved by the Engineer. The samples shall be tested in accordance with ASTM D 638 for tensile strength, ASTM D 790 for flexural modulus, and ASTM D 2444 for impact resistance to confirm that the liner pipe conforms to the minimum requirements per 500-1.10.2 (b). All costs incurred for the testing shall be borne by the Contractor.

### 500-1.10.3 Type B Folded and Re-formed PVC Pipe Liner.

(a) This method applies to rehabilitation of 100 mm through 450 mm (4-through 18 inch) diameter pipe. The standard dimension ratio may be SDR 26, 32.5, or 41 as specified by the Engineer. This rehabilitation system may be capable of expanding up to ten percent. The initial pipe stiffness factor shall conform to Table 500-1.10.3 (A):

**TABLE 500-1.10.3 (A)**

CELL CLASS 12111		
Nominal ID of Original Pipe mm (inch)	SDR	Stiffness Factor (EI) <sup>1,2</sup> Pa - m <sup>3</sup> (in <sup>3</sup> - lbf/in <sup>2</sup> )
100 (4)	32.5	2.7 (23)
	26	5.3 (47)
150 (6)	32.5	9.0 (79)
	26	17 (153)
200 (8)	32.5	21 (187)
	26	42 (365)
250 (10)	32.5	42 (364)
	26	81 (711)
300 (12)	32.5	72 (630)
	26	140 (1228)
375 (15)	32.5	140 (1226)
	26	274 (2397)
450 (18)	41	121 (1057)

1. Pipe Stiffness (PS) shall be determined in accordance with ASTM D 2412. Stiffness factor is EI = 0.149<sup>3</sup> (PS). The stiffness factors listed in the table are typical values for gravity flow conditions. For pressure applications, the stiffness factors are usually higher.

2. Effects of ovality and safety factor are not included.

(b) **Material Composition.** The folded pipe shall be made from PVC compounds having a cell classification of 12111, as defined in ASTM D 1784.

(c) **Material and Equipment Acceptance.** At the time of manufacture, the extruded material shall be inspected for defects and physical properties in accordance with ASTM D 790 1 a, D2122, D2152, D2412, and F1057 to show compliance with 500-1.10.3 (b) or as indicated in the Specifications. Testing shall be performed once per shift, change in material batch, or coil. Certification shall be supplied per 4-1.5.

At the time of installation, the material shall be homogeneous and free of defects, cracks, holes, blisters, foreign materials, or other deleterious faults.

The Contractor shall furnish and maintain in good condition all equipment necessary for proper execution and inspection of the work.

(d) **Marking.** Marking shall conform to 207-17.2.1, except that under Item 3 there is no ASTM designation for this product.

(e) **Chemical Resistance and Physical Testing.** The PVC material shall be tested in accordance with 211-2 and conform to 500-10.2(B), as modified in Table 500-1.10.3(B) and 210-2.3. The various requirements shall be met with samples taken from pipe that has experienced the folding and re-forming process.

**TABLE 500-1.10.3 (B)**

CELL CLASS 12111			
Property	ASTM Test Method	Initial Values	Values After 112 Days Exposure
Tensile Strength Yield, MPa (psi) min.	D 638	24.1 (3,500) min.	24.1 (3,500) min.
Impact Strength J/m (Feet-lbs/in) min.	D 256 Method A Size 12.7 mm x 3.75 mm x 63.5 mm (1/2 in x 1/8 in x 2-1/2 in)	64 (1.2) of notch, min.	64 (1.2) of notch, min.
Weight Change (%) Unconditioned Conditioned	D 543		± 1.5% max. ± 1.5% max.

(f) **Installation and Field Inspection.**

- 1) The existing pipeline shall be cleaned of any obstacles and televised per 500-1.1.4 and 500-1.1.5, and the host pipe condition shall be satisfactory to the Engineer prior to the insertion of the folded pipe.
- 2) Prior to insertion into the host pipe, heat may be applied to the folded pipe (while on the spool) until pliable. Once the material has become pliable, the pulling cable shall be attached to the insertion end of the folded pipe. Using a winch at the termination point, the folded pipe shall then be inserted through the existing pipe via a manhole or access point. Pulling force shall not exceed 8.9 kN (2,000 pounds).
- 3) After the folded PVC pipe is pulled through the host pipe, it shall be cut off at the starting point and restrained at the terminating point. Thermocouples shall be placed on the exterior of the liner pipe at the downstream end for monitoring of the re-forming and cool-down process. Steam shall be introduced at the insertion end inside the folded pipe until a

minimum temperature of 93°C (200°F) is attained at the manifold with an instrument designed to monitor the temperature and pressure during the expanding and cool-down process at the terminating end. This temperature shall be held for a minimum of 5 minutes and shall not exceed 115°C (240°F).

- 4) After the material has reached the required temperature, a specifically designed pressure driven rounding/expanding device shall be used to progressively round/expand the folded PVC at a maximum rate of 1.5 m (5 feet) per second using steam at a maximum of 69 kPa (gage) (10 psig). The rounding/expanding process shall not cause any scraping, tearing, abrasion, movement, or other damage to the liner.
- 5) When the rounding/expanding process is complete, the steam shall be transitioned to cooling air, maintaining an internal pressure of up to 69 kPa (gage) (10 psig). After the conversion to air pressure, the air will be exhausted at the downstream manifold to cool the liner. As the downstream manifold exhaust temperature approaches 38°C (100°F), the water valve on the upstream manifold shall be gradually opened to allow incoming air/water mixture to reach 27°C (80°F). At this point, the air/water pressure shall be relieved and both ends of the rounded/expanded pipe shall be cut off in the manholes.
- 6) If testing of the installed PVC liner pipe is required in the Special Provisions, the physical properties of the installed PVC liner shall be verified through field sampling and laboratory testing as approved by the Engineer. Unless the Special Provisions call for more than one sample, a sample shall be cut from a section of rounded/expanded PVC liner pipe at the upstream, downstream, or an intermediate manhole/access pit that has been inserted through a same diameter pipe acting as a mold. PVC liner pipe samples shall be submitted to a certified laboratory which has been pre-approved by the Engineer. The samples shall be tested in accordance with ASTM D 638 for tensile strength, ASTM D 790 for flexible modulus, ASTM D 2444 for impact resistance to confirm that the liner pipe conforms to the minimum requirements per 500-1.10.3 (b). All costs incurred for the testing shall be borne by the Contractor.

**500-1.10.4 End Seals.** When required by the Contract Documents, both ends of the new PVC liner shall be sealed to the existing pipeline structure in order to prevent water movement between the two systems. The end seal material shall be an approved epoxy or other material that is compatible with the PVC liner and shall provide a watertight seal as approved by the Engineer.

**500-1.10.5 Service Connections.** Existing service connections shall be reinstated through the use of a remote controlled unit or open excavation in conformance with 500-1.1.7 (a).

**500-1.10.6 Repair and Rejection.** The Contractor shall provide to the Engineer for approval an evaluation and repair specification for liner pipe damaged during or after installation. Any liner pipe damaged shall be removed from the project site. Refer to 500-1.1.8.

#### **500-1.11 HDPE Spirally-Wound Profile Wall Liner Pipe.**

**500-1.11.1 General.** High density polyethylene (HDPE) profile liner pipe for use in lining sanitary sewers shall conform to the requirements of ASTM F 894.

Unless otherwise indicated the minimum pipe stiffness shall be 155 kPa (22.5 psi). Pipe stiffness and its respective ring stiffness constant (RSC) are detailed in Table 500-1.11.1. These shall be tested in accordance with ASTM D 2412 and ASTM F 894. The profile configuration shall be either external or internal unless otherwise indicated on the Plans or in the Special Provisions.

**500-1.11.2 Material Composition.** The material shall conform to 207-19.2. Rubber gaskets shall conform to the requirements of 208-3.

**500-1.11.3 Liner Pipe Acceptance.** At the time of manufacture, all lot components of the liner pipe and fittings shall be inspected for defects. At the time of delivery, the liner pipe shall be homogeneous throughout, uniform in color, free of cracks, abrasions, holes, foreign materials, blisters, or deleterious faults. For testing purposes, a production lot shall consist of all liner pipe having the same lot marking number, but shall not exceed a total of 50 lengths per day. Pipe length, wall thickness, and joint dimension shall be verified by testing each lot per ASTM F 894 or more frequently as required by the Engineer.

TABLE 500-1.11.1 (A)

Nominal Diameter		RSC (Min.)	Pipe Stiffness (PS) (Min.)	
mm	(inches)		kPa	(psi)
450	(18)	64	155	(22.5)
525	(21)	74	155	(22.5)
600	(24)	84	155	(22.5)
675	(27)	95	155	(22.5)
750	(30)	106	155	(22.5)
825	(33)	116	155	(22.5)
900	(36)	127	155	(22.5)
1050	(42)	148	155	(22.5)
1200	(48)	169	155	(22.5)
1350	(54)	191	155	(22.5)
1500	(60)	212	155	(22.5)
1650	(66)	233	155	(22.5)
1800	(72)	255	155	(22.5)

Note: Higher RSC values with respectively higher pipe stiffness values may be available. RSC values are dimensionless.

**500-1.11.4 Marking.** Pipe sections having an exterior profile shall be marked at both ends on the inside of each pipe. Each pipe section having an interior profile shall be marked at both ends on the inside and outside of the pipe to show the manufacturer's name, manufacturer's number (identifies factory location, date, shift, and sequence), nominal inside diameter, minimum RSC, pipe stiffness, ASTM F 894 designation, and lot number.

**500-1.11.5 Chemical Resistance and Physical Testing.** Liner pipes and gaskets shall be tested in accordance 211-2 and conform to the requirements of 207-19.5 and 208-3 respectively.

**500-1.11.6 Installation and Field Inspection.** This pipe installation shall conform to 500-1.1. Maximum jacking loads shall not exceed the values noted in Tables 500-1.11.6 (A) and (B).

TABLE 500-1.11.6 (A) – EXTERIOR PROFILE

Nominal Inside Diameter		Safe Axial Compressive Loads*			
mm	(inches)	RSC 100 kN (Tons)		RSC 160 kN (Tons)	
		450	(18)	20.4	(2.3)
525	(21)	20.4	(2.3)	33.8	(3.8)
600	(24)	29.3	(3.3)	33.8	(3.8)
675	(27)	34.6	(3.9)	33.8	(3.8)
750	(30)	34.6	(3.9)	35.5	(4.0)
825	(33)	N/A.		51.6	(5.8)
900	(36)	N/A.		51.6	(5.8)
1050	(42)	N/A.		83.6	(9.4)
1200	(48)	N/A.		87.1	(9.8)
1350	(54)	N/A.		159.2	(17.9)

\* Includes a Safety Factor of 2:1.

TABLE 500-1.11.6 (B) – INTERIOR PROFILE

Nominal Inside Diameter		Safe Axial Compressive Loads*		
mm	(inches)	RSC	kN (Tons)	
450	(18)	64	84.5	(9.5)
525	(21)	74	97.8	(11.0)
600	(24)	84	111.2	(12.5)
675	(27)	95	124.5	(14.0)
750	(30)	106	137.8	(15.5)
825	(33)	116	164.5	(18.5)
900	(36)	127	177.9	(20.0)
1050	(42)	148	222.4	(25.0)
1200	(48)	169	266.9	(30.0)
1350	(54)	191	400.3	(45.0)
1500	(60)	212	515.0	(58.0)
1650	(66)	233	640.5	(72.0)
1800	(72)	255	1040	(117.0)

\* Includes a Safety Factor of 2:1.

**500-1.11.7 Repair and Rejection.** Liner pipe may be repaired for minor superficial pipe damage. Major damage which penetrates over 25 percent of the inner or outer wall thickness shall be repaired by cutting out the damaged section and replacing the damaged section with a new pipe. All repair methods shall be submitted to the Engineer for prior approval in accordance with 2-5.3. The liner pipe sections shall be a minimum of 2.4 m (8 feet) in length unless shorter sections are authorized by the Engineer. Liner pipe shall be inspected immediately prior to installation for damage. If liner pipe is found to be superficially damaged, the Engineer may allow the pipe to be repaired or may reject it. Major liner pipe damage shall be rejected and replaced with new section of liner pipe.

**500-1.11.8 Annular Space Grouting.** The entire annular space between the outside of the liner pipe and the inside of the existing host pipe shall be grouted. The grout mix and placement procedure shall conform to 500-3. Grouting of the annular space shall be performed in such a manner as to prevent damage or collapse of the liner pipe. Maximum safe annular space grouting pressure for single-stage or multi-stage grouting shall not exceed the pipe stiffness divided by 4.5.

**500-1.11.9 Service Connections.** Service connections shall be exposed and connected to the liner pipe by use of a saddle approved by the Engineer. Refer to 2-5.3 and 500-1.1.7 (a).

#### **500-1.12 Polyvinyl Chloride (PVC) Closed Profile Liner Pipe.**

**500-1.12.1 General.** Polyvinyl Chloride (PVC) closed profile segmented liner pipe for use in lining sanitary sewers shall conform to ASTM F 1803. Unless otherwise specified, the minimum pipe stiffness shall be 318 kPa (46 psi), as tested in accordance with ASM D 2412.

**500-1.12.2 Material Composition.** The material shall be made from unplasticized PVC compounds having a cell classification of 12364 as defined in ASTM D 1784. Elastomeric sealing gaskets shall conform to the requirements of 208-4.

**500-1.12.3 Liner Pipe Acceptance.** The liner pipe shall be free from cracks, holes, blisters, foreign inclusions or other defects that would, due to their nature, degree, or extent, have a deleterious effect on the pipe performance as determined by the Engineer.

For testing purposes, a production lot shall consist of all liner pipe having the same lot marking number, but shall not exceed one shift of production for sizes 525 mm through 750 mm (21 in - 30 in) or two shifts of production for sizes 925 mm through 1200 (36 in - 48 in). Pipe length, wall thickness and

joint dimensions shall be verified by testing for each lot in accordance with ASTM F-794. Records of this testing shall be made available if so requested by the Engineer.

**500-1.12.4 Marking.** Each pipe section shall be marked at one end on the inside and every 1.5 m (5 ft) on the outside showing the manufacturer's name, manufacturing number (identifies production plant, date, shift), cell classification, lot number, nominal diameter, pipe stiffness and ASTM F-794. Internally the pipe shall have a numbered air testing certificate (sticker) that can be correlated through plant records to each piece of pipe. A key of the manufacturer's production and lot codes shall be submitted to the Engineer prior to delivery.

**500-1.12.5 Chemical Resistance and Physical Testing.** Liner pipe and gaskets shall be tested in accordance with 211-2 and conform to the requirements of Table 500-1.12.5(A) and 208-4 respectively.

**TABLE 500-1.12.5 (A)**

Property	ASTM Test Method	Value (Initial and After 112-Day Exposure) Cell Class 12364
Tensile Strength (Yield), Mpa (psi), min.	D 638	41.4 (6000)
Impact Strength J/m (Ft-lbs/in) of notch, min.	D 256 Method A Size 12.7 mm x 3.17 mm x 63.5 mm (Size 1/2 in x 1/8 in x 2-1/2 in)	34.7 (0.65)
Weight Change % Unconditioned Conditioned	D 543	± 1.5 max. ± 1.0 max.

Verification shall be provided that physical testing of the product confirms conformance to ASTM F 794 (qualification test only) and ASM D 2412.

**500-1.12.6 Installation and Field Inspection.** The existing sewer may be maintained in operation during the relining process. The host pipeline shall be cleaned of any obstructions and televised per 500-1.1.4 and 500-1.1.5. Liner pipe installation shall conform to 500-1.1.7(b). The pushing force shall be applied to the grooved end of the pipe. Maximum pushing loads shall not exceed the values noted in Table 500-1.12.6 (A).

**TABLE 500-1.12.6 (A)**

Nominal Pipe Diameter mm (in)	318 kPa (46 psi) Pipe Stiffness Maximum Pushing Load – N (Tons) <sup>1</sup>
525 (21)	5620 (12.5)
600 (24)	5620 (12.5)
700 (27)	5620 (12.5)
750 (30)	5620 (12.5)
925 (36)	5620 (12.5)
1050 (42)	5620 (12.5)
1200 (48)	5620 (12.5)

1. A factor of safety of 2:1 is included for the maximum pushing load.

**500-1.12.7 Annular Space Grouting.** The entire annular space between the outside of the liner pipe and inside of the host pipe shall be grouted in accordance with 500-3. Grouting of the annular space shall be done in such a manner as to prevent damage or collapse of the liner pipe. Maximum safe grouting pressure is 69 kPa (10 psi).

**500-1.12.8 Service Connections.** Service laterals shall be connected to the liner pipe by a method approved by the Engineer. Refer to 500-1.1.7(a).

**500-1.12.9 Repair and Rejection.** Prior to installation, liner pipe shall be inspected for damage. Liner pipe with superficial damage may be repaired without field cutting. Major damage which penetrates 50% or more of the inner or outer wall shall be rejected. All repair methods shall be submitted to the Engineer for prior approval in accordance with 2-5.3. Rejected liner pipe shall be replaced with a new section of liner pipe. Refer to 500-1.1.8.

### 500-1.13 Machine Spiral Wound Polyvinyl Chloride (PVC) Pipe Liner.

**500-1.13.1 General.** Machine spiral-wound PVC liner pipe for use in the rehabilitation of pipelines is wound directly into the existing pipeline from an access point. In pipe sizes 150 mm through 750 mm (6 in. through 30 in.) the pipe liner is expanded radially against the existing pipe. See Table 500-1.13.1(A) for profile diameter ranges.

**500-1.13.2 Material Composition.** The material shall be made from unplasticized PVC compounds having a cell classification of 13354 as defined in ASTM D 1784. The profile type or initial stiffness factor shall be indicated on the plans or in the specifications.

**500-1.13.3 Material and Equipment Acceptance.** At the time of manufacture, each lot of extruded profile strip shall be inspected for defects and physical properties tested in accordance with the ASTM Standards listed in this subsection, or as indicated herein. A lot is defined as a continuous extrusion run of a given profile designation on a reel.

The system consists of a single, one part, PVC ribbed profile strip with interlocking edges. The edges are locked together as the strip is wound into a pipe. The profile strip has 'T' shaped ribs which vary in height and width as a function of pipe diameter.

The initial stiffness factor of the ribbed profile strips used to form the liner pipe shall conform to Table 500-1.13.1(A).

**Table 500-1.13.1 (A)**

Profile Type	Diameter Range		Initial Stiffness Factor, EI <sup>1</sup>	
	mm	(in)	MPa-mm <sup>3</sup>	(in <sup>3</sup> -lbf/in <sup>2</sup> )
1	150 - 250	(6 - 10)	20.0 x 10 <sup>3</sup>	(177.0)
2	200 - 375	(8 - 15)	54.0 x 10 <sup>3</sup>	(478.0)
3	350 - 750	(14 - 30)	195.0 x 10 <sup>3</sup>	(1725.0)

1. Stiffness factors shall be determined in accordance with ASTM D790 as modified in ASTM F 1697.

The minimum width, height and waterway thickness of the ribbed profile strips shall conform to Table 500-1.13.1(B).

**Table 500-1.13.1 (B)<sup>1</sup>**

Profile Type	Minimum Width		Minimum Height		Waterway Minimum Wall	
	mm	(in)	mm	(in)	mm	(in)
1	51.0	(2.00)	5.5	(0.216)	1.6	(0.063)
2	80.0	(3.14)	8.0	(0.314)	1.6	(0.063)
3	121.0	(4.76)	13.0	(0.511)	2.1	(0.083)

1. Physical dimensions shall be determined in accordance with ASTM D 2122.

At the time of installation, the profile strip material shall be homogeneous and free of defects, cracks, holes, blisters, foreign materials or other deleterious faults.

The contractor shall furnish and maintain in good condition all equipment necessary for proper execution and inspection of the work.

**500-1.13.4 Marking.** Each PVC continuous strip shall be distinctively marked on its inside surface at intervals not to exceed 1.5 m (60 in.) with a coded number which identifies the manufacturer, plant, date of manufacture and shift, cell classification and profile type. This information shall also appear on each reel.

**500-1.13.5 Chemical Resistance.** The PVC compound and cured sealant/adhesive shall conform to the chemical resistance test requirements of 210-2.3.

**500-1.13.6 Installation and Field Inspection.** The existing pipeline shall be cleaned of any obstacles and televised per 500-1.1.4 and 500-1.1.5 and proven per 500-1.1.7(b) and the condition shall be approved by the Engineer prior to the insertion of the liner pipe. During this phase of operation all service openings shall be precisely located longitudinally and radially, and logged for subsequent reconnection after the insertion of the liner pipe.

Installation of the spiral-wound PVC liner shall be in accordance with ASTM F1741. End seals, between the liner pipe and the existing pipe, shall be installed using a sealing material that is compatible with the liner pipe material.

**500-1.13.7 Service Connections.** Service lateral connections shall be re-established with the liner in accordance with 500-1.1.7(a).

**500-1.13.8 Repair and Rejection.** The contractor shall provide an evaluation and repair specification to the Engineer for approval for any profile strips or liner pipe found to be damaged during or after installation. Any portion of the profile strip damaged in transit or on the project site prior to installation will be marked "Rejected" and that portion shall be removed from the project site. Refer to 500-1.1.8.

## **500-2 MANHOLE AND STRUCTURE REHABILITATION.**

### **500-2.1 Requirements.**

**500-2.1.1 General.** This subsection covers the various manhole and structure rehabilitation materials and methods. The types of rehabilitation materials and methods for a given project will be designated on the Plans. The Engineer may require testing of the materials and methods for compliance with these requirements prior to delivery to the jobsite and/or prior to acceptance, depending upon the alternate selected.

**500-2.1.2 Measurement and Payment.** Manhole and structure rehabilitation will be measured along the longitudinal axis between the ends of the manhole or structure as shown on the Plans to the nearest 0.03 m (0.1 foot).

Payment for structures, including but not limited to manholes, junction structures, and lampholes, will be made at the Contract Unit Price bid for each structure and shall be full payment for point repair and rehabilitation for each structure, including excavation, backfilling, reconstruction of inverts, furnishing and installing castings, restoration of the street or ground surface, and all other required work.

**500-2.1.3 Manhole Steps.** Manhole steps shall be installed or removed as indicated on the Plans or in the Specifications.

**500-2.1.4 Safety.** The Contractor shall comply with all Federal, State, local, and CAL/OSHA safety regulations. The Contractor's personnel shall be certified for confined space entry.

**500-2.1.5 Removal and Disposal.** The Contractor shall be responsible for removal and disposal of all debris removed during the cleaning and rehabilitation process. The Contractor shall comply with all Federal, State, and local regulations regarding disposal of debris.

## **500-2.2 Manhole Re-forming System.**

**500-2.2.1 General.** This subsection describes the installation of the integral locking PVC liner by temporarily erecting a form inside an existing manhole and filling the annular space between the erected form and the existing manhole wall with concrete that will result in a new PVC-lined, monolithic manhole within the old one. This work is for sanitary sewer manholes. The same re-forming system can be utilized for storm drain manholes except, when indicated on the Plans or in the Specifications, the PVC liner may not be required.

**500-2.2.2 Concrete.** Concrete, unless otherwise specified by the Engineer, shall be Class 330-C-23 (560-C-3250) per 201-1.1.2.

**500-2.2.3 Integral Locking PVC Liner.** The liner shall conform to the applicable requirements in 210-2 unless otherwise shown on the Plans or in the Specifications. Proof of meeting these requirements shall be provided to the Engineer for approval at least 15 days prior to commencement of work.

**500-2.2.4 Chemical Resistance and Physical Testing.** The liner shall meet the requirements of 210-2.3 and 210-2.4.

**500-2.2.5 Installation and Field Inspection.** The manhole walls and base shall be cleaned of loose debris by brushing or low pressure washing. Steps shall be removed to a minimum depth of 25 mm (1 inch) inside the structure. The formwork shall be installed in a manner that substantially fits the existing walls of the manhole and creates an equal and approximate 75 mm (3 inch) annular space. Concrete shall be used to fill the annular space. The installation of the liner shall comply with 311-1. Replacement of steps shall conform to requirements shown on the Plans or in the Specifications.

Existing lines to the manhole shall be extended through the newly formed manhole wall. The exposed concrete surfaces within the manhole shall be protected as shown on the Plans or in the Specifications.

## **500-2.3 PVC Manhole and Wet Well Lining Systems.**

**500-2.3.1 General.** This subsection describes the installation of the PVC liner by placing the liner strips so that an annular space is created between the PVC liner and the existing manhole/wet well. This annular space is then filled with cementitious grout or other approved materials that will result in a monolithic manhole/wet well within the existing manhole/wet well.

**500-2.3.2 Materials.**

(a) **PVC Liner.** The PVC liner shall comply with the applicable requirements in 500-1.5.

(b) **Grout.** Cementitious grout or other approved materials shall conform to 201-5.6 and as indicated on the Plans or in the Special Provisions.

(c) **Sealant/Adhesive.** Sealant/adhesive shall be as indicated on the Plans or in the Special Provisions.

**500-2.3.3 Chemical Resistance.** The PVC material and sealant/adhesive shall conform to 500-1.5.5.

**500-2.3.4 Installation and Field Inspection.** Surface preparation shall consist of thorough cleaning to remove all loose material and surface contaminants. Any protrusions on the wall surface which interfere with the installation of the liner shall be removed. The Contractor, when required, shall provide for the flow of sewage around the manhole/wet well designated for lining. Installation shall be accomplished by either manually spirally winding the PVC strip or manually placing the PVC panels and by engaging the complimentary locks (male/female) at the edges of the strips/panels in a manner which creates the annular space, as specified and approved by the Engineer.

A bead of sealant/adhesive, approved by the Engineer, shall be applied to the female locking edge of the strip/panel prior to engaging the locking edges. Cementitious grout or other approved materials, as specified by the Engineer and as indicated on the Plans or in the Specifications, shall be used to fill the annular space. The grout mix and placement procedure shall be submitted to the Engineer for approval in accordance with 2-5.3. Grouting of the annular space shall be done in such a manner to prevent damage or collapse of the liner. Any holes in the plastic shall be covered with a patch or similar material as approved by the Engineer. The installation of the PVC liner shall conform to the applicable requirements of 500-1.5.

**500-2.3.5 Service Connections.** Service connections shall be re-established with the liner in accordance with the manufacturer's written recommendations as approved by the Engineer.

**500-2.4 Air-Placed Concrete and Polyurethane Protective Lining Manhole Rehabilitation.**

**500-2.4.1 General.** This specification is for the installation of air-placed concrete (APC) and polyurethane spray-applied protective lining for the structural and environmental rehabilitation of manhole interior surfaces.

**500-2.4.2 Cleaning.** Prior to the application of the APC and the polyurethane protective lining, the manhole shall be thoroughly cleaned by high water pressure blast at pressures of 34.5 MPa (5,000 psi) minimum to 68.9 MPa (10,000 psi) maximum. Debris from cleaning shall not be allowed to enter the sewer system. The Contractor shall provide the necessary debris containment devices while maintaining sewer flow. The Contractor shall remove and dispose of all debris collected from the cleaning operation per 500-1.1.4

**500-2.4.3 APC Materials.** APC shall conform to 303-2.3.1.

**500-2.4.4 APC Placement.** APC shall be applied in continuous lifts between 25 and 75 mm (1 and 3 inches) in thickness to restore the dimensions shown on the Plans or in the Specifications. Proper containment devices shall be used to prevent rebound (nonadhering excess APC) from entering the sewer system. Sewer flows shall be maintained unless otherwise specified on the Plans or in the Specifications.

**500-2.4.5 APC Curing.** Immediately following the APC placement operation, the containment device shall be removed and the manhole cover reinstalled to provide a moist curing environment. Where moist conditions within the manhole do not exist, the Contractor shall provide a water cure to the APC for a minimum of 24 hours prior to application of the primer and lining as specified in 500-2.4.7

**500-2.4.6 Primer and Lining Materials.** The primer materials shall be 100 percent solids, moisture-tolerant epoxy capable of spray application to 127  $\mu\text{m}$  (5 mils) thickness in one continuous coat.

The polyurethane lining material shall be 100 percent solid, high-build polyurethane capable of spray application to 3175  $\mu\text{m}$  (125 mils) thickness in one continuous coat. The material shall be tested in accordance with the requirements of 211-2 and conform to 210-2.3.3, 500-2.4.10 and the weight change requirements in Table 210-2.4.1(A). Proof of meeting these requirements shall be provided to the Engineer for approval per 2-5.3.4.

**500-2.4.7 Lining Application.** The polyurethane lining application shall take place after the APC has cured for a minimum of 24 hours and shall be applied to all concrete surfaces from 75 mm (3 inches) below the low-flow water level to the base of the ring and cover. Prior to the polyurethane application, the manhole surfaces shall be primed with the epoxy primer to a thickness of 76  $\mu\text{m}$  (3 mils) minimum to 127  $\mu\text{m}$  (5 mils) maximum. Prior to the epoxy primer becoming tack-free, the polyurethane lining shall be immediately applied to a thickness of 2540  $\mu\text{m}$  (100 mils) minimum to 3175  $\mu\text{m}$  (125 mils) maximum. The polyurethane lining shall be uniform in color, fully cured, and free of pinholes, surface imperfections, and blisters.

**500-2.4.8 Spark Test.** The cured polyurethane lining shall be spark tested for pinholes with a spark tester set at 15,000 volts minimum. All pinholes shall be repaired as specified in 500-2.4.9.

**500-2.4.9 Repair Methods.** All defects in the APC shall be repaired as specified in 303-2. All pinholes in the protective lining shall be marked off on surface areas containing pinholes to a point 150 mm (6 inches) beyond all pinholes, primed with epoxy, and recoated with polyurethane to a minimum additional thickness of 762  $\mu\text{m}$  (30 mils). Blisters, uncured lining, and surface imperfections shall be completely removed and the areas recoated with epoxy primer and polyurethane lining to a point 150 mm (6 inches) beyond the repair areas at a minimum thickness of 2540  $\mu\text{m}$  (100 mils).

**500-2.4.10 Applicable Standards.** APC, epoxy primer, and polyurethane lining shall meet or exceed the requirements specified in 303-2 and Table 500-2.4.10 (A).

**TABLE 500-2.4.10 (A)**

	<b>Polyurethane</b>	<b>Epoxy</b>
Tensile Strength ASTM D 638, Type IV, MPa (psi)	13.8 (2,000)	41.4 (6,000)
Elongation at Break, % ASTM D 638, Type IV	50	5
Wear Resistance, mg. wt. Loss Taber abrasion, ASTM D4060	60 <sup>2</sup>	100 <sup>2</sup>
Hardness, Shore D, Durometer ASTM D 2240	55	75
Tear Resistance, kg/mm (ppi) ASTM D 624	2.7 (150)	N/A
Peel Strength, Concrete, g/mm (pli) ASTM D 903	125 (7) <sup>1</sup>	125 (7) <sup>1</sup>

1. Tested as a system. Test results shall be verified on a per job basis or as required by the Engineer.

2. Abrasive wheel No. CS-17.

## **500-3 ANNULAR SPACE GROUTING.**

### **500-3.1 Requirements.**

**500-3.1.1 General.** This subsection covers various requirements of continuous annular space grouting of sliplining systems. The annular space (void between the host and liner pipes) shall be completely grouted to support the liner and provide long-term stability. The Contractor shall engage the services of an Agency approved testing laboratory to certify that the proposed materials and methods comply with these requirements. All proposals shall be submitted to the Engineer per 2-5.3, 201-1, and 500-3.1.10.

**500-3.1.2 Preparation.** Upon completion of sliplining but prior to grouting, bulkheading of the ends and appropriate venting will be required. This is to seal the annular space from sewer flow to permit the grout to set and withstand the loads imposed by the grout and groundwater. The Contractor shall test the integrity of the installed liner pipe and constructed bulkheads for any leaks by performing the following:

- 1) Dewater and inject dye water into the annular space (this alternative will not be permitted if the crown or any portion of the host pipe is severely deteriorated to the point where water may escape through the host pipe).
- 2) Pressurize the annular space to the maximum permissible grouting pressure per the manufacturer's recommendation with approval by the Engineer.
- 3) The Contractor shall submit a detailed plan to the Engineer that will hold the liner pipe on the invert for a period of time long enough to allow the grout to set where buoyant uplift is a factor.

**500-3.1.3 Planned Vents.** The Contractor shall submit plans, including the proposed number and location of vents relative to pipe diameter and stiffness and the depth of sewer flow in the pipeline for the grouting operation.

**500-3.1.4 Materials.** The grout materials shall consist of portland cement, portland cement and fly ash, and/or additives, providing materials are not biodegradable.

(a) **Compressive Strength.** The grout shall have a minimum penetration resistance of 690 kPa (100 psi) in 24 hours when tested in accordance with ASTM C 403 and a minimum compressive strength of 2070 kPa (300 psi) in 28 days when tested in accordance with ASTM C 495 or C 109.

(b) **Performance Requirements.** The Contractor shall submit the proposed grout mixes, methods, plans, and criteria of the grouting operations. The grouting system shall have sufficient gauges, monitoring devices, and tests to determine the effectiveness of the grouting operation and to ensure compliance with the liner pipe specifications and design parameters.

(c) **Mix Design.** One or more mixes shall be developed to completely fill the annular space based on the following requirements:

- 1) Size of the annular void
- 2) Void (size) of the surrounding soil
- 3) Absence or presence of groundwater
- 4) Sufficient strength and durability to prevent movement of the pipe
- 5) Provide adequate retardation, and
- 6) Provide less than 1 percent shrinkage by volume

(d) **Density and Viscosity.** The Contractor shall design a grout mix with a density to meet the requirements of 500-3.1.6 and to prevent floating of the liner pipe. The apparent viscosity shall not exceed 20 seconds in accordance with ASTM C 939 unless otherwise approved by the Engineer.

**500-3.1.5 Qualifications.** The Contractor shall demonstrate to the Engineer its worker's capabilities of filling the annular space and performing their work in conformance with the Plans and the Specifications.

**500-3.1.6 Grouting Equipment.** The materials shall be mixed in equipment of sufficient size and capacity to provide the desired amount of grout material for each stage in a single operation. The equipment shall be capable of mixing the grout at densities required for the approved procedure and shall also be capable of changing density as dictated by field conditions any time during the grouting operation.

**500-3.1.7 Injection Procedure and Pressure.** The gauged pumping pressure shall not exceed the liner pipe manufacturer's approved recommendations as stated in 500-1.3.7, 500-1.8.7, and 500-1.11.8. Pumping equipment shall be of a size sufficient to inject grout at a volume, velocity and pressure compatible with the size of the annular space and degree of host pipe corrosion. Once grouting operations begin, grouting shall proceed uninterrupted from bulkhead to bulkhead. Grout placement shall not be terminated until the following conditions are met, unless otherwise approved by the Engineer:

- 1) The estimated annular volume of grout has been injected;
- 2) The exhausted grout at each vent is not less than 85 percent of the density of freshly injected grout;
- 3) The exhausted grout at each vent is not less than 85 percent of the original viscosity of the freshly injected grout; and
- 4) When recommended by the grout installer.

A grout pressure gauge and recorder shall be installed immediately adjacent to each injection port. During operations, the recorder shall continuously record the actual grouting pressure versus the time on paper with ink. The gauge shall conform to an accuracy of  $\pm 3.5$  kPa ( $\pm 0.5$  psi). The range of the gauge shall not be more than 100 percent greater than the design and attached to a saddle-type diaphragm seal (gauge saver) to prevent clogging with grout. All gauges shall be certified and calibrated in accordance with ANSI B40, Grade 2A. The grout pressure recordings shall be identified, as a minimum, with the date, batch, and time of day grouting was performed and shall be submitted to the Engineer at the end of the work day that grouting was performed.

**500-3.1.8 Onsite Test.** For each batch, the Contractor shall provide all equipment and personnel necessary to perform the following tests in the presence of the Engineer:

- 1) Density per ASTM C 138 or by other methods as approved by the Engineer.
- 2) Viscosity per ASTM C 939.

Grout that exceeds  $\pm 48$  kg/m<sup>3</sup> (3 pounds per cubic foot) of the design density will be rejected.

**500-3.1.9 Test Section.** The Contractor will be required to perform a test on each type of grout and grout system proposed to be used. The test section to be grouted and the size of the annular space considered for each type of grout system shall be determined by the Contractor and approved by the Engineer.

**500-3.1.10 Submittals and Required Calculations.** The Contractor shall submit the following to the Engineer at least 30 working days prior to the start of the grouting operation in accordance with 2-5.3:

- 1) The proposed grouting mix
- 2) The proposed grout densities and viscosity
- 3) Initial set time of the grout
- 4) The 24-hour and 28-day minimum grout compressive strengths
- 5) The grout working time before a 15 percent change in density or viscosity occurs.
- 6) The proposed grouting method and procedures
- 7) The maximum injection pressures
- 8) Proposed grout stage volumes (e.g., Stage 1, to springline; Stage 2, fully grouted)
- 9) Bulkhead designs and locations
- 10) Buoyant force calculations during grouting
- 11) Flow control
- 12) Provisions for re-establishment of service connections

- 13) Pressure gauge, recorder, and field equipment certifications (e.g., calibration by an approved certified lab)
- 14) Vent location plans
- 15) Written confirmation that the Contractor has coordinated grouting procedures with the grout installer and the liner pipe manufacturer

Data for 1) through 5) shall be derived from trial grout batches by an approved, independent testing laboratory.

For each different type of grout or variation in procedure or installation, a complete package shall be submitted. The submittal shall include each of the above items and the sewer locations or conditions to which it applies. The Contractor shall obtain approval from the Engineer for any changes to be made in grout mix, grouting procedure, or installation prior to commencement of grouting operations.

# PART 6

## SECTION 600 - MODIFIED ASPHALTS, PAVEMENTS AND PROCESSES

600-1 (Not Used.)

600-2 (Not Used.)

### 600-3 RUBBERIZED EMULSION – AGGREGATE SLURRY

**600-3.1 General.** This work shall consist of formulating a mix design, cleaning pavement surfaces, mixing and applying a crumb rubber asphalt slurry-seal surface treatment, and protecting the completed slurry seal until set. All work shall be in accordance with this specification, the dimensions, and details shown on the plans, and as approved by the Engineer.

**600-3.2 Materials.** Rubberized Emulsion – Aggregate Slurry (REAS) shall consist of Rubberized Polymer Modified Emulsion (RPME) and aggregate. Materials for REAS shall conform to the following, immediately prior to mixing.

**600-3.2.1 Rubberized Polymer Modified Emulsion.** The RPME shall be a slow-set or a quick-set type of emulsion as determined by the Engineer. RPME shall contain asphalt, crumb rubber, and polymer modifiers.

**600-3.2.2 Polymer Modifier.** Polymer modifier shall be latex which is added at a minimum of 2 percent by weight of the RPME.

**600-3.2.3 Crumb Rubber.** The material shall be granulated scrap tire rubber free from fabric wires and other contaminants. Rubber shall be dry and free flowing. Calcium carbonate or talc may be added to a maximum of 4 percent by weight of rubber to prevent rubber particles from sticking together. The rubber shall have a specific gravity between 1.15 and 1.20. one hundred percent of the rubberized material shall pass a 1.18 mm (No. 16) sieve, 95 percent shall pass a 900  $\mu$ m (No. 20) sieve, and a maximum of 2 percent shall pass a 75  $\mu$ m (No. 200) sieve. The RPME shall contain between 66 g/L (0.55 lbs/gal) and 78 g/L (0.65 lbs/gal) of crumb rubber.

**600-3.2.4 Quality Requirements.** Manufacturers shall certify that materials meet the following requirements:

TABLE 600-3.2.4 (A)

#### TESTS ON RUBBERIZED POLYMER MODIFIED EMULSION

Viscosity, 25°C (77°F), Brookfield, Model RVT #6	2,500 min.
Spindle @ 10 RPM (Centipoise)	20,000 max.
Residue by Evaporation % ASTM D 244	50 min.
Sieve Test % retained on No. 20 screen ASTM D 244	2.0 max. <sup>1</sup>
Weight per Liter (Gallons)	1.0 kg/L (8.33 lbs/gal) min. 1.05 kg/L (8.75 lbs/gal) max.
Penetration of Residue, 25°C (77°F), 100 g. 5 sec. ASTM D 5	20 min. - 40 max.
Percent Residue Soluble in Trichloroethylene ASTM D 2042	75 min.

1. Sieve test of original emulsion is 0.10 max.

**TABLE 600-3.2.4 (B)**  
**TEST ON POLYMER MODIFIER**

Total Solids (residue)	ASTM D1417	60% min.
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**TABLE 600-3.2.4 (C)**  
**COMPOSITION OF REAS**

Aggregate Type	RPME % of Dry Aggregate Weight	Residual RPME % of Dry Aggregate Weight	kg of Dry Aggregate Per Liter of RPME	Pounds of Dry Aggregate per Gallon of RPME
Fine Slurry Aggregate	60 - 80	30 - 40	1.27 - 1.70	10.6 - 14.2
Type I Slurry Aggregate	50 - 75	25 - 38	1.35 - 2.00	11.3 - 17.0

**600-3.2.5 Aggregate.** The aggregate shall consist of sound and durable natural or manufactured sand, crushed stone, or crushed stone and rock dust, or a combination thereof, free of deleterious amounts of organic material, mica, and other substances not suitable for the purpose. Smooth-textured sand of less than 1.25 percent water absorption, as tested by ASTM C 128, shall not exceed 50 percent of the total combined aggregate. Aggregate retained on the 300 µm sieve (No. 50) shall be 100 percent crushed.

The combined aggregate shall meet the requirements of Table 203-5.2(B) prior to any chemical additions.

The combined aggregate shall conform to the gradation shown in Table 600-3.2.5(A) when tested in accordance with ASTM C 136.

**TABLE 600-3.2.5 (A)**  
**GRADATION OF AGGREGATES**

Sieve Size	% By Weight Passing Sieves	
	Fine Slurry Aggregate	Type I Slurry Aggregate
4.75 mm (No. 4)	100	100
2.36 mm (No. 8)	95-100	90-100
1.18 mm (No. 16)	75-92	65-90
600 µm (No. 30)	50-75	40-60
300 µm (No. 50)	35-50	25-42
150 µm (No. 100)	15-30	15-30
75 µm (No. 200)	10-20	10-20

**600-3.2.6 Water.** All water used in making the slurry shall be potable and free from harmful soluble salts.

**600-3.2.7 Additives.** Additives up to 1.5 percent of the dry aggregate weight, as approved in the mix design, may be used in the slurry to modify viscosity, setting, and curing characteristics. Field adjustments to additives may be made only if approved by the Engineer.

**600-3.2.8 Mix Design Submittal.** Mix designs and calibration shall be per 203-5.4 and the following. Mix design results shall include any proposed additives. The completed slurry shall have a minimum skid resistance of 40 when tested per California Test No. 342. The standard Wet Track Abrasion Test (WTAT) template may be modified to a thickness of 3.18 mm (0.125 in), when using slow-set emulsion. The mix design shall include the weight per liter (weight per gallon) of REAS.

**600-3.3 Slurry Mixing and Spreading Equipment.** The REAS shall be mixed either by a continuous flow mixer per 302-4.2.2 or a central mixing plant. A central mixing plant shall not be used for quick set REAS.

If a central mixing plant is used, combining of the RPME and aggregate in the mixing tank shall be in the presence of the Engineer. The tank shall be calibrated in liters and gallons and equipped with load cells and a full sweep agitator capable of producing a homogeneous slurry mix. All storage tanks and delivery vehicles shall be equipped with an agitator. The REAS shall be delivered to the slurry site and spread directly behind the truck with a mechanical-type squeegee distributor, or the slurry may be pumped into smaller trucks equipped with mechanical-type squeegee distributors. All spreading equipment shall contain fog/water systems per 302-4.3.2. The mixing tank shall not be used to batch more than one job at a time. Storage tanks for RPME and REAS shall not be used to supply more than one job at a time.

The weight per liter (weight per gallon) of REAS delivered to the spreader box shall be within 0.11 kg/L (0.92 lbs/gal) of the mix design.

**600-3.3.1 Field Mixing and Spreading Equipment Calibration.** Calibration shall conform with 203-5.4 and the following. Calibration shall be per International Slurry Surfacing Association (ISSA). If the tests do not meet specification requirements, additional tests shall be performed at the Contractor's expense until an acceptable mix is obtained.

**600-3.4 Application of REAS.** The application of REAS shall conform to 302-4.3.2, except for the following conditions, and RPME application rates specified in Table 600-3.4(A). REAS shall not be applied when the atmospheric temperature is less than 10 °C (50 °F) or when the atmospheric temperature at 7 a.m. is 24 °C (75 °F) or over, and rising to a forecast high of 39 °C (100 °F). The total time of mixing in the slurry machine shall not exceed 5 minutes.

**TABLE 600-3.4 (A)**  
**RPME APPLICATION RATES**

Aggregate Type	Application Rate meter <sup>2</sup> /liter of RPME	Application Rate feet <sup>2</sup> /gallon of RPME
Fine Slurry Aggregate	0.86 to 0.98	35 to 40
Type I Slurry Aggregate	0.69 to 0.86	28 to 35

**600-3.5 Field Sampling.** Field sampling shall conform to 302-4.3.3.

**600-3.6 Public Convenience and Traffic Control.** Public convenience and traffic control shall conform to 302-4.3.3.

**600-3.7 Measurement and Payment.** The REAS shall be paid based on the liters (gallons) of RPME used. Measurement of RPME shall be the liter (gallon) computed by dividing the weight obtained from Certified Weighmaster Certificates by 1.02 kg/L (8.5 lbs/gal). The Contractor shall also present Weighmaster's Certificates for the amount of such material remaining unused at the completion of the work at no cost to the Agency. Payment will be determined by deducting the amount of the unused material from the total amount of material delivered.

The pay quantity for REAS shall be the total number of liters (gallons) for RPME (excluding aggregate) used on the project. Such price shall include full compensation for specified surface preparation, removals, sweeping, aggregate required in the mix design, and for constructing the REAS in place.

Payment reduction for noncompliance shall conform to 302-4.6.1 and 302-4.6.2.

**600-4 CRUMB RUBBER MODIFIED (CRM) BINDERS AND PAVEMENTS - DRY PROCESS.****600-4.1 Crumb Rubber Modified Asphalt Concrete-Gap Graded (CRUMAC-GG)**

**600-4.1.1 General.** CRUMAC-GG shall be the product of mixing mineral aggregate, asphalt binder, and Crumb Rubber Modifier (CRM) at a central mixing plant and shall conform to 203-6 except as modified herein. The contractor shall submit test reports and certificates of compliance for the paving asphalt and the CRM to be used. In addition, when requested by the Engineer, the contractor shall submit samples of the material.

**600-4.2 Materials.**

**600-4.2.1 Asphalt Rubber.** Asphalt used for asphalt rubber shall be AR 4000 conforming to 203-1. The Crumb Rubber gradation for Crumb Rubber Modified Asphalt Concrete-Gap Graded (CRUMAC-GG) will be designated by class, i.e., CRUMAC -C, to meet requirement per section 600-4.2.2. The proportions of the two materials, by weight, shall be  $82 \pm 2$  percent paving asphalt and  $18 \pm 2$  percent CRM.

**600-4.2.2 Crumb Rubber Modifier (CRM).** CRM shall be scrap tire CRM as required in 203-11.2.3. CRM Gradation test method shall conform to the requirements of 203-11.2.3.1. CRM gradation for CRUMAC shall be designated by class, i.e., CRUMAC-B, CRUMAC-C, and conform to the requirements of this section and Table 600-4.2.2 (A). The CRM gradation shall be specified with the same class of aggregate gradation, i.e. CRM (CRUMAC-B) shall be specified with aggregate gradation CRUMAC-GG-B.

**TABLE 600-4.2.2 (A)**  
**GRADING REQUIREMENTS FOR CRM (CLASS B and C)**

SIEVE SIZE	CLASS	
	CRUMAC-B Min.-Max.	CRUMAC-C Min.-Max.
2.00 mm (No. 10)	98-100	100
1.18 mm (No. 16)	30-50	50-70
600 $\mu$ m (No. 30)	3-13	10-20
300 $\mu$ m (No. 50)	0-6	3-8
150 $\mu$ m (No. 100)	0-2	0-3

**600-4.3 Composition and Grading.** Crumb Rubber Modified Asphalt Concrete-Gap Graded (CRUMAC-GG) will be designated by type and class, i.e., CRUMAC-GG-C and shall conform to the requirements of this subsection and Table 203-11.3, except GG-D requirements shall be deleted.

**600-4.4 Mix Designs and Certifications.** Mix designs for CRUMAC shall conform to 203-11.6. Once the percent asphalt rubber binder is determined by the mix design, the production tolerance shall be  $\pm 0.5\%$  as determined by California Test Method 382.

**600-4.5 Proportioning.** Proportioning shall conform to 203-6.6, except that proportioning of CRM shall be performed using an automatic batching system and the only manual operation required for proportioning of all materials shall be the single operation of a switch or starter. The CRM feeder system shall be able to deliver CRM to the mixture at an accuracy of 0.1% of the total weight of mix. The Contractor shall submit to the Engineer, in writing, the method proposed to deliver the CRM to the mixture. The method and equipment proposed for use shall be so designated and accessible that the Engineer can visually observe the materials being incorporated into the mixture. All weighing and

metering devices used in the production of CRUMAC shall be calibrated in accordance with 4.1.7 and 4.1.8. When batch-type plants are used, the CRM shall be proportioned by weight. When continuous plants are used, the systems provided shall maintain positive interlock between the flow of CRM, asphalt binder and aggregate.

**600-4.6 Mixing.** Mixing shall conform to 203-6.7, except that the aggregate and the CRM shall be combined and mixed thoroughly for a minimum of 5 seconds, prior to introducing the asphalt binder. The asphalt binder, aggregate, and CRM shall be mixed for a minimum of 35 seconds. If the Engineer determines that the mixture is not thoroughly blended or that the aggregate and CRM are not fully coated with binder, the mixing time shall be increased. The temperature of the mix at discharge shall be a minimum of 161 °C (320 °F) and a maximum of 177 °C (350 °F).

**600-4.7 Distribution and Spreading.** Distribution and spreading shall conform to 302-9.4.

**600-4.8 Rolling.** Rolling shall conform to 302-9.5, except that breakdown rolling shall begin immediately behind the paver and shall be complete before the temperature falls below 141 °C (285 °F) measured immediately in front of the roller. Pneumatic rollers shall not be used.

**600-4.9 Rock Dust Blotter.** Rock Dust Blotter shall conform to 302-9.6.

#### **600-5 TIRE MODIFIED ASPHALT CONCRETE (TMAC).**

**600-5.1 General.** Tire Modified Asphalt Concrete (TMAC) shall be the product of mixing mineral aggregate and an asphalt-rubber binder at a central mixing plant.

**600-5.2 Materials.** TMAC shall be designated by class, i.e., TMAC-C, and shall conform to the requirements in this subsection.

**600-5.2.1 Asphalt.** The asphalt binder to be mixed with the aggregate shall consist of asphalt cement having a minimum of 10% ground whole scrap tire rubber. The whole scrap tire rubber material shall be totally incorporated into the asphalt binder providing a smooth and homogeneous composition. The asphalt binder shall be designated as MAC-10TR with properties conforming to Table 600-5.2.1 (A).

**TABLE 600-5.2.1 (A)**

<b>MAC-10TR</b>		
<b>Properties</b>	<b>Test Method No.</b>	<b>Requirements</b>
<b>TESTS ON ORIGINAL ASPHALT:</b>		
Minimum Recycled Whole Scrap Tire Rubber Content, %	CERTIFICATION	10.0
Penetration, at 25 °C, 0.1 mm, 100 grams, 5 seconds	ASTM D5	40-60
Penetration, at 4 °C, 0.1 mm, 200 grams, 60 seconds, Min.	ASTM D5	20
Dynamic Viscosity, at 60 °C (140 °F), Poise, Min.	ASTM D2171	5000
Kinematic Viscosity, at 135 °C (275 °F), Centistokes, Max.	ASTM D2170	1000
Flash Point, Cleveland Open Cup, °C (°F), Min.	ASTM D92	232 (450)
Softening Point, °C (°F), Min.	ASTM D36	53 (127)
Solubility in Trichloroethylene, %, Min.	ASTM D2042	97.5
<b>TESTS ON RESIDUE FROM RTFO PROCEDURE:</b>		
Penetration, at 25 °C, 0.1 mm, 100 grams, 5 seconds	ASTM D5	20-40
Penetration, at 4 °C, 0.1 mm, 200 grams, 60 seconds, Min.	ASTM D5	14
Dynamic Viscosity, at 60 °C (140 °F), Poise, Min.	ASTM D2171	20,000
Kinematic Viscosity, at 135 °C (275 °F), Centistokes, Max.	ASTM D2170	1500
Percent of Original Penetration, at 25 °C, 0.1 mm, 100 grams, 5 seconds, Min.	ASTM D5	50

**600-5.2.2 Aggregate.** Coarse aggregate shall be crushed rock conforming to Section 200-1.2.

**600-5.2.3 Mineral Filler.** Mineral filler shall conform to 203-6.3.3.

**600-5.3 Tire Modified Asphalt Concrete Mixtures.**

**600-5.3.1 Combined Aggregates.** Combined aggregates, after all processing except the adding of asphalt and mineral filler, shall have a minimum sand equivalent of 50 when tested by California Test 217.

**600-5.3.2 Composition and Grading.** The grading of the combined aggregates shall conform to Table 203-11.3 (A). Percentages for the combined gradings, within the specified limits, shall be of such uniformity that material passing the indicated sieves during any one day's run will not exceed the following maximum variations:

4.75 mm (No. 4) Sieve = 6 percentage points

600  $\mu$ m (No. 30) Sieve = 5 percentage points

75  $\mu$ m (No. 200) Sieve = 3 percentage points

The gradations in the tabulations given in Table 203-11.3(A) represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The aggregate as finally selected shall have a gradation within the limits designated in the tabulations and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but shall be uniformly graded from coarse to fine and shall conform to ASTM C 136 and C 117 or California Test 202.

All classes of TMAC shall conform to the following requirements shown in Table 600-5.3.2 (A):

**TABLE 600-5.3.2 (A)**

Properties	Requirements
% Asphalt Binder by Weight of Dry Aggregate*	5.0 - 7.0
Air Voids % California Test 367	3 - 6
Stabilometer Value per California Test 304 and 366, Min.	23
Voids in Mineral Aggregate Percent, Min.	16

Once the percent asphalt binder is determined by the mix design, the production tolerance shall be  $\pm 0.5$  % as determined by California Test Method 362, 379, or 382.

**600-5.4 Aggregate Storing, Drying, and Screening.** Aggregate storing, drying, and screening shall conform to 203-6.5.

**600-5.5 Proportioning.** Proportioning shall conform to 203-6.6.

**600-5.6 Mixing.** Mixing shall conform to 203-6.7 except that the temperature of the aggregates at the time of adding the paving grade binder shall not exceed 176° C (350° F) nor be less than 149° C (300° F).

**600-5.7 Storage.** Storage shall conform to 203-6.8.

**600-5.8 Mix Designs and Certifications.** Mix designs and certifications shall conform to 203-11.6.

**600-5.9 Distribution and Spreading.** Distribution and spreading shall conform to 302-9.4 except that the temperature of the TMAC-GG shall be 149° C (300° F) minimum to 166° C (330° F) maximum.

**600-5.10 Rolling.** Rolling shall conform to 302-5.6 except that vibratory rollers using the vibratory mode shall be used for initial breakdown rolling. The initial coverage of breakdown rolling shall commence before the TMAC-GG temperature falls below 143° C (290° F). If the atmospheric temperature is above 29° C (85° F), the initial breakdown rolling temperature may be reduced to 138° C (280° F). If the temperature of the mat during breakdown rolling is reduced, this will not relieve the Contractor of his compaction requirements.

**600-5.11 Rock Dust Blotter.** Rock dust blotter shall conform to 302-9.6.

**600-5.12 Miscellaneous Requirements.** Miscellaneous requirements shall conform to 203-11.7.

## APPENDIX

### SAMPLE ENABLING ORDINANCE

*(For use by municipalities in adopting Standard Specifications For Public Works Construction by reference)*

Ordinance No \_\_\_\_\_

An ordinance regulating materials of construction and their use in the erection, installation, alteration, repair, removal, conversion, demolition, and construction of public works improvements in the City (County) of .....; providing for the administration of contracts as well as permits issued in connection with such improvements; and repealing all ordinances and parts of ordinances in conflict therewith.

The People of the City (County) of.....do ordain as follows:

Except as may otherwise be provided herein, the provisions of the 2003 edition of the "Standard Specifications for Public Works Construction," prepared and promulgated by the Southern California Chapter of the American Public Works Association and the Southern California Districts of the Associated General Contractors of California, are adopted and applicable to all public works construction undertaken after the effective date of this ordinance.

## REFERENCE DOCUMENTS

Following is a list of documents referred to in this book, arranged alphabetically. For convenience of all readers of the specification book, its publisher, BNi Publications, Inc., offers most of these documents for sale at its bookstore, located at 1612 S. Clementine St., Anaheim, California 92802, for information, call (714) 517-0970.

**AMERICAN FOREST AND PAPER ASSOCIATION.** 1111 19<sup>th</sup> St., N.W. Suite 800, Washington, D.C. 20036.

**AMERICAN NATIONAL STANDARDS INSTITUTE.** (Formally the United States of American Standards Institute, also the American Standards Association). Published by the American National Standards Institute, 25 West 43<sup>rd</sup> St., 4<sup>th</sup> Floor, New York, New York 10036.

**AMERICAN PETROLEUM INSTITUTE STANDARDS.** Published by the American Petroleum Institute, 1220 L St., N.W. Washington, D.C. 20005.

- AMERICAN SOCIETY FOR TESTING AND MATERIALS.** Standards and Metric Practice Guide E380. Published by the American Society for Testing and Materials, 100 Barr Harbor Dr., Conshohocken, PA 19428-2959.
- AMERICAN WATER WORKS ASSOCIATION STANDARDS (AWWA).** Published by the American Water Works Association, 6666 W. Quincy Avenue, Denver, CO 80235.
- AMERICAN WELDING SOCIETY (AWS) STANDARDS AND SPECIFICATIONS.** Published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.
- AMERICAN WOOD PRESERVERS ASSOCIATION (AWPA) BOOK OF STANDARDS.** Published by the American Wood Preservers Association, 2345 Grand Blvd Ste 500, Kansas City, MO 64108-2625.
- ASPHALT PROTECTIVE COATING FOR PIPELINES.** Published by the Asphalt Institute, Research Park Dr., P.O. Box 14052, Lexington, KY 40512-4052.
- FEDERAL SPECIFICATIONS.** Available through the Federal Supply Service Bureau, Specification Section, 470 East L'Enfant Plaza S.W., Suite 8100, Washington, D.C. 20407.
- MANUAL OF STANDARD PRACTICE.** Published by the Concrete Reinforcing Steel Institute, 933 N. Plum Grove Rd., Schaumburg, IL 60173-4758.
- MANUAL OF STEEL CONSTRUCTION (AISC).** Published by the American Institute of Steel Construction, Incorporated, One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001.
- MANUAL OF WARNING SIGNS LIGHTS, AND DEVICES.**
- MATERIALS MANUAL, VOLUMES I, II, & III TESTING AND CONTROL PROCEDURES.**
- MILITARY SPECIFICATIONS.** Available through the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.
- NATIONAL ELECTRIC CODE.** Published by the National Fire Protection Association, One Batterymarch Park, Quincy, MA 02269.
- NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION STANDARDS.** Published by the National Electrical Manufacturers Association, 1300 N 17<sup>th</sup> St. Ste 1847, Rosslyn, VA 22209.
- PLACING REINFORCING BARS.** (Formerly Recommended Practice for Placing Reinforcing Bars). Published by the Concrete Reinforcing Steel Institute, 933 N. Plum Grove Road, Schaumburg, IL 60173-4758.
- PROTECTIVE COATINGS.**
- RULES FOR OVERHEAD ELECTRIC LINE CONSTRUCTION- GENERAL ORDER NO. 95.** Published by the State of California, Public Utilities Commission, 505 Van Ness Ave, San Francisco, CA 94102.
- SAFETY ORDERS-BASIC ELECTRICAL REGULATIONS, TITLE 24, CONSTRUCTION, GENERAL INDUSTRY, TUNNEL.** Published by the Office of Procurement, Publications Section<sup>1</sup>, P.O. Box 1015, North Highlands, California 95660.
- SOFTWOOD PLYWOOD, CONSTRUCTION & INDUSTRIAL.** (Formerly Douglas Fir Plywood, Construction & Industry). Published by the U.S. Department of Commerce, Business and Defense Services Administration, Office of Technical Services, Commodity Standards Division; Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
- SPECIFICATIONS FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS.** Published by the American Institute of Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.
- SPECIFICATION FOR WELDED HIGHWAY AND RAILWAY BRIDGES.** Published by the American Welding Society, 550 N.W. LeJeune Rd., Miami, FL 33126.

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**STANDARD SPECIFICATIONS.**

**STANDARD SPECIFICATIONS FOR GRADES OF CALIFORNIA REDWOOD LUMBER.** Published by the California Redwood Association, 405 Enfrente Dr., Suite 200, Novato, CA 94949.

**STANDARD SPECIFICATIONS FOR HIGHWAYS MATERIALS AND METHODS OF SAMPLING AND TESTING.** Published by the American Association of State Highway and Transportation Officials, PO Box 96716, Washington DC, 20090-6716.

**STANDARDS FOR INSULATED POWER CABLE.** Published by the Insulated Cable Engineers Association, P.O. Box 1568, Carrollton, GA 30112.

**STANDARDS OF OPERATIONS OF TRUCK MIXERS AND AGITATORS.** (National Ready Mixed Concrete Association). Published by the National Ready Mixed Concrete Association, 900 Spring Street, Silver Spring, MD 20910.

**TRUCK MIXER & AGITATORS STANDARDS.** (Truck Mixer Manufacturers Bureau). Published by the Truck Mixer Manufacturers Bureau, 900 Spring Street, Silver Spring, MD 20910.

**UNDERWRITERS LABORATORY, INC. LISTINGS AND STANDARDS.** Published by the Underwriters Laboratory, Inc., 333 Pfingsten Rd., Northbrook, IL 60062-2096.

**U.S. CORPS OF ENGINEERS TEST METHODS.** Available through the Corps of Engineers, U.S. Army, Waterways Experimental Stations, 3909 Halls Ferry Rd., Vicksburg, MS 39180-6199.

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FOR CONTRACT NO.: 07-2159C4

# INFORMATION HANDOUT

## MATERIALS INFORMATION

2007 Supplement to  
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For  
Public Works Construction  
(SSPWC)  
2006 Edition

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— PAGE 4 —

REVISE OR ADD THE FOLLOWING COMMON USAGE TERMS IN 1-3.2 TO READ

BMPs.....	Best Management Practices
CCFRPM.....	Centrifugally Cast Fiberglass Reinforced Plastic Mortar
CIPCP .....	Cast-in-place concrete pipe
CIPP .....	Cured-in-place pipe
HDPE .....	High Density Polyethylene
LED .....	Light emitting diode
MUTCD .....	Manual on Uniform Traffic Control Devices
PAV.....	Pressure Aging Vessel
PG .....	Performance Graded
RTFO .....	Rolling Thin Film Oven
SWPPP .....	Stormwater Pollution Prevention Plan
VTCSH.....	Vehicle Traffic Controls Signal Heads

— PAGE 6 —

ADD THE FOLLOWING INSTITUTIONAL ABBREVIATIONS TO 1-3.3

EIA .....	Electronic Industries Association
ETL .....	Electrical Testing Laboratories
FCC .....	Federal Communications Commission
IEEE .....	Institute of Electrical and Electronics Engineers
IMSA.....	International Municipal Signal Association
ITE.....	Institute of Traffic Engineers
REA.....	Rural Electrification Administration

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REVISE 7-1 TO READ:

**7-1 THE CONTRACTOR'S EQUIPMENT AND FACILITIES.**

**7-1.1 General.** The Contractor shall furnish and maintain in good condition all equipment and facilities as required for the proper execution and inspection of the Work

The Contractor shall provide and maintain enclosed toilets for the use of employees engaged in the Work. These accommodations shall be maintained in a neat and sanitary condition, and regularly pumped out.

**7-1.2 Temporary Utility Services.** The Contractor shall, at its own expense, make all arrangements necessary for the provision of temporary utility services necessary for its own use during performance of the Work.

The Contractor shall not draw water from any fire hydrant (except to extinguish a fire), without obtaining permission from the water utility owner.

**7-1.3 Crushing and Screening Operations.** Unless otherwise specified in the Special Provisions, the establishment and operation of portable screens and crushers will not be allowed on or adjacent to the Work site.

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REVISE 7-8 TO READ:

## **7-8 WORK SITE MAINTENANCE.**

**7-8.1 General.** Throughout all phases of construction, including suspension of the Work, and until acceptance per 6-8, the Contractor shall keep the Work site clean and free from rubbish and debris. Rubbish and debris collected on the Work site shall only be stored in roll-off, enclosed containers prior to disposal. Stockpiles of such will not be allowed.

When required by the Special Provisions, the Contractor shall provide a self-loading motorized street sweeper equipped with a functional water spray system. The sweeper shall clean all paved areas within the Work site and all paved haul routes at least once each working day

The Contractor shall ensure there is no spillage along haul routes. Any such spillage shall be removed immediately and the area cleaned.

Should the Contractor fail to keep the Work site free from rubbish and debris, the Engineer may suspend the Work per 6-3 until the condition is corrected.

**7-8.2 Air Pollution Control.** The Contractor shall not discharge smoke, dust, equipment exhaust, or any other air contaminants into the atmosphere in such quantity as will violate any Federal, State, or local regulations. The Contractor shall also abate dust nuisance by cleaning, sweeping and spraying with water, or other means as necessary. The use of water shall conform to 7-8.6.

**7-8.3 Noise Control.** Noise generated from the Contractor's operations shall be controlled as specified in the Special Provisions.

### **7-8.4 Storage of Equipment and Materials.**

**7-8.4.1 General.** Materials and equipment shall be removed from the Work site as soon as they are no longer necessary. Before inspection by the Engineer for acceptance, the Work site shall be cleared of equipment, unused materials, and rubbish so as to present a satisfactory clean and neat appearance.

Excess excavated material shall be removed from the Work site immediately unless otherwise specified in the Special Provisions.

Forms and form lumber shall be removed from the Work site as soon as practicable after stripping.

**7-8.4.2 Storage in Public Streets.** Construction materials and equipment shall not be stored in streets, roads, or highways for more than 5 days after unloading unless otherwise specified in the Special Provisions or approved by the Engineer. All materials or equipment not installed or used in construction within 5 days after unloading shall be stored at a location approved by the Engineer.

Excavated material, except that which is to be used as backfill in the adjacent trench, shall not be stored in public streets unless otherwise specified in the Special Provisions or approved by the Engineer. Immediately after placing backfill, all excess material shall be removed from the Work site.

### 7-8.5 Sanitary Sewers.

**7-8.5.1 General.** The flow of sewage shall not be interrupted. Should the Contractor disrupt the operation of existing sanitary sewer facilities, or should disruption be necessary for performance of the Work, the Contractor shall bypass the sewage flow around the Work. Sewage shall be conveyed in closed conduits and disposed of in a sanitary sewer system. Sewage shall not be permitted to flow in trenches nor be covered by backfill.

Whenever sewage bypass and pumping is required by the Plans or Specifications, or the Contractor so elects to perform, the Contractor shall submit per 2-5.3 a working drawing conforming to 7-8.5.2 detailing its proposed plan of sewage bypass and pumping.

**7-8.5.2 Sewage Bypass and Pumping Plan.** The plan shall indicate the locations and capacities of all pumps, sumps, suction and discharge lines. Equipment and piping shall be sized to handle the peak flow of the section of sewer line to be bypassed and pumped. Equipment and piping shall conform to 7-10, the Plans, and the Special Provisions. Bypass piping, when crossing areas subject to traffic loads, shall be constructed in trenches with adequate cover and otherwise protected from damage due to traffic. Lay-flat hose or aluminum piping with an adequate casing and/or traffic plates may be allowed if so approved by the Engineer. Bypass pump suction and discharge lines that extend into manholes shall be rigid hose or hard pipe. Lay flat hose will not be allowed to extend into manholes. The Contractor shall provide a backup bypass pumping system in case of malfunction. The backup bypass system shall provide 100 percent standby capability, and be in place and ready for immediate use. Each standby pump shall be a complete unit with its own suction and discharge piping. In addition to the backup system, the Contractor shall furnish and operate vacuum trucks when required by the Plans or Special Provisions.

**7-8.5.3 Spill Prevention and Emergency Response Plan.** The Contractor shall prepare and submit per 2-5.3 a spill prevention and emergency response plan. The plan shall address implementation of measures to prevent sewage spills, procedures for spill control and containment, notifications, emergency response, cleanup, and spill and damage reporting.

The plan shall account for all storm drain systems and water courses within the vicinity of the Work which could be affected by a sewage spill. Catch basins that could receive spilled sewage shall be identified. Unless otherwise specified in the Special Provisions, these catch basins shall be sealed prior to operating the bypass and pumping system. The Contractor shall remove all material used to seal the catch basins when the bypass and pumping system operations are complete.

The Contractor shall be fully responsible for containing any sewage spillage, preventing any sewage from reaching a watercourse, recovery and legal disposal of any spilled sewage, any fines or penalties associated with the sewage spill imposed upon by the Agency and/or the Contractor by jurisdictional regulatory agencies, and any other expenses or liabilities related to the sewage spill.

### 7-8.6 Water Pollution Control.

**7-8.6.1 General.** The Contractor shall conform to all applicable local, state and Federal regulations and laws pertaining to water pollution control. The Contractor shall conduct and schedule its operations, and follow and implement best management practices in such a manner as to prevent water pollution. The Contractor shall also conform to the following requirements:

- 1) Sediments shall not be discharged to a storm drain system or receiving waters.
- 2) Sediments generated on the Work site shall be contained on the Work site using appropriate BMPs.
- 3) No construction-related materials, waste, spill, or residue shall be discharged from the Work site to streets, drainage facilities, receiving waters, or adjacent property by wind or runoff.
- 4) Non-storm water runoff from equipment, vehicle washing, or any other activity shall be contained within the Work site using appropriate BMPs.
- 5) Erosion shall be prevented. Erosion susceptible slopes shall be covered, planted or otherwise protected in a way that prevents discharge from the Work site.

**7-8.6.2 Best Management Practices(BMPs).** The Contractor shall implement and maintain such BMPs as are relevant to the Work, and as are specifically required by the Plans or Special Provisions.

The Contractor shall be responsible throughout the duration of the Contract for installing, constructing, inspecting, maintaining, removing and disposing of BMPs for wind erosion control, tracking control, erosion and sediment control, non-storm water control, and waste management and materials pollution control. Unless otherwise directed by the Engineer, the Contractor shall be responsible for BMP implementation and maintenance throughout any temporary suspension of the Work.

**7-8.6.3 Storm Water Pollution Prevention Plan(SWPPP).** When so specified in the Special Provisions, or if so required by a jurisdictional regulatory agency, the Contractor shall prepare and submit per 2-5.3 a storm water pollution prevention plan. The SWPPP shall conform to the requirements specified in the Special Provisions and those of the jurisdictional regulatory agency. The Notice of Intent will be filed by the Agency.

**7-8.6.4 Dewatering.** Dewatering shall be performed by the Contractor when specifically required by the Plans or Specifications, and as necessary for construction of the Work. Dewatering shall be performed in conformance with all applicable local, state and Federal laws and permits issued by jurisdictional regulatory agencies. Permits necessary for treatment and disposal of accumulated water shall be obtained by the Contractor or the Agency as specified in the Special Provisions. Accumulated water shall be treated prior to disposal if so specified in the Special Provisions or required by a permit. The Contractor shall submit a working drawing and related supporting information per 2-5.3 detailing its proposed plan and methodology of dewatering and treatment and disposal of accumulated water.

The plan shall identify the location, type and size of dewatering devices and related equipment, the size and type of materials composing the collection system, the size and type of equipment to be used to retain and, if required, treat accumulated water, and the proposed disposal locations. If the proposed disposal location is a sanitary sewer, the Contractor shall submit to the Engineer written evidence of permission from the owner. If the proposed disposal location is a storm drain system or receiving body of water, the Contractor shall submit written evidence of permission from the owner of the storm drain

## 2007 Supplement to "Greenbook"

system and, if not obtained by the Agency, original signed permits from jurisdictional regulatory agencies or written evidence that such permits are not required.

**7-8.6.5 Payment.** Unless otherwise specified in the Special Provisions, payment for implementation and maintenance of BMPs shall be considered as included in the Contract Unit Price for each item in the Bid.

Payment for dewatering shall be as specified in the Special Provisions.

— PAGE 32 —

DELETE 7-10.2 AND REPLACE WITH:

**7-10.2 (Not Used)**

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ADD 200-2.2.3 TO READ:

**200-2.2.3 Quality Requirements.** The material shall conform to the following:

**TABLE 200-2.2.3 (A)**

Tests	Test Method No.	Requirements
R-value <sup>1</sup>	Calif. 301	80 Minimum
Sand Equivalent	Calif. 217	50 Minimum
Percentage Wear	ASTM C 131	
100 revolutions		15 Maximum
500 revolutions		52 Maximum
Specific Gravity (Bulk saturated surface dry)	ASTM C 127	2.58 Minimum <sup>2</sup>

1. The R-value requirement will be waived, provided the material has an SE of 55 or more.

2. Not more than 15 percent by weight shall be particles with a bulk specific gravity below 2.50.

The Engineer may waive percentage wear and specific gravity requirements, provided that the material has a minimum durability of 40 in accordance with Calif. Test 229.

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REVISE 201-1.2.5 TO READ:

**201-1.2.5 Fly Ash.** Fly ash is specified in alternate class and special exposure mixes. Fly ash may be used in any other mix when approved by the Engineer. The amount of fly ash and portland cement used shall be based upon trial batches in accordance with 201-1.1.4. Fly ash shall not be used with Type IP (MS) or Type III portland cement.

Class C fly ash shall not be used where sulfate resistant concrete is required. Except for special exposure mixes, whenever Type V portland cement is specified Type II portland cement and Class F fly ash may be used or Class F fly ash may be used as an addition to Type V portland cement.

The Contractor shall furnish a Certificate of Compliance conforming to 4-1.5 as specified in 2-5.3. The Certificate of Compliance shall be signed by the supplier identifying the type of fly ash and stating that the fly

ash complies with ASTM C 618 and these Specifications. Supporting test data shall be furnished when requested by the Engineer. All testing and sampling procedures shall conform to ASTM C 311.

Separate silo storage facilities shall be provided. Suitable facilities shall be provided to discharge the fly ash into the cement hopper in accordance with 201-1.3.1. Fly ash shall be stored in such a manner as to permit ready access for the purpose of inspection and sampling and be suitably protected against contamination or moisture. Should any fly ash show evidence of contamination or be otherwise unsuitable, the Engineer may reject it and require that it be removed from the site.

All fly ash used in concrete for any individual structure shall be from the same source and of the same class in combination with the same source and type of portland cement, unless otherwise approved by the Engineer.

(a) **Class F Fly Ash.** Class F fly ash shall conform to ASTM C 618 and the following:

Loss on ignition	4% maximum
SO <sub>3</sub> content	3% maximum
Moisture content	1% maximum

When sulfate resistant or special exposure concrete is specified, test results shall be submitted to the Engineer as specified in 2-5.3. The test result shall show that the fly ash to be used is effective in contributing to sulfate resistance in conformance with ASTM C 618, Table 3 (optional physical requirements) as tested in accordance with ASTM C 1012. The data submitted shall be less than 6 months old.

Class F fly ash, as a percent by weight of total cementitious material, may exceed 20 percent when approved by the Engineer.

(b) **Class C Fly Ash.** Class C fly ash shall conform to ASTM C 618 and the following:

Loss on ignition	2% maximum
SO <sub>3</sub> content	4% maximum
Moisture content	1% maximum

Class C fly ash, as a percent by weight of total cementitious material, shall not exceed 30 percent, unless otherwise approved by the Engineer.

Class C fly ash shall not be used where sulfate resistant concrete is required.

— PAGE 62 —

REVISE THE FIRST PARAGRAPH OF 201-3.6 TO READ:

**201-3.6 Type "C" Sealant (Asphalt-Latex Emulsion Joint Sealant).** Asphalt-latex emulsion joint sealant shall be designated for mixing and application by hand methods and shall be suitable for use at temperatures above 10°C (50°F). The sealing compound shall be an emulsion consisting of paving asphalt, emulsified with rubber latex in a suitable emulsifying agent. Rubber latex shall be natural rubber or synthetic latex containing approximately 40 percent solids. The resulting emulsion shall consist of a minimum of 55 percent paving asphalt and a minimum of 36 percent rubber latex.

— PAGE 69 —

REVISE 203-1.1 TO READ:

**203-1.1 General.** Paving asphalt shall be steam-refined asphalt produced from crude asphaltic petroleum or a mixture of refined liquid asphalt and refined solid asphalt. It shall be homogeneous and free from water and residues from distillation of coal, coal tar, or paraffin oil.

— PAGE 70 —

REVISE 203-1.2 TO READ:

**203-1.2 Testing Requirements.** Paving asphalt shall be specified by performance grade and shall conform to the requirements in Table 203-1.2 (A).

TABLE 203-1.2 (A)

Grade	AASHTO Test	PG 64-10	PG 64-16	PG 64-28	PG 70-10
<b>Original Binder</b>					
Flash Point, °C, minimum	T48	230	230	230	230
Solubility, %, minimum	T44	99.0	99.0	99.0	99.0
Viscosity, 135°C, Pa·s, maximum <sup>a</sup>	T316	3.0	3.0	3.0	3.0
Dynamic Shear Test Temperature, °C	T315	64	64	64	70
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, minimum	T315	1.00	1.00	1.00	1.00
<b>RTFO Aged Binder (T240)</b>					
Mass Loss, %, maximum	T240	1.00	1.00	1.00	1.00
Dynamic Shear Test Temperature, °C	T315	64	64	64	70
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, minimum	T315	2.20	2.20	2.20	2.20
Ductility, 25°C, 5 cm/min, cm, minimum	T51	75	75	75	75
<b>RTFO and PAV Aged Binder (R28)</b>					
PAV Aging Temperature, °C	R28	100	100	100	110
Dynamic Shear Test Temperature, °C	T315	31 <sup>b</sup>	28 <sup>b</sup>	22 <sup>b</sup>	34 <sup>b</sup>
Dynamic Shear, 10 rad/s, G*•Sinδ, kPa, maximum	T315	5000	5000	5000	5000
Bending Beam Test Temperature, °C	T313	0	-6	-18	0
Creep Stiffness, MPa, maximum	T313	300	300	300	300
m-value, minimum	T313	0.300	0.300	0.300	0.300

<sup>a</sup>This requirement may be waived by the Engineer if the supplier warrants that the paving asphalt can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

<sup>b</sup>If the PAV aged binder exceeds 5000 kPa at the designated test temperature, it will be deemed acceptable if it is less than 5000 kPa when tested at a 3°C higher test temperature.

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REVISE 203-1.3 TO READ:

**203-1.3 Test Reports and Certification.** Paving asphalt shall be supplied by Caltrans or other State Department of Transportation approved vendors or as specified in the Special Provisions. At delivery time, the supplying vendor shall deliver to the purchaser a certified copy of the test report. This report shall indicate the vendor's name, grade of paving asphalt delivered, date and point of delivery, quantity delivered, ticket number, purchase order number, and results of specified tests. The certified test report and the testing required in connection with the report shall be submitted to the Agency in accordance with 2-5.3.4.

Until the certified test report and samples of the material have been reviewed by the Engineer to determine their conformity with the specified requirements, the material to which such report relates and any work in which it may have been incorporated as an integral component, will be only tentatively accepted by the Agency. Final acceptance will be dependent upon the determination by the Engineer that the material involved conforms to the Specifications.

REVISE 203-1.4 TO READ:

**203-1.4 Temperatures.** Paving asphalt shall not be heated during its manufacture, storage, or during construction so as to cause formation of carbonized particles. At no time shall the temperature be higher than 5°C (10°F) below the actual flash point of the paving asphalt, nor shall it be raised above 190°C (375°F) after loading into a tank car or truck for transport.

Unless otherwise specified in the Special Provisions, the various grades of paving asphalt shall be applied within the temperature range indicated in Table 203-1.4 (A).

TABLE 203-1.4 (A)

ASPHALT GRADE	PLANT MIXING TEMPERATURE °C (°F)		DISTRIBUTION APPLICATION TEMPERATURE °C (°F)	
	Minimum	Maximum	Minimum	Maximum
PG 70-10	150 (300)	175 (350)	140 (285)	175 (350)
PG 64-28	135 (275)	160 (325)	140 (285)	175 (350)
PG 64-16	135 (275)	160 (325)	140 (285)	175 (350)
PG 64-10	135 (275)	160 (325)	140 (285)	175 (350)

Paving asphalt shall be heated in such a manner that no steam or hot oils will be introduced into the paving asphalt during heating. The Contractor shall furnish and keep on-site an accurate thermometer suitable for determining the temperature of the paving asphalt.

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REVISE 203-1.5 TO READ:

**203-1.5 Distributing Equipment.** Distributing equipment shall conform to 203-2.5.

## — PAGE 71 —

REVISE 203-1.6 TO READ:

**203-1.6 Measurement and Payment.** For all volumetric quantities to be paid for at a Contract Unit Price, the unit of measurement shall be the liter (U.S. gallon) at a temperature of 15°C (60°F).

In converting weight to volume, computations shall be based on Table 203-1.6 (A).

TABLE 203-1.6 (A)

Grade of Material	Liters Per Tonne At 15°C (Gallons Per Ton At 60°F)	Grams Per Liter At 15°C (Lbs. Per Gallon At 60°F)
PG 70-10	981 (235)	1020 (8.51)
PG 64-28	981 (235)	1020 (8.51)
PG 64-16	981 (235)	1020 (8.51)
PG 64-10	981 (235)	1020 (8.51)

## — PAGE 80 —

REVISE 203-6.1 TO READ:

**203-6.1 General.** Asphalt concrete shall be the product of mixing mineral aggregate and up to 15 percent reclaimed asphalt pavement (RAP) with paving asphalt conforming to 203-1 at a central mixing plant. RAP shall conform to 203-7.2.2, except the viscosity of RAP asphalt recovered in accordance with ASTM D 1856 (Absorption Recovery Method) will not be required. RAP asphalt content may be determined in accordance with Calif. Test 382, except the aggregate correction factor shall not be applied.

Asphalt concrete will be designated by class and grade i.e., "C2-PG 64-10". Asphalt concrete containing up to 15 percent RAP shall be identified by adding the suffix "RAP" to the class and grade, i.e., "C2-PG 64-10 RAP".

## — PAGE 85 —

REVISE THE FIRST LINE OF 203-6.7.1 TO READ:

**203-6.7.1 General.** All aggregates, binder, and RAP, where applicable, shall be mixed in a

REVISE THE SECOND PARAGRAPH OF 203-6.7.1 TO READ:

Uniformity of distribution of binder shall be determined by an extraction test made in accordance with any of the following test methods or other published test methods approved by the Engineer:

ASTM D 2172

California Test Method 382

ASTM D 4125

## — PAGE 87 —

REVISE 203-7.1 TO READ:

**203-7.1 General.** Recycled Asphalt Concrete (RAC) shall be the product of mixing reclaimed asphalt pavement, virgin aggregates and paving asphalt and/or recycling agent.

RAC will be designated by class and grade, i.e., "C2-PG 64-10-RAC." The end product shall meet both the gradation and asphalt grade specified.

REVISE THE SECOND PARAGRAPH OF 203-7.2.2 TO READ:

The RAC supplier shall perform sand-equivalent tests on the unextracted RAP, and tests for RAP asphalt content, RAP asphalt viscosity or performance grade, and gradation of RAP aggregates on solvent extracted samples of RAP taken from stockpiles. Solvent extractions shall be performed in accordance with ASTM D 2172 and the RAP asphalt shall be recovered in accordance with ASTM D 1856 (Abson Recovery Method). The minimum sand-equivalent value of the unextracted RAP shall be 80, when determined in accordance with California Test 217.

REVISE THE LAST PARAGRAPH OF 203-7.2.3 TO READ:

The test results of the RAC binder shall meet the RTFO and PAV test requirements in Table 203-1.2(A) for the PG grade specified.

## — PAGE 89 —

REVISE THE THIRD PARAGRAPH OF 203-7.3.2 TO READ:

When the amount of RAP to be added is over 15 percent of the total mix, a job mix formula, supporting test data, and blending charts shall be submitted to the Engineer for approval in accordance with 2-5.3. Blending charts shall be used to determine the grade of new paving asphalt. The supporting test data for RAC shall include the result for stability, swell and moisture vapor susceptibility. These tests are in addition to the tests for the RAP stockpile specified in 203-7.2.2.

## — PAGE 94 —

REVISE 203-10.2.1 TO READ:

**203-10.2.1 Paving Asphalt.** Paving asphalt shall be PG 64-10 conforming to 203-1, or as specified in the Special Provisions.

## — PAGE 95 —

REVISE THE FIRST PARAGRAPH OF 203-10.2.4 TO READ:

**203-10.2.4 Composition and Grading.** The class shall be C2 unless otherwise specified on the Plans or in the Special Provisions. Where Alternate Rock Products-Type S, Section 400, are specified, the class and grade shall be Type III-C3-PG 64-10 or as specified in the Special Provisions.

REVISE 203-11.2.1 TO READ:

**203-11.2.1 Paving Asphalt.** Paving asphalt used for asphalt-rubber shall be PG 64-16 and shall be modified with an asphalt modifier. Performance Graded paving asphalts other than PG 64-16 may be used if so specified in the Special Provisions.

## — PAGE 103 —

REVISE THE LAST PARAGRAPH OF 203-12.2.2 TO READ:

Screenings shall be medium 9.5mm (3/8 inch) unless otherwise specified. Screenings shall be preheated to between 127°C (260°F) to 163°C (325°F) and adequately coated with 0.70 percent to 1 percent PG 64-10 paving asphalt at a central mixing plant to prevent free dust. The exact amount of paving asphalt shall be recommended by the Contractor and approved by the Engineer. Screenings shall conform to the requirements of Table 200-1.2 (B).

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REVISE 209 TO READ:

## SECTION 209 – STREET LIGHTING AND TRAFFIC SIGNAL

**209-1 GENERAL.** The following material specifications set forth the requirements for components installed in conjunction with the construction of street lighting and traffic signal systems.

**209-2 REFERENCE SPECIFICATIONS.** In addition to the requirements of the Plans, Specifications, and Special Provisions, all of the components shall conform, where applicable, to the current following regulations and codes:

- a. NEMA
- b. UL
- c. EIA
- d. REA
- e. Aluminum Association Publication 30
- f. ANSI
- g. AASHTO "Standard Specification for Structural Support for Highway Signs, Luminaires and Traffic Signals"
- h. ETL
- i. IEEE
- j. MIL SPEC
- k. AWS D1.1 "Structural Welding Code"
- l. FCC.

### 209-3 COMPONENTS FOR STREET LIGHTING AND TRAFFIC SIGNAL SYSTEMS.

**209-3.1 General.** The following material Specifications set forth the requirements for components that are common to street lighting and traffic signal systems. All materials furnished and installed shall be new, except materials specified on the Plans or in the Special Provisions to be reused.

**209-3.2 Anchor Bolts, Nuts, and Washers.** Anchor bolts shall conform to ASTM A307 and shall be tested in accordance with 206-1.1.3. Each anchor bolt shall be round, have a minimum of

200mm (8 inches) of thread, and be provided with 2 nuts and 2 flat 6mm (1/4 inch) thick washers.

Nuts shall be symmetrically formed with the hole centered and at right angles to the face. Nuts shall be tapped to fit a corresponding thread on the anchor bolt such that the nut can be run the entire length of the thread by the fingers without undue forcing, and without play or rocking.

Anchor bolts, nuts, and washers shall be galvanized by the hot-dip process conforming to 210-3, or cadmium plated with Type NS coating conforming to ASTM A165.

### 209-3.3. Standards.

**209-3.3.1 General.** Standards shall have an aluminum identification plate attached with stainless steel rivets or screws, as specified on the Plans. Each Standard shall have a handhole in the base and a handhole cover. The handholes shall conform to the details shown on the Plans or Standard Plans.

The handhole cover shall be securely attached to the Standard with tamper-resistant hardware or as detailed on the Plans or specified in the Special Provisions.

**209-3.3.2 Straightness.** For street lighting and pedestrian Standards the maximum deviation shall not exceed the tolerance specified in Table 209-3.3.2(A) when measured with the Standard in the vertical position. For traffic signal standards the maximum deviation shall not exceed the tolerance specified in Table 209-3.3.2(A) when measured with the Standard in the horizontal position.

**TABLE 209-3.3.2(A)**

Length of Standard – Excluding Base		Maximum Allowable Deviation From String Line <sup>1</sup>
Over	Equal to or Less	
---	6.4 m (21 feet)	12.7 mm (1/2 inch)
6.4 m (21 feet)	7.92 m (26 feet)	19.04 mm (3/4 inch)
7.92 m (25 feet)	10.67 m (35 feet)	25.40 mm (1 inch)
10.67 m (35 feet)	12.19 m (40 feet)	31.75 mm (1 ¼ inch)
12.19 m (40 feet)	---	As specified in the Special Provisions.

1. The maximum deviation shall be measured from a string line on the face of the Standard, in a plane passing through the longitudinal axis.

Short crooks in the Standard shall not exceed 0.35mm (1/4 inch) deviation from the centerline of the Standard for each 1.52m (5 feet) of length.

Offsets or jogs due to mold extensions or joints shall not exceed 1.59mm (1/16 inch) in thickness along the surface of the Standard.

### 209-3.3.3 Metal Standards.

**209-3.3.3.1 General.** The top of each Standard shall be equipped with an ornamental cap which shall be securely held in place by a 19mm (3/4 inch) diameter hex head machine bolt. Provisions shall be made for substituting 19mm (3/4 inch) diameter steel insulator pin. The cap and cap support surface shall have sufficient strength to transfer to the Standard, from a point 127mm (5 inches) above the top of the cap, a 4,226 N (950 lbs) horizontal loading.

Metal standards shall withstand, without permanent deformation, a maximum horizontal load of 4,226 N (950 lbs) applied to the center of the cap that is attached to the Standard. In addition, metal standards shall withstand, without exceeding a deflection of 59mm (2-5/16 inches) a normal horizontal load of 1,646 N (370 lbs) applied to the cap that is attached to the top of the Standard.

Exposed edges of plates that comprise the base assembly shall be finished smooth. Exposed corners shall be rounded unless otherwise shown on the Plans. Slots or drilled holes shall have a tolerance of 0 to + 3.18mm (1/8 inch).

Metal standards shall be equipped with anchor bolt covers made of metal of the same type as that used for the shafts or as specified on the Plans or Standard Plans. Anchor bolt covers shall be equipped with all necessary fittings and hardware for securing the bolt covers to the Standard.

**209-3.3.3.2 Steel Standards.** Unless otherwise specified in the Special Provisions, steel standards shall be fabricated from sheet steel of weldable grade having minimum yield strength, after fabrication, of 276 MPa (40,200 psi). When a single-ply 8 mm (5/16 inch) thick steel standard is specified, a 2-ply steel standard with an equivalent section modulus may be substituted unless otherwise specified in the

Special Provisions. Certified test reports that verify conformance to this minimum yield strength shall be submitted to the Engineer in accordance with 2-5.3.4.

Steel standards may be fabricated from full length sheets or shorter sections. Each section shall be fabricated from not more than 2 pieces of sheet steel. Where 2 pieces are used, the longitudinal welded seams shall be directly opposite each other. When the sections are butt welded together, the longitudinal welded seams on adjacent sections shall be placed to form continuous straight seams from the base to the top. In addition, butt welded sections shall be strengthened by inserting a welded sleeve at each joint. The sleeve shall be fabricated from steel 3.43 mm (1/8 inch) nominal thickness or thicker of the same composition as the steel used in the Standard. The sleeve shall have a minimum length of 2.54 cm (1 inch). The sleeve shall be centered at the joint and have the same taper as the Standard such that the outside of the sleeve is in full contact throughout its length and circumference. The weld metal at the transverse joint shall extend to the sleeve. No transverse joint shall occur within 7.62 cm (3 inches) of mast arm fittings.

All welds shall be continuous and conform to the requirements of 209-2. Welds joining the shafts of Standards to their base plates shall be as shown on the Plans or Standard Plans. However, alternative weld joint details may be approved by the Engineer. Approval of alternative weld joint details will be contingent upon the proposed weld joint passing both weld procedure and nondestructive testing as deemed necessary by the Engineer. All costs of the weld procedure and nondestructive testing shall be borne by the Contractor.

Longitudinal welds in steel tubular sections will be tested by the Agency in conformance with the requirements in California Test 664. The sampling frequency shall be as directed by the Engineer. Welds may be made by the electric resistance welding process. Exposed welds shall be ground flush with the base metal.

Steel standards shall be galvanized by the hot-dip process conforming to 210-3, or cadmium plated with Type NS coating conforming to ASTM A165. If specified in the Special Provisions or shown on the Plans, steel standards shall be painted in accordance with 210-1.

**209-3.3.3.3 Aluminum Standards.** Aluminum standards shall be fabricated from seamless tubing conforming to "6063-T6 wrought aluminum alloy of the Specifications of the Aluminum Association" or the specifications in Table 209-3.3.3.3(A).

**TABLE 209-3.3.3.3(A)**

ITEM	ASTM SPECIFICATION NO.
Castings	B26/B26M
Luminaire Arm	B490-90a
Spun Shaft	B241/B241M
Square Extruded Shaft	B429

The wall thickness of the shaft shall be a minimum of 6mm (1/4 inch). Aluminum standards shall be supplied with a mill finish, and be uniform and commercially sound in conformance with ASTM B209M.

**209-3.3.4 Fiberglass Standards.** Fiberglass standards shall consist of fiberglass-reinforced thermosetting plastic poles. Fiberglass standards shall be hollow, tapered or with tapered sections, be non-conductive and chemically inert. Fiberglass standards shall be in conformance with AASHTO and ANSI specifications in 209-2. The Contractor shall submit to the Engineer a Certificate of Compliance from the manufacturer in accordance with 2-5.3. The certificate shall include a copy of all applicable test reports. The test reports shall

be signed and stamped by the licensed engineer that supervised the tests. The certificate shall also comply with 4-1.5 and certify that the Standards were manufactured in accordance with an Agency-approved testing and quality control program.

Fiberglass standards shall be constructed of continuous fiberglass filaments combined with thermosetting polyester and ultraviolet-resistant resin. The fiberglass and resin ratio shall contain at least 65 percent glass and 35 percent resin by weight. The resin shall be pigmented as required by the Standard Plans or Special Provisions and be of uniform color throughout the entire body of the Standard. The glass filament shall be helically wound under tension at angles to provide axial strength. The finish of shall be smooth.

Fiberglass standards shall be flame resistant in accordance with ASTM D635. In addition fiberglass standards shall be reinforced in areas of handholes, conduit entrance openings, and mast arm connections.

Fiberglass standards shall be direct burial or have an anchor base as shown on the Plans or the Standard Plans. The base shall be bonded to the pole with an adhesive recommended by the manufacturer, and coated with an aliphatic-type acrylic-modified polyurethane finish. Each Fiberglass standard shall be equipped with a removable aluminum or galvanized steel pole top cap.

An aliphatic-type acrylic-modified polyurethane coating shall be applied to the exterior of each fiberglass standard. The coating shall be semi-gloss, weather resistant and match the color of the resin specified in the Special Provisions. The coating shall have a minimum of 0.075mm (3 mils) dry film thickness. A one liter (1 quart) can of the coating that matches the specified color shall be furnished as specified in the Special Provisions. The polyurethane coating shall be tested by for adhesion in accordance with the requirements of ASTM D 3359, Method A and shall have a scale rating of 5A. The adhesion testing shall be conducted before and after the accelerated weathering evaluation by the manufacturer. The Contractor shall provide the Engineer with a copy of the test results from the manufacturer in accordance with 2-5.3. The test reports shall be signed and stamped by the licensed engineer that supervised the tests.

Finished surfaces shall be capable of withstanding a minimum of 2,500 hours of accelerated weathering when tested by the Agency, in accordance with the requirements of ASTM G 53. Testing lamps shall be UV-B (313nm wavelength). The testing cycle shall consist of 4 hours of ultraviolet (UV) exposure at 60°C (140°F), followed by 4 hours of condensate exposure at 40°C (100°F). After testing, the finished surface of fiberglass standards shall exhibit the following:

- a) Fiber Exposure – None
- b) Crazeing – None
- c) Checking – None
- d) Chalking – Very slight
- e) Change in color - May dull slightly.

Each fiberglass standard shall be spiral-wrapped in its entirety with a weatherproof wrap for protection during shipping and storage.

**209-3.4 Mast Arms.** Mast arms shall be fabricated from the same material specified for the adjoining Standards, except for fiberglass standards. Mast arms for fiberglass standards shall be fabricated from aluminum. Mast arms shall be fabricated in conformance with 209-2, 209-3.3.3.2 or 209-3.3.3.3 depending on the material the mast arm is fabricated from. Mast arms shall be smoothly curved to the approximate configuration shown on the Plans or Standard Plans. A smooth curving arm is required. Mast arms shall have an aluminum identification plate attached with stainless steel rivets or screws, as specified on the Plans.

Exposed welds, except fillet and fatigue resistant welds on top of the mast arms shall be ground flush with the base metal.

Mast arms shall be furnished complete with all necessary fittings and hardware for attachment of the arm to the adjoining Standard.

### **209-3.5 Conduit.**

**209-3.5.1 General.** Conduit shall be as shown on the Plans or specified in the Special Provisions.

**209-3.5.2 Rigid Metallic Conduit.** Conduit and conduit fittings shall be galvanized by the hot-dip, electrodepositing, or metallizing process in accordance with 210-3. Conduit shall conform to Underwriters' Laboratories, Inc., publication UL 6 for Rigid Metallic Conduit, and shall bear the UL label on each length. The zinc coating shall be tested in conformance with the requirements in ASTM Designation: A 239.

**209-3.5.3 Galvanized Pipe.** Galvanized pipe used as conduit shall conform to the following:

- a) ASTM A53 Grade A.
- b) Only standard lengths shall be supplied to the Work site.
- c) Need not be UL listed.

**209-3.5.4 Rigid Non-Metallic Conduit.** Rigid non-metallic conduit shall conform to the requirements of the UL Standard for Rigid Non-Metallic Conduit, Publication UL 651 (PVC Schedule-80) and UL 651B (HDPE). Rigid non-metallic conduit connections shall be of the solvent weld type.

**209-3.6 Pull Tape or Rope.** Pull tape or rope shall be as specified in the Special Provisions and used to install wires or cables. Pull tape shall consist of a flat, woven, lubricated, soft-fiber polyester tape with a minimum tensile strength of 8,000 N (1,800 lbs.) and shall have a painted sequential measurement marking at least every meter (3 ft.).

Pull rope shall be a 6.25 mm (¼ in.) diameter polyethylene rope with a minimum tensile strength of 8,000 N (1,800 lbs).

**209-3.7 Pull Boxes.** Pull boxes, covers, and extensions shall be approved by the Agency or as shown on the Plans or Standard Plans and/or specified in the Special Provisions.

When a ballast, transformer or other device is to be placed in a non-metallic pull box, the pull box shall be provided with recesses for a hanger.

### **209-3.8 Splice Insulation.**

**209-3.8.1 General.** Splice insulation shall be as specified herein or as specified in the Special Provisions.

**209-3.8.2 Splice Insulation Tape and Pads.** Splice insulation shall consist of layers of vinyl chloride electrical insulating tape, conforming to ASTM D 2301, Type I.

Low-voltage tape shall be UL or ETL listed and shall be the following types:

- a) Self-fusing, oil and flame-resistant, synthetic rubber.
- b) Pressure-sensitive, adhesive, polyvinyl chloride, 0.15 mm minimum thickness.

Tape for insulating splices in high-voltage (over 600 V) circuits shall be designed for use on 5kV circuits and shall be resistant to ozone, corona and water. Insulating pads shall be composed of a laminated 2 mm (1/16 inch) thickness of electrical grade polyvinyl chloride and a 3mm (1/8 inch) thickness of butyl splicing compound with removable liner.

**209-3.8.3 Heat-Shrink Tubing.** Heat-shrink tubing shall be medium or heavy wall thickness, irradiated polyolefin tubing containing an adhesive mastic inner wall. The minimum wall thickness prior to contraction shall be 1 mm (1/32 inch). When heated, the inner wall shall melt and fill all crevices and interstices of the object being covered while the outer wall shrinks to form a waterproof insulation. Each end of the tube or open end of the end cap of heat-shrink tubing shall, after contraction, overlap the conductor insulation at least 38 mm (1 1/2 inches). Heat-shrink tubing shall conform to the requirements of UL 468D and ANSI C119.1 for extruded insulated tubing at 600 V. Heat-shrink tubing shall also meet the following requirements:

- a) **Shrinkage Ratio** – 33 percent, maximum, of supplied diameter when heated to 125°C (257°F) and allowed to cool to 25°C (77°F).
- b) **Dielectric Strength** – 140kV per 10 mm (3/8 in.), minimum.
- c) **Resistivity** –  $10^{13}$  Ω-mm, minimum.
- d) **Tensile Strength** – 14 Mpa (2000 psi), minimum.
- e) **Operating Temperature** – 40°C to 90°C (-40°F to 194°F) [135°C (275°F) Emergency].
- f) **Water Absorption** – 0.5 percent, maximum.

**209-3.9 Bonding and Grounding.** Bonding jumpers shall be copper wire or copper braid of the same cross sectional area as No. 6 AWG conductor for multiple circuit lighting systems and No. 8 AWG conductor or larger for series and all other street lighting and traffic signal systems. The cross sectional area of the jumper shall match the cross sectional area of the conductors in the circuit, or shall be as shown on the Plans or specified in the Special Provisions. Equipment grounding conductors shall be color coded to code requirements or shall be bare.

Bonding bushings to be installed on metal conduit shall be of the galvanized or zinc alloy type.

Ground electrodes shall be one-piece, 2.51 m (99 inches) long galvanized steel rod or pipe no less than 25 mm (1 inch) in diameter, or of copper-coated (minimum thickness of rod coating 0.3 mm (0.01 inch)) steel rod not less than 13 mm in diameter by 2.4 m long (1/2 inch in diameter by 8 feet long).

#### **209-3.10 Service.**

**209-3.10.1 General.** Service conduit shall conform to the requirements of the serving utility and shall not be less than 51 mm (2 inches) in diameter.

Where a kilowatt-hour meter is required, a meter socket with sealing ring, as approved by the serving utility, shall be furnished and installed. Where a meter socket is installed, the meter enclosure shall be provided with factory installed test bypass facilities as required by the serving utility.

Service equipment enclosures shall be galvanized or if so specified on the Plans, Standard Plans or in the Special Provisions, the enclosures shall be provided with a factory applied rust resistant prime coat and finish coat instead of galvanizing.

**209-3.11 Circuit Breakers:** Circuit breakers shall be of the quick-break type and also be capable of either automatic or manual operation. The operating mechanism shall be enclosed and shall be trip-free from the operating handle on overload. Circuit breakers shall be trip-indicating, have the frame size plainly marked, and have the trip rating clearly indicated on the operating handle. Overload tripping breakers shall not be influenced by an ambient temperature range from -18°C (0°F) to 50°C (122°F). Multiple-pole breakers shall be the internal trip type. All circuit breakers shall be listed by UL or ETL.

**209-4 MATERIALS FOR STREET LIGHTING SYSTEMS.****209-4.1 Reinforced Concrete Standards.**

**209-4.1.1 General.** The manufacture of, and all material used in the construction of reinforced concrete standards shall conform to 201-1 and 201-2. Portland cement concrete shall be as specified in the Special Provisions. Shop drawings and a concrete mix design shall be submitted to the Engineer for approval in accordance with 2-5.3.

Reinforced concrete standards shall have a uniform color and surface appearance.

Reinforced concrete standards shall be constructed of pre-stressed, centrifugally spun, exposed aggregate, portland cement concrete. They may have black and white marble aggregate or natural exposed aggregate, and be direct burial or anchor base type. The cross section shall not deviate more than 4.76mm (3/16 inch) from the shape and dimensions shown on the Plans, Standard Plans or approved shop drawings. The length shall not deviate more than 1% of its total length or a maximum of 76.2mm (3 inches) from the dimensions shown on the Plans, Standard Plans or approved shop drawings. Maximum deviation from a stringline at any point shall not exceed 2.5 mm per meter (1/32 inch per foot) of length. Reinforced concrete standards shall be sufficiently straight when in a vertical position such that the maximum deviation from a string line on the face of the Standard in a plane passing through the longitudinal axis shall not exceed the tolerance listed in Table 209-3.3.2(A).

A central opening or duct shall be formed throughout the entire length. The opening or duct shall be 31.8mm (1-1/4 inches) in diameter or as shown on the Standard Plans or approved shop drawings. The opening or duct shall be free from sharp projections or edges which might damage wire or cable. The base shall be cored to the dimensions shown on the Standard Plans or approved shop drawings.

Reinforced concrete standards used with post-top luminaires shall be terminated with a post-top adapter with a tenon as shown on the Plans, Standard Plans or approved shop drawings.

**209-4.1.2 Reinforcement.** Reinforced concrete standards shall be reinforced with at least four prestressed strands. The prestressed steel strand shall consist of an uncoated seven-wire stress relieved strand conforming to 201-2. Each strand shall be mechanically anchored to the base plate or base-reinforcing cage depending on type of base specified. Strands shall be pretensioned to develop the design strength specified in the Special Provisions or on the Standard Plans. However, in no case shall the stress in the strands immediately after transfer exceed 70 percent of the minimum specified ultimate strength of the strands. Deformed bars may be used in addition to the prestressed strands depending on the size and loading.

Longitudinal reinforcing shall be spirally wrapped with 3.18mm (No. 11 GA) or larger steel wire on a variable pitch, dependent upon the loading. The maximum pitch shall not exceed 152mm (6 inches). Transformer bases cast integral with the shaft shall be reinforced with deformed steel bars securely attached to the base anchor lugs or plate and prestressing cables.

Four galvanized deformed bar studs at least 300mm (1 foot.) long shall be extended 25.4mm (1 inch) above the top of the reinforced concrete standard for attachment of a bracket arm or tenon when required. The metal components of the reinforced concrete standard shall conform to the requirements in Table 209-4.1.2(A)

TABLE 209-4.1.2(A)

MATERIAL	ASTM NO.
Prestressed Steel	A 416
Deformed Bar	A615 Grade 40 or Grade 60/A706
Base Plate	A 36
Base Anchor Lugs	A 36

**209-4.1.3 Casting of Concrete Standards.** Reinforced concrete standards shall be cast in rigid steel molds such that the relief in the design of the concrete standard is sharp and distinct. Longitudinal steel reinforcement shall be securely anchored to the top and bottom of the mold plates and shall be placed to provide 19.1mm (3/4 inch) minimum concrete cover except within 610mm (2 feet) of the top where the minimum cover shall be 15.9 mm (5/8 inch).

Reinforced concrete standards shall be cured in accordance with the following phases:

a) Mold Cure:

Reinforced concrete standards shall be cured in their molds until the concrete has attained a set sufficiently hard to prevent deformation or slipping of cable strands.

b) After the mold cure is complete, the remaining cure shall conform to 207-2.7.

After sufficient curing, the entire outside surface shall be blasted to remove cement laitance and develop the surface texture.

**209-4.1.4 Finish of Concrete Standards.** The finish shall be without cracks or crazing, rock pockets or any discoloration or ridges and shall have a uniform surface (without objectionable mold marks) and texture throughout the entire length.

Surface defects extending less than 15.9mm (5/8 inch) in the shell may be repaired without the prior approval of the Engineer. The repair shall be made by a method that will produce a permanent bond and a surface that blends into the color and surface appearance of the remainder. Surface defects extending greater than 15.9 mm (5/8 inch) into the shell shall not be repaired prior to inspection by the Engineer. Reinforced concrete standards containing voids or insufficient cover over prestressing cables, reinforcing steel or a blocked central opening or duct will not be accepted.

**209-4.1.5 Acceptance and Rejection of Concrete Standards.** Reinforced concrete standards shall be labeled or marked in a permanent fashion to indicate the manufacturer, and month and year of fabrication. Markings shall be located within 610mm (2 ft.) of the bottom but not on the hand-hole cover. Markings shall be visible through the handhole opening.

A lot shall be defined as 100 reinforced concrete standards or less of the same design, produced in sequence on consecutive working days, and bearing the specified markings. The standards composing each lot shall be uniform in color and surface appearance. A new lot number shall be assigned if there is any change in the size, type, or spacing of reinforcing or prestressing steel, concrete mix, or curing method. The frequency of sampling and testing shall be as specified in the Special Provisions. The Contractor shall notify the Engineer, in writing, at least five days prior to any contemplated change in supplier or source of raw materials, and shall obtain approval of any changes before the standards are delivered to the Agency.

**209-4.2 Wire/Conductors.**

**209-4.2.1 General.** Wire shall be a single strand of drawn metal that may or may not be insulated. Conductor shall be a single (solid) or multiple (stranded) strands metal that are insulated. Cable shall be multiple wires or conductors that are insulated and enclosed in an insulating cable jacket. Copper wire shall conform to ASTM B 3 and B 8. Wire sizes shall be based on the American Wire Gage (AWG). The wire diameter shall not be less than 98 percent of the specified AWG diameter.

All conductors shall have clear, distinctive and permanent markings on the outer surface throughout the entire length showing the manufacturer's name or trademark, insulation type letter designation, wire size, and voltage rating.

Conductor insulation shall be a solid color or basic colors with a permanent colored stripe unless otherwise specified in the Special Provisions. Solid or basic colors shall be homogenous throughout the full depth of insulation except for the clear nylon layer, if present.

**209-4.2.2 Series Circuits Conductors.** Wire for series street lighting systems shall be No. 8 solid copper wire. The wire shall be insulated with a 2.80mm (0.110 inch) thickness of black polyethylene insulation per Standard S-61-402 of the Insulated Power Cable Engineers Association, and designated for operation at 5,000 volts. The Contractor shall submit a Certificate of Compliance in accordance with 2-5.3.3 and 4-1.5, for all 5,000-volt (6.6 Amp.) series lighting conductors.

Where isolating transformers or external (remote) ballasts are used, the secondary wires, in the Standard, from the transformer or external (remote) ballast to the luminaire shall be insulated No. 10 AWG solid copper wire. The insulation for these wires shall be black, rated, and UL approved for 600V operation. The insulation shall be standard THW or THWN/THHN grade polyvinyl chloride, conforming to the applicable provisions of ASTM D 2219 and D 2220.

**209-4.2.3 Multiple Circuits Conductors.** Conductors for multiple circuits shall be of the type, size and insulation colors specified in Table 209-4.2.3(A) or on the Plans. The insulation shall be THW or THHN/THWN, or as specified on the Plans, grade polyvinyl chloride, conforming to the applicable provisions of ASTM D 2219 and D 2220. At any point the minimum thickness of any THW or THHN/THWN insulation shall be 1.4mm (0.055 inches) for conductor sizes No. 14 AWG to No. 10 AWG, inclusive and 1.5 mm (0.059 inches) for No. 8 AWG to No. 2 AWG inclusive.

TABLE 209-4.2.3 (A)

Multiple Circuits	Function	Identification			Size
		Insulation Colors <sup>d</sup>		Band Symbols <sup>c</sup>	
		Base	Stripe <sup>a</sup>		
Multiple Service (Stranded)	Ungrounded Line 1	Blk.	None	NBR	8
	Ungrounded Line 2	Red	None	NBR	8
	Grounded/Neutral	Wht.	None	NBR	8
Street Lighting Pull Box to Pull Box <sup>b</sup> (Stranded)	Ungrounded Line 1 (odd)	Blk.	None	NBR	8
	Ungrounded Line 2 (even)	Red	None	NBR	8
	Grounded/Neutral	Wht.	None	NBR	8
Street Lighting Pull Box to Luminaire <sup>b</sup> (Solid)	Ungrounded Line 1 (odd)	Blk.	None	NBR	10
	Ungrounded Line 2 (even)	Red	None	NBR	10
	Grounded/Neutral	Wht.	None	NBR	10
Lighting Control From Luminaire's with PEU's to Luminaire's without PEU's (Solid)	Ungrounded to PEU	Blk.	None	C1	10
	Switching leg of PEU to terminal strip.	Red	None	C2	10
	Switching leg of PEU to unswitched Luminaire <sup>e</sup> .	Pur.	None	NBR	8/10 <sup>e</sup>

NBR = No Band Required

PEU = Photoelectric Unit

- Band conductors in each pull box and near ends of termination point.
- Both wires between external high intensity discharge (HD) ballast lamp shall be black No. 10 Solid wire.
- "S" if circuit is switched on line side of service equipment by utility.
- Color code: Blk-Black, Pur.-Purple and Wht.-White
- No. 8 Stranded conductor from pull box to pull box and No. 8 solid wire in the Standards.

### 209-4.3 Splicing Units and Terminal Blocks.

#### 209-4.3.1 Disconnecting Splice Connector (High Voltage).

**209-4.3.1.1 Connector Case.** The case or shell shall be formed of a neoprene or plastic composition having a volume resistivity not less than  $10^{13}$  ohms per cm ( $3.94 \times 10^{12}$  ohms per inch). The diameter of the case shall not exceed 6.35cm (2 1/2 inches) and the length shall not exceed 25.4 cm (10 in). The case shall withstand a load of 888.9 N (200 lbs) applied normal to the axis of the case without rupture, cracking, or permanent deformation.

The two halves of the case shall lock together with screw threads forming a watertight joint and be separated by a neoprene "O" ring under compression when the connector is assembled. The wires that are to be spliced shall attach to the connector by a self threading lug made from a No. 8 AWG solid copper wire. The connecting lug shall be slotted at 90 degrees to provide a pressure fit between the male and female parts. All metal parts shall be cadmium plated.

Each half of the case shall be completely filled with a sealing compound complying with 209-4.3.1.2 and held in place with a wire/cable entrance plug designed to accommodate any cable having an overall diameter of between 8.79 mm (11/32 inch) and 15.24mm (5/8 inch).

**209-4.3.1.2 Sealing Compound.** The sealing compound for the cable connector case shall be a viscous paste composed of oil and an inert mineral filler. The compound shall be waterproof and resistant to oxidation, weathering and biological attack. The volume resistivity shall not be less than  $10^{12}$  ohms per cm ( $3.94 \times 10^{11}$  ohms per inch).

When the sealing compound is exposed to air for 18 hours in a film 3.18 mm (1/8 inch) thick at a temperature of  $21^{\circ}\text{C} \pm 1.1^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 2^{\circ}\text{F}$ ) absorption of water shall not exceed 3mg per sq cm. (0.02 oz per sq in) of surface area in contact with the water.

When allowed to dry in contact with air, the lineal shrinkage of the exposed surface of the compound shall not exceed 0.2%.

**209-4.3.1.3 Electrical Characteristics.** When two wire/cable ends are connected and sealed in the connector case with sealing compound, the unit shall sustain an electrical stress of 11,000 volts at of  $21^{\circ}\text{C} \pm 1.1^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 2^{\circ}\text{F}$ ), without breakdown, after immersion in water for 18 hours.

**209-4.3.2 Fused Splice Connectors.** Fused disconnect connectors shall have no exposed metal parts except for the head of a stainless steel assembly screw. The head of the stainless steel assembly screw shall be recessed a minimum of 0.8 mm (1/32 inch) below the top of a plastic boss which surrounds the head.

Fused splice connectors shall completely enclose the fuse and shall protect the fuse against damage from water and weather. The contact between the fuse and the fuseholder shall be spring pressure.

Fuses shall be standard midget, ferrule type, with "Slow Blow" feature and shall be 10mm x 38 mm (3/8 inch x 1-1/2 inch).

**209-4.3.3 Terminal Blocks.** Terminal blocks shall have a minimum of 12 positions with terminals rated at size No. 8 AWG or larger, to accept the field wires indicated on the Plans.

#### **209-4.4 High Pressure Sodium Luminaires.**

**209-4.4.1 General.** High-pressure sodium luminaires shall be the enclosed cutoff type with a horizontal burning lamp unless otherwise specified in the Special Provisions or on the Plans. Each luminaire shall consist of a housing, a reflector, a refractor or lens, a lamp socket, an internal (integral) ballast, starter, a terminal strip and a lamp.

Each mast arm mounted luminaire shall be furnished without a photoelectric unit receptacle unless otherwise specified in the Special Provisions or on the Plans. If a photoelectric unit receptacle is included, a rain tight shorting cap shall be installed. If a luminaire housing is provided with a hole for the receptacle, the hole shall be closed, covered and sealed with weatherproof material.

The housing shall be fabricated from aluminum. Housings that are painted shall withstand a 1000-hour salt spray test as specified in ASTM B 117. Other metal parts of the housing shall be fabricated from metal that equals or exceeds the corrosion resistance and finish of the metal used for the housing. The housing shall be equipped with a slip-fitter capable of mounting on a 50 mm (2 inches) pipe tenon and of being adjusted 5 degrees from the axis of the tenon. The clamping brackets of the slip-fitter shall not bottom out on the housing bosses when adjusted within the  $\pm 5$  degree range.

No part of the slip-fitter mounting brackets shall develop a permanent set in excess of 0.5 mm (1/64 inches) when the four 10 mm (3/8 inches) diameter cap screws used for mounting are tightened to 13 N·m (9.62 ft·lbs).

Luminaires to be mounted on horizontal mast arms, shall be tested in conformance with California Test 611, and be capable of withstanding cyclic loading in ( $G = \text{Acceleration of Gravity}$ ):

- a) A vertical plane at a minimum peak acceleration level of 3.0 G peak-to-peak sinusoidal loading (same as 1.5 G peak) with the internal ballast removed, for a minimum of 2 million cycles without failure of any luminaire parts, and

- b) A horizontal plane perpendicular to the direction of the mast arm at a minimum peak acceleration of 1.5 G peak-to-peak sinusoidal loading (same as 0.75 G peak) with the internal ballast installed, for a minimum of 2 million cycles without failure of any luminaire parts, and
- c) A vertical plane at a minimum peak acceleration level of 1.0 G peak-to-peak sinusoidal loading (same as 0.5 G peak) with the internal ballast installed, for a minimum of 2 million cycles without failure of any luminaire parts.

The surface of each reflector shall be specular and shall be protected by either an anodized finish or a silicate film.

Each refractor or lens shall be mounted in a frame that is hinged to the housing and secured with a spring-loaded latch. Each refractor shall be made of glass or polycarbonate plastic as specified in the Special Provisions. Each lens shall be made of heat and impact resistant glass.

The optical system, consisting of the reflector, refractor or lens, lamp socket and lamp, shall be contained in a sealed chamber. The seal shall consist of a gasket between the reflector and refractor or lens and a gasket between the reflector and lamp socket. The chamber shall have provision for a filtered flow of air in and out due to lamp heat. Filtering shall be accomplished by either a separate filter or a filtering gasket.

Each lamp socket shall be a porcelain enclosed mogul-multiple type. The shell shall contain integral lamp grips to assure electrical contact under conditions of normal vibration. The socket shall be mounted in the luminaire in a manner to permit pre-setting a variety of specified light distribution patterns. The socket shall be rated for 1500W and 600V, and shall be rated for a 4KV pulse.

When the ballast, starter and terminal strip are mounted on a down-opening door, the door shall be hinged and secured to the luminaire separately from the refractor or flat lens frame. The door shall be removable and replaceable. The door shall be secured to the housing in a manner to prevent its accidental opening when the refractor or flat lens frame is opened.

Field conductors connected to the luminaire shall terminate on a barrier type terminal block secured to the housing. Terminal screws shall be captive and equipped with wire grips for conductors up to No. 6 AWG. Each terminal position shall be clearly identified.

The minimum light distribution for each luminaire shall be as shown on the isolux diagrams on the Plans. The maximum brightness of each cutoff luminaire, with the lamp indicated shall be as specified in Table 209-4.4.1(A).

TABLE 209-4.4.1(A)

Lamp ANSI Code No.	Lamp Wattage	Maximum Brightness (cd/m <sup>2</sup> )
S55	150	140
S66	200	140
S50	250	175
S67	310	210
S51	400	260

Brightness readings specified are based on the use of a brightness meter with an acceptance angle of 1.5 degrees. When measured on the 90-degree and 270-degree lateral angle line, the maximum brightness shall not exceed the above specified brightness when the meter is located at a horizontal distance of 37m (121 ft 6 1/2 in) and a vertical distance of 2.3m (7 ft 6 in) between the luminaire and the meter, or at an angle of 3 degrees 35 minutes from the horizontal to the line between the luminaire and the meter. Measurements shall be made from both the 90 degree line and the 270 degree line and

averaged. The lamp for each test shall be operated at the wattage necessary to produce a light output as specified in Table 209-4.4.1(B).

TABLE 209-4.4.1(B)

Lamp Wattage	Lumens
150	16,000
200	22,000
250	27,000
310	37,000
400	50,000

### 209-4.5 Lamp Ballasts.

**209-4.5.1 General.** The input voltage for ballasts and ballast types shall be as shown on the Plans or as specified in the Special Provisions. The ballast shall be plainly marked as to its operating voltage and wattage characteristics. Noise generated by the ballast or in combination with the starting aid shall be minimized. The ballast, including starting aid, shall incorporate protection against normal lamp failure modes. Ballasts for luminaires to be mounted on mast arms, brackets or lowering assemblies shall be located within the luminaire housing.

Each ballast shall be designed for the type, characteristics and wattage of the lamp it is to operate and it shall provide lamp starting and waveforms, voltage and current specified in the Special Provisions. Ballasts shall also be designed to operate under outdoor conditions, either mounted internally (integral) within the luminaire or lighting fixture or mounted externally (remote) to the luminaire. Ballasts shall provide reliable starting and operation at ambient temperatures down to  $-30^{\circ}\text{C}$  ( $-22^{\circ}\text{F}$ ) for the rated life of the lamp.

The ballast shall be designed for continuous operation at ambient air temperatures from  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ ) to  $65^{\circ}\text{C}$  ( $149^{\circ}\text{F}$ ) without reduction in ballast life. Ballasts shall have a design life of not less than 100,000 hours. Ballast shall be designed to operate for a minimum of 180 cycles of 12 hours on and 12 hours off, with the lamp circuit in an open or short-circuited condition and without measurable reduction in the operating requirements in 209-4.4.1.

Heat-generating components shall be mounted so as to use the portion of the luminaire they are mounted on as a heat sink. Capacitors shall be located as far as practicable from heat-generating components or shall be thermally shielded to limit the case temperature to  $75^{\circ}\text{C}$  ( $167^{\circ}\text{F}$ ).

Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors, except those in starting aids, shall be encased in metal and hermetically sealed.

Ballasts shall be tested in conformance with ANSI C82.6-1980.

**209-4.5.2 Internal Ballasts.** Each internal ballast shall consist of separate components, each of which shall be capable of being easily replaced. A starting aid which is encapsulated will be considered as a single component. Each component shall be provided with screw terminals, NEMA tab connectors or a single multi-circuit connector. All conductor terminals shall be identified as to the component terminal to which they are connected.

Internal ballasts shall be tested within the luminaire and shall be rated at a minimum temperature of  $105^{\circ}\text{C}$  ( $221^{\circ}\text{F}$ ) or as specified in the Special Provisions.

**209-4.5.3 Remote Ballasts.** Ballasts to be located remote (external) from the luminaire shall be the submersible type and shall conform to 209-4.8.3. All components, including starting aids, shall be enclosed in a single housing. Ballast leads shall extend a minimum of 300 mm (11-13/16 inches) from the housing. Steel

housings shall be galvanized or painted. Ballast housings shall be clearly labeled to indicate lamp type, lamp wattage and input voltage.

**209-4.5.4 Starting Aids.** Starting aids, if required, shall be interchangeable between ballasts of the same wattage and manufacturer without adjustment.

**209-4.5.5 High Pressure Sodium Lamp - Constant Wattage (CW) or Constant Wattage Auto-Regulator (CWA) – Ballasts.** CW and CWA ballasts shall have a ballast characteristic curve which will intersect both of the lamp-voltage limit lines between the wattage limit lines and remain between the wattage limit lines throughout the full range of lamp voltage. This requirement shall be met not only at the rated input voltage of the ballast, but also at the lowest and highest input voltage that the ballast is rated. Throughout the rated lifetime of the lamp, the ballast curve shall fall within the limits of lamp voltage and wattage specified in the Special Provisions.

**209-4.5.6 Regulator Type Ballasts.**

**209-4.5.6.1 General.** Regulator type ballasts shall be lag-type or lead-type conforming to the following:

- a) For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7.5 percent from rated lamp wattage.
- b) The ballast shall be designed such that a capacitance variance of  $\pm 6$  percent will not cause more than a  $\pm 8$  percent variation in lamp wattage regulation throughout the rated lamp life for nominal input voltage.
- c) The lamp current crest factor shall not exceed 1.8 for input voltage variation of  $\pm 10$  percent at any lamp voltage from initial through life.

**209-4.5.6.2 Lag-Type.** Lag-type regulator ballasts shall have the primary and secondary windings electrically isolated and, when operated with the appropriate lamp, shall have the following characteristics and maintain the following lamp operation:

- a) The power factor shall be not less than 90 percent throughout the life of the lamp at nominal line voltage with a nominally rated reference lamp.
- b) Lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 18 percent for a  $\pm 10$  percent input voltage variation.

**209-4.5.6.3 Lead-Type.** Lead-type regulator ballast (CWA) shall when operated with the appropriate lamp, have the following characteristics and shall maintain the following lamp operation:

- a) The power factor shall be not less than 90 percent when the ballast is operated at nominal line voltage with a nominally rated reference lamp.
- b) Lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 30 percent for  $\pm 10$  percent input voltage variation.

**209-4.5.7 Autotransformer or Reactor Type Ballast.** Each nonregulating reactor, autotransformer, or high reactance ballast shall, when operated with the appropriate lamp, have the following characteristics and maintain the following lamp operations:

- a) The power factor shall be not less than 90 percent when the ballast is operated at nominal line voltage with a nominally rated reference lamp.
- b) Lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 25 percent for  $\pm 5$  percent input voltage variation.

- c) For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7.5 percent from rated lamp watts.
- d) The lamp current crest factor shall not exceed 1.8 for an input voltage variation of  $\pm 5$  percent at any lamp voltage from initial through life.

**209-4.5.8 Physical Requirements.** External leads for multiple to multiple and series to multiple secondary connections shall be Type USE No. 10, rated 600VAC. Primary conductors for series to multiple ballasts shall be rated for use on 5000VAC circuits.

Ballast leads shall extend a minimum of 300 mm (11-13/16 inches) from the case. The ballast insulation shall be NEMA 185°C (365°F) or as specified in the Special Provisions.

Series to multiple ballasts shall withstand the application of 12,000VAC from core to primary coil and from coil to coil for a one minute period. Series to multiple ballasts secondaries and multiple-to-multiple ballast shall withstand the application of 2,200VAC from core to coils and, for multiple units only, from coil to coil for a one minute period. These tests shall be made immediately after operation of the ballast at full load for 24 hours.

Non-submersible ballast shall be provided with metal half-shell coil protection, moisture resistant, synthetic varnish impregnated windings and shall be suitable for outdoor operation in a rain tight enclosure.

Each ballast to be installed in a pull box shall be the submersible type and be provided with handle and a hanger.

**209-4.6 High Pressure Sodium Lamps.** High pressure sodium lamps shall conform to ANSI Standard C 78 "Lamp Specifications, Physical and Electrical Characteristics of High-Intensity Discharge Lamps," when tested in conformance with the requirements in ANSI Standard C78.388, "Methods of Measurement of High Pressure Sodium Lamp Characteristics." High-pressure sodium lamps shall have a minimum average rated life of 24,000 hours.

#### **209-4.7 Photoelectric Controls.**

**209-4.7.1 General.** Photoelectric controls shall consist of a photoelectric unit which plugs into an EEL-NEMA twist lock receptacle integral with the luminaire. Photoelectric controls, if required in the Special Provisions or on the Plans, shall be capable of switching multiple lighting systems directly.

**209-4.7.1.1 Photoelectric Unit.** Photoelectric units shall provide an output in response to changing light levels. The response level shall remain stable throughout the life of the control unit. Components shall not require periodic replacement.

Photoelectric units shall have a "turn-on" between 10 and 50 lux and a "turn off" at between 1.5 and 5 times "turn-on." Measurements shall be by the procedures specified in "EEL-NEMA Standards for Physical and Electrical Interchangeability of Light-Sensitive Control Devices Used in the Control of Roadway Lighting".

Photoelectric units shall also conform to the following:

- a) The supply voltage rating shall be 60 Hz, 105-130 V, 210-240 V, or 1-5-240 V, as specified.
- b) The load rating shall be 1000 W minimum, incandescent, mercury or fluorescent.
- c) The operating temperature range shall be from -29°C (-20°F) to 65°C (149°F).
- d) The power consumption shall be less than 10 W.
- e) The unit shall be housed in a weatherproof enclosure.
- f) The base of the unit shall be provided with a three prong, EEL-NEMA standard, twist-lock plug mounting.
- g) Be equipped with a "fail-on" feature.

**209-4.7.1.2 Contactor.** The contactor shall have contacts rated to switch the specified lighting load and shall be normally open, unless otherwise specified in the Special Provisions. The contactor shall be either the mechanical armature type or the mercury displacement type. The contacts of the mechanical armature type contactor shall be either fine silver, silver alloy, or superior alternative material. The contactor shall have a minimum rating of 30A, per contact, inductive load.

**209-4.7.1.3 Terminal Blocks.** Terminal blocks shall be rated at a minimum of 30A, 600V or as specified in the Special Provisions. Terminal blocks shall be molded from phenolic or nylon material and shall be the barrier type with plated brass screw terminals and integral type marking strips.

#### **209-4.8 Transformers.**

**209-4.8.1 General.** Multiple to multiple and series to multiple transformers shall be of the single-phase, dry type designed for operation on a 60 Hz supply.

**209-4.8.2 Electrical Requirements.** Transformer ratings shall be 120/480V, 240/480V, 480/120V or 480/240V for multiple to multiple units or as shown on the Plans. Transformer ratings for series to multiple units shall be 6.0A/120V or 6.6A/4.8kv or as shown on the Plans. Secondary 480V windings shall be center tapped. Volt-ampere ratings shall be as shown on the Plans. Transformer efficiency shall exceed 95 percent for multiple to multiple units and 80 percent for series to multiple units.

Secondary voltage regulation and tolerance shall be  $\pm 3$  percent from half load to full load for multiple to multiple units and +10 percent (maximum) at no load to  $\pm 3$  percent at full load for series to multiple units.

Transformers shall have a decal showing a connection diagram. The diagram shall show either color coding or tagging of wires with primary (H1, H2) or secondary (X1, X2) markers, and shall also show the primary and secondary voltage and volt-ampere rating.

**209-4.8.3 Submersible Type Transformers.** Submersible type transformers shall be securely encased in a rugged corrosion resistant, watertight case and shall withstand a 5-day test submerged in 600 mm (23-5/8 inches) of salt water (2 percent salt by mass) with 12-hour on and off periods. The operating periods shall be at full load. Leads of submersible transformers shall be brought out through one or more sealed hubs and shall be secured in a manner that will withstand a 450-N (101 lbs force) static pull without loosening or leaking.

#### **209-5 MATERIALS FOR TRAFFIC SIGNAL SYSTEMS.**

**209-5.1 Steel Pedestrian Standards and Pedestals for Controller Cabinets.** All steel pedestrian standards and pedestals for controller cabinets shall be constructed of 3mm (1/8 inch) or thicker galvanized steel, 100mm (4 inch) schedule 40 galvanized steel pipe, or size 103 conduit. Steel pedestrian standards and pedestals shall be constructed in conformance with 209-3.3, with the top designed for post top slip-fitting. Galvanized steel pipe shall conform to ASTM A53. Push button posts shall also be manufactured of 63.5 mm (2-1/2 inch) schedule 40 galvanized steel pipe conforming to ASTM A 53.

**209-5.2 Pedestals.** Pedestals shall have an aluminum identification plate attached with stainless steel rivets or screws, as specified on the Plans.

All welds shall be continuous and conform to the requirements of 209-2, 209-3.3.3.2 or 209-3.3.3.3 depending on the material the pedestal is fabricated from. Exposed welds shall be ground flush with the base metal.

Pedestals shall be galvanized by the hot-dip process conforming to 210-3, or cadmium plated with Type NS coating conforming to ASTM A 165. If specified in the Special Provisions or shown on the Plans, pedestals shall also be painted in accordance with 210-1.

Pedestals shall be furnished complete with all necessary fittings and hardware for attachment of the controller cabinet to the adjoining pedestal.

**209-5.3 Conductors and Cable.**

**209-5.3.1 General.** Copper wire shall conform to ASTM B 3 (solid) and 209-4.2. Wire sizes, other than wires used in loop detector lead-in cable, shall be based on the American Wire Gage (AWG). The wire diameter shall not be less than 98 percent of the specified AWG diameter. Conductors used in loop detector lead-in cable shall conform to the requirements in ASTM B 286. A Certificate of Compliance shall be submitted by the Contractor in conformance with 2-5.3 and 4-1.5 for each type of cable used in the Work.

Unless otherwise specified on the Plans or in the Special Provisions, Table 209-5.3.1(A) shall be used to identify the conductors to be used in the Work.

**TABLE 209-5.3.1(A)**

Circuit	Signal Phase Or Function	Identification			Size
		Insulation Colors <sup>f</sup>		Band Symbols <sup>d</sup>	
		Base	Stripe <sup>a</sup>		
Vehicle Signals <sup>c</sup>	2, 6	Red, Yel., Brn.	Blk.	2.6	14
	4, 8	Red, Yel., Brn.	Ora.	4.8	14
	1, 5	Red, Yel., Brn.	None	1.5	14
	3, 7	Red, Yel., Brn.	Pur.	3.7	14
Pedestrian Signals <sup>c</sup>	2p, 6p	Red, Brn.	Blk.	2p, 6p	14
	4p, 8p	Red, Brn.	Ora.	4p, 8p	14
	1p, 5p	Red, Brn.	None	1p, 5p	14
	3p, 7p	Red, Brn.	Pur.	3p, 7p	14
Pedestrian Push Buttons <sup>c</sup>	2p, 6p	Blue	Blk.	P-2, P-6	14
	4p, 8p	Blue	Ora.	P-4, P-8	14
	1p, 5p	Blue	None	P-1, P-5	14
	3p, 7p	Blue	Pur.	P-3, P-7	14
Traffic Signal Controller Cabinet	Underground between Service Switch & Cabinet	Blk.	None	CON-1	6
		Red	None	CON-2	6
Sign Lighting <sup>e</sup>	Ungrounded Line 1	Blk.	None	SL-1	10
	Ungrounded Line 2	Red	None	SL-2	10
Grounded and Common	Pedestrian Push Buttons	Wht.	Blk.	NBR	14
	Signals	Wht.	None	NBR	10
	Sign Lighting	Wht.	None	NBR	12
Railroad Pre-Emption		Blk.	Blk.	R	14
Spares		Blk.	None	NBR	14

NBR = No Band Required

- a. On overlaps, insulation is striped for first phase in designation, e.g. Phase (2 & 3) insulation is striped as for phase 2.
- b. Band for overlap and special phases as required.
- c. These requirements do not apply to signal cable.
- d. Band conductors in each pullbox and near each termination point. On signal light circuits, a single band may be placed around 2 or 3 ungrounded conductors comprising a phase.
- e. Conductors between ballasts and sign lighting lamps shall be No. 16 and color shall correspond to the ballast leads.
- f. The No. 14 AWG conductor shall be solid copper in a 0.41 mm (0.016 in) minimum polyvinyl chloride insulation incased in a 0.13 mm (0.005 in) minimum clear nylon jacket. The No. 10 conductor shall be solid copper in a 0.56 mm (0.022 in) minimum polyvinyl chloride insulation incased in a 0.20 mm (0.008 in) minimum clear nylon jacket.
- g. Color Code: Yel-Yellow, Brn-Brown, Blu-Blue, Blk-Black, Wht-White, Ora-Orange and Pur-Purple.

All single conductors, multi-conductor cables, and lead-in cables, shall have clear, distinctive and permanent markings on the outer surface throughout the entire length showing the manufacturer's name or trademark, insulation type letter designation, conductor size, voltage rating and the number of conductors. The multi

conductor cable jacket shall be black polyethylene binder sheath, rated for 600V and 75°C (167°F), or black polyvinyl chloride conforming to IMSA 9-1. Filler material, if used to make the multi-conductor round, shall be polyethylene.

Conductor insulation shall be of a solid color or of basic colors with a permanent colored spiral stripe under the nylon jacket, as detailed in Table 209-4.2.3(A) unless otherwise specified in the Special Provisions. Solid or basic colors shall be homogeneous through the full depth of insulation. Identification stripes shall be a continuous spiral over the entire length of the conductor. For conductor size No. 2 and larger, the insulation may be black and the ends of the conductors shall be taped with electrical insulating tape of the required color for a minimum of 508 mm (20 inches).

**209-5.3.2 Materials.**

**209-5.3.2.1 General.** Individual wires in the cable shall be solid copper with Type THWN or polyvinyl chloride insulation as specified in the Special Provisions, and shall conform to the requirements in 209-4.2.1 and ASTM B286. The minimum thickness of Type THWN insulation, at any point, shall be 0.3mm (0.012 inches) for No. 14 conductor and 0.4mm (0.016 inches) for No. 10 conductor. The minimum thickness of the polyvinyl chloride insulation, at any point shall be 0.41mm (0.016 inches) for No. 14 AWG conductor and 0.56mm (0.022 inches) for No. 10 AWG conductor. No. 14 AWG conductors shall have a 0.127mm (0.005 inches) minimum thickness clear nylon jacket and the No. 10 AWG conductors shall have a 0.203mm (0.008 inches) clear nylon jacket.

**209-5.3.2.2 Three-Conductor Cable.** Three conductor cable shall be used for pedestrian push buttons and a spare.

Three conductor cable shall consist of 3 No. 14 AWG wires. The cable jacket shall have a minimum average thickness of 1.1 mm (0.043 inches) and a minimum thickness of 0.9mm (0.035 inches). The nominal outside diameter of the cable shall not exceed 10 mm (3/8 inches). The color code of the wires shall be blue/black stripe, blue/orange stripe and white/black stripe.

**209-5.3.2.3 Five-Conductor Cable.** Five conductor cable shall consist of 5-No. 14 AWG wires. The cable jacket shall have a minimum average thickness of 1.1mm (0.043 inch) and a minimum thickness of 0.9mm (0.035 inch). The nominal outside diameter of the cable shall not exceed 13mm (1/2 inch). The color code of the wires shall be red, yellow, brown, black, and white.

**209-5.3.2.4 Nine-Conductor Cable.** The nine conductor signal cable shall consist of 8-No. 14 AWG wires and 1-No. 12 AWG wire. The cable jacket shall have a minimum average thickness of 1.5mm (0.059 inch) and shall have a minimum thickness of 1.2mm (0.047 inch). The nominal outside diameter of the cable shall not exceed 17mm (11/16 inch). The color for the No. 12 AWG wire shall be white. The color code for the No. 14 AWG wires shall be as specified in Table 209-5.3.2.4(A).

**TABLE 209-5.3.2.4(A)**

PRIMARY COLOR	COLOR CODE
Red	Yellow/Black strip
Yellow	Brown/Black strip
Brown	Black
Red/Black strip	White/Black strip

**209-5.3.2.5 Twelve-Conductor Cable.** Twelve conductor cable shall be used for vehicle signals, pedestrian signals, spares, and the signal common or as specified in the Special Provisions. Twelve conductor cable shall consist of 11-No. 14 AWG wires and 1-No. 12 AWG wire. The cable jacket shall have a minimum average thickness of 1.5mm (0.059 inch) and shall have a minimum thickness of 1.2mm (0.047 inch). The nominal

outside diameter of the cable shall not exceed 20mm (3/4 inch). The color code of the No. 12 AWG wire shall be white. The color code and functional connections for the No. 14 AWG wires shall be as specified in Table 209-5.3.2.5(A), unless otherwise specified in the Special Provisions or approved by the Engineer.

TABLE 209-5.3.2.5(A)

Color Code	Termination	Phase
Red	Vehicle Signal Red	2, 4, 6, or 8
Yellow	Vehicle Signal Yellow	2, 4, 6, or 8
Brown	Vehicle Signal Green	2, 4, 6, or 8
Red/Black stripe	Vehicle Signal Red	1, 3, 5, or 7
Yellow/Black stripe	Vehicle Signal Yellow	1, 3, 5, or 7
Brown/Black stripe	Vehicle Signal Green	1, 3, 5, or 7
Black/Red stripe	Spare, or Ped. Signal use as required for Vehicle Signal red or "Don't Walk"	—
Black/White stripe	Spare, or use as required for Yellow	—
Black	Spare, or Ped. Signal use as required for Vehicle Green or "Walk"	—
Red/White stripe	Ped. Signal "Don't Walk"	—
Brown/White stripe	Ped. Signal "Walk"	—

**209-5.3.2.6 Twenty Eight -Conductor Cable:** Twenty Eight conductor signal cable shall consist of 27-No. 14 AWG wires and 1-No. 10 AWG wire cabled with polyethylene fillers, if necessary to make the cable round. Clear binder tape shall be used to wrap the cable core. The black polyvinyl chloride cable jacket shall have a minimum average thickness of 2mm (0.08 inch) and shall have a minimum thickness at any point of 1.6mm (0.06 inch). The cable jacket shall have printed on the outside the manufacturers name, the type of insulation for each wire, the number of wires of each size, the size of the wires in the cable and the voltage rating. Sequential footage marking shall also be shown on the surface of the jacket, printed at 0.61m (2 foot.) intervals. The nominal outside diameter of the cable shall not exceed 23mm (7/8 inch). The voltage rating shall be 600V and the temperature rating shall be 75°C (167°F). Signal commons in each cable shall be kept separate except at the signal controller. Each cable shall be labeled in each pull box, "C1" or "C2". The cable identified as "C1" shall be used for signal Phases 1,2,3, and 4. The cable identified "C2" shall be used for signal Phases 5,6,7, and 8. The "C1" and "C2" cable may also be used as shown on the Plans or as specified in the Special Provisions. The reel size shall allow for up to 610m (2000 ft) of cable maximum with a 69.8mm (2-3/4 inch) arbor hole.

The color code for the No. 10 AWG wire shall be white. The color code and functional connections for the No. 14 AWG wires shall be as shown in Table 209-5.3.2.6(A), unless otherwise specified in the Special Provisions.

TABLE 209-5.3.2.6(A)

Color Code	Termination	Phase
Red/Black stripe	Vehicle Signal Red	2 or 5
Yellow/Black stripe	Vehicle Signal Yellow	2 or 5
Brown/Black stripe	Vehicle Signal Green	2 or 5
Red/Orange stripe	Vehicle Signal Red	4 or 8
Yellow/Orange stripe	Vehicle Signal Yellow	4 or 8
Brown/Orange stripe	Vehicle Signal Green	4 or 8
Red/Silver stripe	Vehicle Signal Red	1 or 5
Yellow/Silver stripe	Vehicle Signal Yellow	1 or 5
Brown/Silver stripe	Vehicle Signal Green	1 or 5
Red/Purple stripe	Vehicle Signal Red	3 or 7
Yellow/Purple stripe	Vehicle Signal Yellow	3 or 7
Brown/Purple stripe	Vehicle Signal Green	3 or 7
Red/2 Black stripes	Ped. Signal DONT WALK	2 or 6
Brown/2 Black stripes	Ped. Signal WALK	2 or 6
Red/2 Orange stripes	Ped. Signal DONT WALK	4 or 8
Brown/ 2 Orange stripes	Ped. Signal WALK	4 or 8
Red/2 Silver stripes	Overlap A, C, Red	OLA, OLC
Brown/2 Silver stripes	Overlap A, C Green	OLA, OLC
Red/2 Purple stripes	Overlap B, D Red	OLB, OLD
Brown/2 Purple stripes	Overlap B, C Green	OLB, OLD
Blue/Black stripe	Ped. Push Button	2 or 6
Blue/Orange stripe	Ped. Push Button	4 or 8
Blue/Silver stripe	Overlap A, C Yellow	OLA(y), OLC(y)
Blue/Purple stripe	Overlap B, D Yellow	OLB(y), OLD(y)
White/Black stripe	Ped. Push Button Common	—
Black/Red stripe	Railroad Preemption	—
Black	Spare	—

### 209-5.3.3 Interconnect Cable.

**209-5.3.3.1 Direct Wire.** Interconnect cable shall consist of 7 - No.14 AWG tinned copper wires as shown on the Plans or specified in the Special Provisions. Each wire shall be insulated with 0.33mm (1/8 inch) minimum nominal thickness color coded, polypropylene material.

The interconnect cable jacket shall be black, high density polyethylene, rated for a minimum of 300V at 60°C (140°F), and shall have a nominal wall thickness of 1.0mm (1/32 inch) minimum. The cable jacket or the moisture-resistant tape directly under the outer jacket shall be marked with the manufacturer's name, insulation type designation, number of wires and wire size, and voltage and temperature ratings.

**209-5.3.3.2 Filled Telephone Cable.** Filled telephone cable shall consist of paired No. 22 AWG solid annealed copper wires. The cable shall be polyethylene insulated and aluminum shielded, conforming to the REA Specification PE-39 for filled telephone cable. The cable sizes shall be 12, 25, 50, and 75 pair.

**209-5.3.3.3 Telephone.** Telephone lines shall be No. 14 AWG stranded, twisted, pair copper wire having 600V insulation and overall shield and jacket.

### 209-5.3.4 Fiber Optic Cable

**209-5.3.4.1 General.** Fiber optic cable shall be a 6 optical glass fiber cable or as specified in the Special Provisions. The optical fibers shall be multi-mode graded index optical glass or as specified in the Special Provisions, with a nominal fiber core diameter of 50 microns and a nominal fiber cladding diameter of 125 microns. The fiber shall have a numerical aperture of 0.2.

**209-5.3.4.2 Performance.** The minimum optical performance of each fiber measured at wave lengths of both 850 nanometers and 1300 nanometers shall have a maximum attenuation of 3.5 decibels per kilometer at 858 nanometers and 1.0 decibel per kilometer at 1300 nanometers, and shall have a minimum bandwidth of 800 megahertz-kilometers.

**209-5.3.4.3 Construction.** The cable shall be constructed using 6 filled, loose-tube, color-coded dual-layer buffer tubes stranded (reverse oscillation) around a steel central member. The 6 color coded fibers shall be contained in a buffer tube and the remaining buffer tubes shall be natural or white. A layer of aramid yarn (e.g. Kevlar) shall hold the tubes in position around the strength member and provide additional tensile strength. The buffer tube diameter shall be a nominal 250 microns. The color code for the fibers and the buffer tubes shall be as shown on the Plans.

**209-5.3.4.4 Jacket.** The filled cable core shall be covered with a medium density polyethylene jacket. The color of the jacket shall be as shown on the Plans. This outer jacket shall be abrasion and crack resistant, non-nutrient to fungus, electronically non-conductive and compatible with all cable components that it may come in contact with. The jacket shall be free from holes, splits, blisters or other imperfections.

**209-5.3.4.5 Identification.** Each length of cable shall be permanently identified by specifying the manufacturer and type of cable at intervals not greater than 2m (6 feet 6-3/4 inches) along the outside of the outer jacket. Each length of cable shall be permanently marked with meter (or foot) marking at intervals not greater than 1 m (3 feet).

**209-5.3.4.6 Reels.** The cable shall be wound on standard reels in a manner which provides access to both ends of the cable for testing while the cable is still on the reel.

## **209-5.4 CONTROLLERS.**

**209-5.4.1 General.** Controllers, controller cabinets and auxiliary equipment shall be as specified in the Special Provisions, Plans, or Standard Plans.

**209-5.4.2 Wiring.** Conductors in controller cabinet wiring shall be No. 22 AWG or larger, with a minimum of 19 strands. Conductors shall conform to Military Specification MIL-W-16878D, Type B or better. The insulation shall have a minimum thickness of 0.25mm and shall be nylon jacketed polyvinyl chloride, irradiated cross-linked polyvinyl chloride, polyhalocarbon or polychloro-alkene, except for conductors No. 14 AWG and larger which may be UL Type THHN.

Flat cable may be used in lieu of individual conductors. Cable shall be constructed of No. 28 or larger wires. Conductor insulation shall be rated at 300V and shall rated be for use at 105°C (221°F). Cables shall be provided with strain relief.

Conductors used in controller cabinet wiring shall conform to the following color-code requirements:

- a) The grounded conductor of a circuit shall be identified by a continuous white or natural gray color.
- b) The equipment grounding conductor shall be identified by a continuous green color or by a continuous green color with one or more yellow stripes.
- c) Ungrounded conductors shall be identified by any color not specified in 1 or 2 above.

Conductors used in cabinet wiring shall terminate with properly sized captive or spring spade type terminals, or shall be soldered to a through-panel solder lug on the rear side of the terminal block.

Crimp-style connectors shall be applied with a tool that is designed to prevent opening of the handles until the crimp is complete.

An equipment grounding conductor bus shall be provided in each controller cabinet. The bus shall be grounded to the cabinet and shall be connected to the metal conduit system or other approved ground with a No. 8 or larger, grounding conductor.

With all of the cabinet equipment in place and connected, the resistance between the grounded conductor terminal bus and the equipment grounding conductor bus shall be 50 MΩ minimum, when measured with an applied voltage of 150VDC.

If a direct current (DC) circuit is to be grounded, the circuit shall be connected to the equipment ground only.

Two or more terminal blocks shall be provided for field connections. Terminal blocks for field connections shall be installed within 560mm (22-1/16 inches) of the face on the cabinet and shall be oriented for screwdriver operation from the door opening. All terminals shall be a minimum of 125mm (4-7/8 inches) above the foundation.

No more than 3 conductors shall be brought to any one terminal. Two flat metal jumpers, straight or U shaped, may also be placed under a terminal screw. At least 2 full threads of all terminal screws shall be fully engaged when the screw is tightened. No live parts shall extend beyond the barrier.

Wiring diagrams shall conform to 307-4.3.

#### **209-5.4.3 Cabinets.**

**209-5.4.3.1 General.** Controller cabinets shall be rainproof and conform to the dimensions shown on the Plans or the Standard Plans. The cabinet top shall be crowned 13mm (1/2 inch.) or slanted to the rear to prevent standing water.

Cabinets and doors shall be fabricated of either 1.8mm (1/16 inch) minimum thickness cold rolled steel, 1.8mm (1/16 inch) minimum thickness stainless steel or 3mm (1/8 inch) minimum thickness aluminum. All exterior seams shall be continuously welded.

Exterior welds shall be ground smooth. Edges shall be filed to a radius of 0.8 mm minimum.

Metal shelves or brackets shall be provided to support the controller unit and auxiliary equipment.

Machine screws and bolts shall not protrude beyond the outside wall of the cabinet.

Conduit shall enter the bottom and towards the front of the cabinet unless otherwise shown on the Plans.

A pliable seal, composed of caulking compound or mastic, shall be placed between each controller cabinet and the concrete foundation to prevent water, dust and dirt from entering the cabinet.

**209-5.4.3.2 Steel Cabinets.** Cabinets fabricated from steel shall be finished with a polymer or enamel coating system conforming to Color No. 14672 of Federal Standard 595B. Coatings shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters and other defects that would impair serviceability or distract from the general appearance. Coatings shall conform to the following requirements:

- a) Coating Hardness: The finish shall have a pencil lead hardness of HB minimum using an Eagle Turquoise pencil.

- b) Salt Spray Resistance: Undercutting of the film of the coating system shall not exceed 3mm (1/8 inch) average, from lines scored diagonally and deep enough to expose the base metal, after 336 hours exposure in a salt spray cabinet in conformance ASTM B117.
- c) The cabinet shall suffer no coating loss when subjected to the following:
  - 1. Two test specimens 100mm x 200mm (3-7/8 inches x 7-7/8 inches), of the same material and coating as the cabinet supplied, shall be furnished by the Contractor for the tests. The samples shall be furnished by the Contractor at no additional cost to the Agency.
  - 2. Two 230mm (9-1/16 inches) diagonal scratches exposing bare metal will be made on one specimen. The specimen will be soaked in de-mineralized water for 192 hours. A 25 mm (1 inch) wide strip of masking tape will be tightly affixed to the scratched surface and removed with one quick motion; evidence of blistering, softening, or peeling of the paint or coating from the base metal shall be cause for rejection. Testing will be in conformance with California Test 645, except that conformance to the 180 degree bend test will not be required.
- d) Metal preparation shall conform to the 3-step iron phosphate conversion coating bonderizing technique.
- e) The inside walls, doors, and ceiling of the housing shall be finished the same as the out side.

**209-5.4.3.3 Stainless Steel Cabinets.** Cabinets fabricated from stainless steel shall conform to the following:

- a) Annealed or quarter hard stainless steel sheet shall be used and shall conform to ASTM A666 for Type 304 Grades A or B.
- b) Welding shall be by the gas tungsten arc welding (GTAW) process using bare stainless steel welding electrodes. Electrodes shall conform to American Welding Society (AWS) A5.9 for ER308 chromium-nickel bare arc welding electrodes.
- c) Procedures, welders and welding operators for welding on stainless steel shall conform to AWS C5.5.
- d) Exposed, exterior surfaces shall be ground or brushed to a 0.6  $\mu\text{m}$  to 1.3  $\mu\text{m}$  finish using iron-free abrasives or stainless steel brushes.
- e) All overlapping exterior seams shall meet the requirements of NEMA Type 4 enclosures.
- f) After grinding or brushing, no rust discoloration shall show when subjected to the following:
  - 1. Forty-eight hours of exposure in a salt spray cabinet in conformance with ASTM B117; and
  - 2. Twenty-four hours of exposure in a tap water spray cabinet with the water temperature between 38°C (100°F) and 45°C (113°F). Any cabinet which shows any rust discoloration anywhere on its surface after the test will be rejected.
- g) Cabinets that have been rejected because of surface discoloration may be cleaned, passivated and resubmitted for testing.

**209-5.4.3.4 Aluminum Cabinets.** Cabinets fabricated from aluminum sheet shall conform to the requirements in ASTM B209 or B209M for 5052-H32 aluminum sheet and conform to the following:

- a) Welding shall be done by the gas metal arc welding (GMAW) process using bare aluminum welding electrodes. Electrodes shall conform to AWS A5.10 for ER5356 aluminum alloy bare welding electrodes.

- b) Procedures, welders and welding operators for welding on aluminum shall be qualified in conformance with AWS B3.0 and C5.6.
- c) Surfaces shall be finished in conformance with Military Specification MIL-A-8625C "Anodic Coatings for Aluminum and Aluminum Alloys" for a Type II, Class 1 coating, except that anodic coating shall have a minimum thickness of 0.02mm and a minimum coating weight of 0.04 mg/mm<sup>2</sup>. Anodic coating shall be sealed in a 5 percent aqueous solution of nickel acetate (pH 5.0 to 6.5) for 15 minutes at 97°C (207°F). Prior to applying anodic coating the cabinets shall be cleaned and etched as follows:
1. Immerse in inhibited alkaline cleaner such as Oaklite 61 A or Diversey 909, or equivalent, 45-60 g/L (6-8 oz./gal), 71°C (160°F) for 5 minutes.
  2. Rinse in cold water.
  3. Etch in a solution of 11 g (0.39 oz.) of sodium fluoride, plus 30-45 g (4-6 oz) of sodium hydroxide per liter (gal) of distilled water at 60°C to 65°C (140°F to 149°F) for 5 minutes.
  4. Rinse in cold water.
  5. Desmut in a 50 percent, by volume, nitric acid solution at room temperature for 2 minutes.
  6. Rinse in cold water.

**209-5.4.3.5 Doors.** The cabinet shall have a single front door equipped with a lock. The door width shall be as shown on the Standard Plans. When the door is closed and latched, the door shall be locked. The handle shall have provision for locking in the closed position. The handle shall have a minimum length and steel shank as shown on the Standard Plans. The handle shall be fabricated of cast aluminum or of zinc-plated or cadmium-plated steel. The cabinet frame shall be designed so that the latching mechanism will hold tension on and form a firm seal between the door gasketing and frame. Locks shall be the solid brass, 6-pin tumbler rim type, with rectangular, spring-loaded bolts. Locks shall be left hand, and rigidly mounted with stainless steel machine screws approximately 50mm (2 inches) apart. Keys shall be removable in the locked and unlocked positions, and 2 keys shall be furnished with each cabinet. The front position of the lock shall extend 3-9mm (1/8-1/4 inches) beyond the outside surface of the door.

The latching mechanism shall be a 3-point cabinet latch with nylon rollers. The center catch and pushrods shall be zinc-plated or cadmium-plated steel. Pushrods shall be turned edgewise at the outer supports and shall be 6mm (1/4 inch) x 20mm (3/4 inch) minimum. Nylon rollers shall have a minimum diameter of 20mm (3/4 inch) and shall be equipped with ball bearings.

Cadmium plating shall conform to the requirements in Military Specification MIL-QQ-416b. Zinc plating shall conform to 210-3.

Doors shall be equipped with 3 bolt butt hinges. Each hinge shall have a fixed pin. Doors larger than 560mm (22-1/16 inches) or 0.56m<sup>2</sup> (6.03 feet<sup>2</sup>) in area shall be equipped with catches to hold the door open at both 90-degrees and 180-degrees, plus or minus 10 degrees. Catches shall be 9 mm (3/8 inch) diameter, minimum plated steel rods. Catches shall be capable of holding the door open at 90-degrees in a 90km/h (56 mph) wind at an angle perpendicular to the plane of the door.

A police panel shall be mounted on the door as shown on the Standard Plans and shall be equipped with a lock keyed to a master police key. Two keys shall be furnished with each cabinet for the police lock. Each police key shall have a shaft at least 45mm (1-3/4 inches) in length. Police panels shall not be furnished for controller assemblies that do not control traffic signals.

Door hinges, pins and bolts shall be made of stainless steel. Hinges on aluminum cabinets may be aluminum with a stainless steel hinge pin. Hinges shall be bolted to the cabinet. Hinge pins and bolts shall not be accessible when the door is closed.

Gasketing shall be provided on all door openings and shall be dust-tight. Gaskets shall be permanently bonded to the metal. The mating surface of the gasketing shall be covered with a silicone lubricant to prevent sticking of the mating surfaces.

Details of alternative designs shall be submitted in conformance with 2-5.3.3.

Metal shelves or brackets shall be provided to support the controller unit and auxiliary equipment.

Machine screws and bolts shall not protrude beyond the outside wall of the cabinet.

Conduit shall enter the bottom and toward the front of the cabinet unless shown otherwise on the Plans.

A pliable seal, composed of caulking compound or mastic, shall be placed between each controller cabinet and the concrete foundation to prevent water, dust and dirt from entering the cabinet.

**209-5.4.3.6 Cabinet Ventilation.** Each controller cabinet shall be provided with one of the following as specified in the Special Provisions:

- a) Eight screened, raintight vent holes 12 mm (1/2 inch) in diameter or larger, in the lower side or bottom of the cabinet.
- b) Louvered vents with a permanent metal mesh.
- c) Four-ply woven polypropylene air filter held firmly in place that will pass 2.83 m<sup>3</sup>/min. (100 cfm) of air.

Each controller cabinet shall be equipped with an electric fan with ball or roller bearings and a capacity of at least 2.83 m<sup>3</sup>/min. (100 cfm). The vents shall be able to pass this volume of air.

The fan shall be thermostatically controlled and shall be manually adjusted to turn on between 32°C (90°F) and 65°C (149°F) with a differential of not more than 6°C (42°F) between automatic turn on and turn off. The cabinet fan circuit shall be fused at 125 percent of the ampacity of the fan motor installed.

The fan and cabinet vent holes shall be located with respect to each other so as to direct the bulk of the air flow over the controller or through the ventilating holes of the controller where those holes exist.

**209-5.4.3.7 Cabinet Accessories.** The following accessories shall be furnished with each cabinet assembly as required by the Plans, Standard Plans, or Special Provisions.

- a) **Labels.** A permanent printed, engraved or silk screened label shall be provided for the following equipment and for all other removable items of equipment:
  1. Receptacles for relays and switching devices.
  2. Switches, fuses and circuit breakers.

Labels shall conform to the designations on the cabinet wiring diagram. Labels for all shelf-mounted equipment shall be on the face of the shelf below the item. Labels for wall-mounted equipment shall be below the item.

- b) **Convenience Receptacle.** A convenience receptacle shall be mounted in a readily accessible location inside the cabinet. The convenience receptacle shall be a duplex, 3-prong, NEMA, Type 5-15R grounding outlet and shall conform to UL Standard 943.

- c) **Lighting Fixture.** The lighting fixture shall be a florescent lighting fixture, mounted on the inside top of the cabinet near the front edge. The fixture shall be provided with an F15T8, cool white lamp operated from a normal power factor UL or ETL listed ballast. The "On-Off" switch for the lighting fixture shall be either of the following:
1. A toggle switch mounted on the inside door panel.
  2. A door-actuated switch that turns the light on when the door is open, and off when the door is closed.
- d) **Surge Arrestor.**

The surge arrestor shall reduce the effects of power line voltage transients and shall have ratings as follows:

Recurrent peak voltage	184V
Energy rating maximum	20 J
Power dissipation average	0.85 W
Peak current for pulses less than 7 ps	1250 A

Standby current shall be one milliampere or less for 60 Hz sinusoidal input.

- e) **Terminal Blocks.** Terminal blocks shall be rated 600VAC, minimum, and shall be provided with nickel, silver or cadmium plated brass binder head screw terminals.

Heavy duty terminal blocks shall be rated at 20A and shall be provided with 12 poles with No. 10 x 8mm (5/16 inch) nickel plated brass binder head screws and nickel plated brass inserts. Each pole position shall be provided with 2 terminal positions. The terminal blocks shall be the barrier type, with shorting bars in each of the 12 positions, and shall be provided with integral type marking strips.

Light duty terminal blocks shall be rated at 5A and shall be provided with 12 poles with No.6 x 3-mm (1/8 inch) binder head screws. Each pole position shall be provided with one terminal position.

#### 209-5.4.4 Components.

**209-5.4.4.1 Toggle Switches.** Toggle switches shall have poles as required and shall be rated at 200 percent of circuit current for circuits of 10A or less and 125 percent of circuit current for circuits over 10A.

**209-5.4.4.2 Cartridge Fuses.** Cartridge fuses shall be installed in panel mounted fuseholders. Fuse type and rating shall be as recommended by the fuse manufacturer for the type of load being protected.

**209-5.4.4.3 Circuit Breakers.** Circuit breakers shall conform to 209-3.11 except that the circuit breakers shall have a minimum interrupting capacity of 5000A, rms.

**209-5.4.4.4 Connectors.** Connectors used for interconnecting various portions of circuits together shall be designed and constructed for the application involved. Connectors shall be designed to provide positive connection of all circuits, and easy insertion and removal of mating contacts. Connectors shall be permanently keyed to prevent improper connection of circuits.

Connectors, or devices plugging into connectors, shall be provided with positive means to prevent any individual circuit from being broken due to vibration, pull on connecting cable or similar disruptive force.

### 209-5.4.5 Dual 5-Way Active Data Bridge.

**209-5.4.5.1 General.** Dual 5-way active data bridges shall be provided in the controller assemblies when shown on the Plans or specified in the Special Provisions. The bridge shall provide a 4-wire transmission interconnection between a dedicated common port and four multiple ports. The bridge shall incorporate a splitter channel and a combiner channel. Multiple inputs shall be connected to a common output in the combiner channel and in the splitter channel a common input shall be connected to multiple outputs. Splitter and combiner shall be separate and independent allowing operation in full-duple data transmission applications.

The bridge shall be equipped with a front-panel-accessible potentiometer with continuous adjustment of cross-bridge gain or loss within two switch-selectable loss/gain ranges suitable for most data applications; -30dB to -10dB and -10dB to +10dB. Either range shall be independently selectable for each channel. The level to which each channel is adjusted shall be common to all cross-bridge port combinations in that channel (that is, if the splitter-channel potentiometer is set for +3dB gain, all common-to-multiple-port paths in the splitter shall receive a +3dB level increase).

All ports of the bridge, both common and multiple, shall be characterized by a balanced 600Ω terminating impedance. The module's active circuit shall allow unused multiple ports to be left unterminated without affecting the transmission response of the ports in use.

Input, output and line monitor jacks on the front panel of the bridge shall allow isolated-module isolated-facility, and cross-bridge measurement of transmission parameters in both the splitter and combiner channels.

The bridge shall be powered from input voltage of -22 to -56VDC at a maximum current of 60mA.

Each dual 5-way active bridge unit shall be individually packaged in a housing. All circuitry shall be solid state, constructed on removable industry standard circuit boards with plug-in edge connectors.

All test jacks, edge connectors and external plug connectors shall be of a type and material suitable for use in the above stated environment without deterioration of electrical connection for the useful life of the equipment. The physical size of the case shall not exceed 3700cm<sup>3</sup> (104.77 ft<sup>3</sup>) (approximately 17.5cm x 20cm x 10cm (6-7/8 inches x 7-7/8 inches x 3-15/16 inches) and shall be suitable for mounting to the frame of a field cabinet.

Mounting holes shall be provided for attaching the unit to one side of the frame of a relay rack. Input and output ports shall be provided for five full duplex telephone circuits with input and output ports labeled as to function. Level control or switches and level adjustment potentiometers along with the input and output level test jacks shall provide external adjustments without removal of the housing.

**209-5.4.5.2 Application.** The bridge shall be used to interconnect several 4-wire data modems to a common data channel or data link. The common data link shall be terminated at the distant end into a central processor unit (CPU) or computer. A bridge shall be used to provide the central transmission arrangement or "hubbing" network, that extends data transmission to outlying terminals.

Tandem bridge arrangements to expand the number of multiple ports of a 4-wire data hubbing network shall be effected by direct connection of one multiple port in each channel of the first bridge to the common port of the same channel of a second bridge to provide a 4-wire data bridge with one common and 7 multiple ports.

**209-5.4.5.3 Circuit Description.** The combiner channel of the bridge shall consist of a variable-gain integrated-circuit operational amplifier with an input summing circuit. The summing circuit shall

add the transmission energy from all multiple input ports at a low-impedance summing point to provide input port isolation. The output of the amplifier shall be connected to a transformer for balanced connection to the facility.

The splitter channel shall consist of a transformer-input-variable-gain, integrated-circuit operational amplifier and a power amplifier. The output of the power transformer shall be a low impedance and shall drive eight 300Ω resistors to drive impedance at the multiple output circuits and provide isolation between output circuits.

The multiple ports in the splitter and combiner channels of the bridge shall be isolated and balanced via an output transformer and matched precision resistors in each channel.

**209-5.4.5.4 Electrical Requirements.** Electrical requirements shall be as specified in Table 209-5.4.5.4(A).

**TABLE 209-5.4.5.4(A)**

Splitter channel loss/gain	-30 to +10dB usable range
Combiner channel loss/gain	-30 to +10dB usable range
Maximum output level (overload point)	Splitter: +5Dbm Combiner: +12dBm
Level change with loading	1dB maximum, one port to all ports loaded.
Noise	20dBm maximum
Input port impedance	Splitter (multiple ports): 600Ω balanced. Combiner (common port): 600Ω balanced.
Output port impedance	Splitter (multiple ports): 600Ω balanced. Combiner (common port): 600Ω balanced.
Harmonic distortion	Splitter: less than one percent at + 3dBm Combiner: less than one percent at + 8 dBm
Frequency response	± 1 dBm re 1000Hz level, 300 to 5000Hz
Delay distortion	Less than 75μs, 400 to 3000Hz
Cross-port coupling loss (crosstalk)	Greater than 55dB
Mounting	One position
Operating environment	- 7°C to 54°C (-19°F to 129°F), humidity to 95% (no condensation)

**209-5.4.5.5 Testing and Trouble shooting.** Complete testing and troubleshooting instructions, circuit diagrams and pictorial component location and identification guides shall be provided with each bridge.

#### **209-5.5 Traffic Signal Faces and Fittings.**

**209-5.5.1 Signal Faces.** Each vehicle signal face shall be of the adjustable type conforming to ITE Publication ST-008B.

Metal signal sections shall conform to the requirements of California Test 666. Any fracture within the housing assembly or a deflection of more than one-half the lens diameter of the signal section during the wind load test will be considered a structural failure.

Plastic signal sections shall conform to the requirements of California Test 605. Any fracture within the housing assembly, or deflection of more than 10 degrees in either the vertical or horizontal plane after the wind load has been removed from the front of the signal face, or a deflection of more than 6 degrees in either the vertical or horizontal plane after the wind load has been removed from the back of the signal face will be considered structural failure.

Vehicle signal faces, except arrow and "X" faces, shall conform to the requirements of California Test 604.

Adjustment shall permit rotation of 360 degrees about a vertical axis. The number and type of sections shall be as specified in the Special Provisions or shown on the Plans. Each vehicle signal face shall be installed at the location and mounted in the manner shown on the plans.

Unless otherwise shown on the Plans, all vehicle signal faces shall contain 3 sections arranged vertically; red-top, yellow-center, and green-bottom.

All new vehicle signal faces, except programmed visibility type, installed at any one intersection shall be of the same manufacturer and of the same material.

Top openings of signal faces shall be sealed with neoprene gaskets.

**209-5.5.2 Optical Units.** Each optical unit shall consist of a lens, a reflector or reflector assembly, a lamp receptacle and a clear traffic signal lamp conforming to the following:

- a) Lenses, reflectors, reflector assemblies, lamp receptacles, lamps, wiring and light distribution shall conform to ITE Publication ST-008B.
- b) Each lens shall be of the best quality glass, true to color and free of imperfections.
- c) Reflectors shall conform to ITE Publication ST-008B except that the reflectors shall be made of silvered glass or of specular aluminum with an anodic coating. Reflector ring holders shall be made of cast aluminum.

A single piece formed metal reflector ring holder may be used.

**209-5.5.3 Signal Sections.** Each signal section housing shall be either die-cast or permanent mold-cast aluminum conforming to ITE Publication ST-088B or, when so specified in the Special Provisions shall be structural plastic.

Signal sections shall conform to the following:

- a) Maximum height shall be 260 mm (10-1/4 inches) for 200 mm (7-7/8 inches) sections and 375 mm (14-3/4 inches) for 300 mm (11-13/16 inches) sections.
- b) Housings shall be provided with a one-piece, hinged, square-shaped door designed to permit access to the section for relamping without the use of tools. The door shall be secured by a method that will hold the door closed during the loading tests specified in these Specifications. The lens shall be mounted in the door in a watertight manner.
- c) Exposed hardware, such as hinge pins and door latching devices, shall be manufactured of Type 304 or 305 stainless steel. Interior screws and fittings shall be manufactured of stainless steel or steel with a corrosion resistant plating or coating.
- d) An opening shall be provided in the top and bottom of each section to receive a 40 mm (1-9/16 inch) pipe. Two hundred millimeter (7-7/8 inches) and 300 mm (11-13/16 inches) sections produced by an individual manufacturer shall be capable of joining to form a signal face in any combination. This interchangeability is not required between metal and plastic signal sections.
- e) Gaskets, including those for the door, lens, reflector and lampholder, shall be made of a material that is not affected when installed in a signal section with a metal or plastic housing that is operated continuously for 336 hours.

**209-5.5.4 Metal Signal Sections.** Each metal signal section shall be provided with a metal visor and/or backplates as specified in the Special Provisions. Visors shall conform to 209-5.5.8. Backplates shall conform to 209-5.5.10.

**209-5.5.5 Plastic Signal Sections.** Housing shall be either molded in one piece or shall be fabricated from two or more pieces joined into a single piece. The plastic shall have ultraviolet stability, be unaffected by the heat of the lamp used and be self-extinguishing. Housing and doors shall be colored throughout and shall be black matching Color No. 17038, 27038 or 37038 of Federal Standard 595B.

Each plastic signal face shall be provided with plastic or metal visor as specified in the Special Provision. Visors shall conform to 209-5.5.8. Plastic signal sections shall also be provided with plastic backplates as specified in the Special Provisions. Plastic backplates shall conform to 209-5.5.10.2.

A serrated nylon washer shall be inserted between each plastic signal section and the metal mounting assembly. Each washer shall be not less than 4mm (5/32 inch) nor more than 6 mm (1/4 inch) thick. Serrations shall match those on the signal section and the mounting assembly.

**209-5.5.6 Fittings.** Each section in a face shall be joined to the adjacent section by one of the following methods:

1. A minimum of 3 machine screws for 200 mm (7-7/8 inch) sections and four machine screws for 300 mm (11-13/16 inch) sections installed through holes near the front and rear of the housings. Machine screws shall be No. 10 and each shall be provided with a nut, flat washer and lock washer.

2. Two machine screws (each with a nut, flat washer and lock washer) through the 40 mm (1-9/16 inch) pipe opening. The fastening system shall consist of two large flat washers to distribute the load around the pipe opening and three cartage bolts, each with a nut and lock washer. Minimum size of the machine screws shall be No. 10. Minimum size cartage bolts shall be 6 mm (1/4 inch).

The supporting section of each signal face supported solely at the top or bottom shall be provided with reinforcement.

Reinforcing plates shall be either sheet aluminum, galvanized steel or cast aluminum. Each plate shall be not less than 2.7mm (7/64 inches) thick and shall have a hole concentric with the 40mm (1-9/16 inch) pipe mounting hole in the housing. Sheet aluminum reinforcing plates shall be placed both inside and outside the housing. Galvanized steel reinforcing plates shall only be placed inside, and aluminum reinforcing plates shall be placed only on the outside of the housing. Reinforcing plates placed on the outside of the housing shall be finished to match the color of the signal face and mounting hardware. A minimum of 3 No. 10 machine screws shall be installed through holes in the plates and matching holes in the housing. Each screw shall have a round or binder head and shall be provided with a nut and lock washer.

Where a signal face is to be supported by a Type MAS side attachment slip-fitter inserted between 2 sections, a spacer or spacers shall be placed between the 2 sections. The vertical dimensions of the spacers shall permit proper seating of the serrations between the slip-fitter and the 2 sections. Holes in spacers shall align with the front holes in the section housings. In addition to the fastening through the large opening in the housings, the 2 sections shall be joined with at least 2 machine screws through holes near the front of the housings and the spacers, and through matching holes in a reinforcing plate installed in each housing. Machine screws shall be No. 10 size. Spacers shall be made of the same material as the signal housings. Reinforcing plates and machine screws shall be as specified herein.

Reinforcing plates will not be required where the housing is provided with reinforcing webs connecting the rear of the housing with the top, bottom and sides.

Holes for machine screws shall be either cast or drilled during fabrication of the signal section. Each hole shall be surrounded by a 3mm (1/8 inch) minimum width boss to permit contact between signal sections about the axis of the hole.

**209-5.5.7 Electrical Components.** Lamp receptacles and wiring shall conform to ITE Publication ST-008B. The metal portion of the medium base lamp socket shall be brass, copper or phosphor bronze.

Each lamp receptacle shall be wired with a conductor, connected to the shell of the receptacle, with white insulation, and a conductor, to the bottom or end terminal of the receptacle, with a black insulation or insulation color-coded.

Conductors shall, in turn, be connected to a terminal block mounted inside at the back of the housing. The terminal block shall have sufficient screw type terminals or NEMA type tab connectors to terminate all field conductors and lamp conductors independently. The terminals to which field conductors are attached shall be permanently identified or conductors shall be color-coded to facilitate field wiring.

Lamp receptacle conductors shall be No. 18, or larger, 600V, appliance wiring material (AWM), with 0.75mm (1/32 inch) thickness insulation rated for 105°C (221°F) or with insulation conforming to Military Specification MIL-W 16878 D, Type B, with vinyl nylon jacket rated for 115°C (239°F). The manufacturer's name or trademark, conductor size, insulation type letter designation and temperature rating shall be marked on the insulation or a Certification of Compliance in conformance with 4-1.5 shall be submitted by the Contractor with each shipment of traffic signal faces in accordance with 2-5.3.

**209-5.5.8 Visors.** Each signal section shall be provided with a removable visor conforming to ITE Publication ST-008B. Visors shall be classified, on the basis of lens enclosure, as full circle, tunnel (bottom open), or cap (bottom and lower sides open). Unless otherwise specified in the Special Provisions, visors shall be the tunnel type.

Visors shall be a minimum of 240 mm (9-7/16 inches) in length for nominal 300 mm (11-13/16 inches) round lenses and 180 mm (7-1/16 inches) in length for nominal 200 mm (7-7/8 inches) round lenses, with a downward tilt between 3 degrees and 7 degrees.

Metal visors shall be made from 1.2 mm (3/64 inch) minimum thickness, aluminum alloy sheets.

Plastic visors shall conform to the following:

- a) Visors shall be either formed from sheet plastic or assembled from one or more injection, rotational or blow molded plastic sections.
- b) Sections shall be joined using thermal, chemical or ultrasonic bonding or with aluminum rivets and washers permanently colored to match the visor.
- c) Visors shall be of black homogeneous colored material with lusterless finish.

Each visor shall be secured to its door in a manner that will prevent its removal or permanent deformation when the wind load specified in California Test 605 for plastic visors or California Test 666 for metal visors is applied to the side of the visor for 24 hours.

**209-5.5.9 Directional Louvers.** Where shown on the Plans, directional louvers shall be furnished and installed in the signal visors. Directional louvers shall be so constructed as to have a tight fit in the signal visors. Dimensions of louvers and arrangements of vanes shall also be as shown on the Plans.

The outside cylinder may be constructed of 0.75 mm (1/32 inch) nominal thickness, or thicker, sheet steel. The vanes may be constructed of 0.4 mm (1/64 inch) nominal thickness, or thicker, sheet

steel. Alternatively, the cylinder and vanes may be constructed of 5052-H32 aluminum alloy of equivalent thickness.

#### **209-5.5.10 Backplates.**

**209-5.5.10.1 General.** Where shown on the Plans, backplates shall be furnished and installed on signal faces. Dimensions, materials and installation details shall be as shown on the Plans. No background light shall show between the backplate and the signal face or between sections.

**209-5.5.10.2 Plastic Backplates.** Plastic backplates shall be either formed from sheet plastic or assembled from extruded molded or cast sections. Backplates shall be of black homogeneous colored material with a lusterless finish. Each plastic backplate shall be secured to the plastic signal face in a manner that will prevent its removal or permanent deformation when the wind-load test specified in 209-5.5.8 is applied to either the front or the rear of the signal face. The permanent deformation of any portion of the backplate shall not exceed 5 degrees forward or backward after the wind loading have been applied for 24 hours.

a) Sections shall be factory joined using:

- 1) Solvent cement recommended by the manufacturer,
- 2) Aluminum rivets and washers painted or permanently colored to match the backplate , or
- 3) No. 10 machine screws with washer, lock washer and nut, painted to match the backplate.

b) When a plastic backplate requires field assembly, it shall be joined with a minimum of 4 No. 10 machine screws at each field assembled joint. Each machine screw shall be provided with an integral or captive flat washer, a hexagonal head slotted for a standard screwdriver, and either:

- 1) A locking nut with an integral or captive flat washer, or
- 2) A nut, flat washer, and lock washer.

Machine screws, nuts, and washers shall be stainless steel or steel with a zinc or black oxide finish.

In lieu of the screws shown on the Plans, plastic backplates may be fastened to the plastic signal face using self-threading No. 10 steel screws. The screws shall have an integral or captive flat washer and a hexagon head slotted for a standard screwdriver, and shall be stainless steel or steel with a zinc or black oxide finish.

**209-5.5.10.3 Metal Backplates.** Where a metal backplate consists of 2 or more sections, the sections shall be fastened with rivets or with aluminum bolts peened after assembly to prevent loosening.

In lieu of the screws shown on the Plans, plastic backplates may be fastened to the plastic signal face using self-threading No. 10 steel screws. The screws shall have an integral or captive flat washer and a hexagon head slotted for a standard screwdriver, and shall be stainless steel or steel with a zinc or black oxide finish.

#### **209-5.5.11 Circular Light Emitting Diode Signal Modules.**

**209-5.5.11.1 General.** LED signal modules shall consist of an assembly that utilizes light emitting diodes as the light source. Modules shall be from the same manufacturer and each size shall be the same model. Modules shall be single, self-contained devices, not requiring on-site assembly for installation into the existing traffic signal housings. Modules shall fit into traffic signal section housings built in conformance with the ITE publication ST-008B without modification to the housing. Special tools shall not be required for their

installation. Installation of LED signal modules shall only require removal of the optical unit components (lens, gaskets, lamp, lamp socket and reflector) from the traffic signal section.

Each LED signal module shall be designed to be installed in the door frame of the signal housings specified in the Contract Documents. The module shall be sealed securely in the door frame with a one-piece ethylene propylene rubber (EPDM) gasket and shall be weather tight.

LED signal modules shall be sealed units with 2 conductors for connecting to power, a printed circuit board, a power supply, a lens and gasket and shall be weatherproof after installation and connection. The circuit board and power supply shall be contained inside the module. Circuit boards shall conform to Chapter 1, Section 6, of the "Transportation Electrical Equipment Specifications" published by the State of California, Department of Transportation or as specified in the Special Provisions.

Conductors for LED signal modules shall be 1 m (3 feet 3-3/8 inches) in length, with terminals attached, and shall conform to 209-5.3.

Connections shall be to the terminal block in the signal face or shall utilize an adapter that screws into the medium base lamp socket. Contacts shall be brass. Splices will not be allowed.

The lens shall be integral to the module, shall be convex with a smooth outer surface and shall be made of ultraviolet stabilized plastic or glass. The lens shall be capable of withstanding exposure to ultraviolet light for a minimum period of 48 months without exhibiting evidence of deterioration.

LED's shall utilize aluminum indium gallium phosphate (AlInGaap) technology and shall be the ultra bright type or equivalent rated for 100,000 hours of continuous operation from -40°C (-42°F) to +74°C (165°F).

Each individual LED shall be wired such that physical damage or the failure of 1 LED will result in the loss of not more than 5 percent of the LED signal module light output.

Maximum power consumption requirements for LED signal modules shall be specified in Table 209-5.5.11.1(A).

**TABLE 209-5.5.11.1(A)**

LED Signal Module	Power Consumption at	
	25°C (77°F)	74°C (165°F)
300 mm (11 13/16 in) Circular	25.0 Watts	30.0 Watts
200 mm (7 7/8 in) Circular	15.0 Watts	18.0 Watts
300 mm (11 13/16 in) Arrow	15.0 Watts	18.0 Watts

LED signal modules shall be rated for a minimum useful life of 48 months.

**209-5.5.11.2 Physical and Mechanical Requirements.** LED signal modules shall:

- a) Have a maximum mass of 2.0 kg (4.4 lb avoirdupois).
- b) Be rated for use in the operating temperature range of -40°C (-42°F) to +74°C (+165°F).
- c) Be protected against dust and moisture intrusion in conformance with NEMA Standard 250-1991 for Type 4 enclosures.
- d) Be manufactured to withstand mechanical shock and vibration from winds and other sources as specified in the Special Provisions.
- e) Have the manufacturer's name, trademark, model number, serial number, lot number and the month and year of manufacture permanently marked on the back of each module.
- f) Have prominent and permanent vertical markings for correct indexing and orientation within a signal housing. The markings shall consist of an "UP" arrow, or the word "UP" or "TOP".

**209-5.5.11.3 Operating Characteristics.** The following operating characteristics shall be identified and submitted to the Engineer in conformance with 2-5.3:

- a) Rated voltage,
- b) Power consumption and
- c) Volt-ampere (VA).

Enclosures, excluding the lens, containing either the power supply or electronic components of LED signal modules shall be made of UL94VO flame retardant materials.

Lens may be tinted or use transparent film or material with similar characteristics to enhance "ON/OFF" contrasts. The use of tinting or other materials to enhance "ON/OFF" contrasts shall not affect chromaticity and shall be uniform across the face of the lens. If a polymeric lens is used, a surface coating or chemical surface treatment shall be used to provide front surface abrasion resistance.

**209-5.5.11.4 Photometric Requirements.** The minimum initial luminous intensity values for LED signal modules shall conform to Section 11.94 of ITE publication ST-008B at 25°C (77°F). Luminous intensity values shall meet or exceed 85 percent of the standard light output values specified in the ITE VTCSH, after 48 months of continuous use over the temperature range of -40°C (-42°F) to +74°C (165°F) in a traffic signal operation.

Measured chromaticity coordinates shall conform to Section 8.04 and Figure 1 of the ITE VTCSH over the temperature range of -40°C (-42°F) to +74°C (165°F).

**209-5.5.11.5 Electrical Requirements.**

- a) LED signal modules shall operate over a voltage range from 95VAC to 135VAC at a frequency of 60 Hz  $\pm$  3 HZ.
- b) Fluctuations of line voltage shall have no visible effect on the luminous intensity of the indications. Rated voltage for the measurements shall be 120V.
- c) LED signal modules and associated on-board circuitry shall conform to FCC Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.
- d) Circuitry shall include voltage surge protection to withstand high-repetition noise transients as specified in Section 2.1.6 of NEMA Standard TS2-1992.
- e) Circuitry shall prevent perceptible flicker over the specified voltage range.
- f) LED signal modules shall provide a power factor of 0.90 or greater while operating throughout the temperature range of -40°C (-42°F) to +74°C (165°F).
- g) Total harmonic distortion (current and voltage) induced into an AC power line shall not exceed 20 percent while operating throughout this temperature range.
- h) Wiring and terminal blocks shall conform to Section 13.02 of the ITE VTCSH. Two secured color coded 600V, 20 AWG minimum, jacketed wires shall be provided for electrical connection for each LED signal module. The wires shall conform to the NEC, rated for service at or greater than 105°C (221°F).

LED signal modules shall be operationally compatible with the controller assemblies (solid state load switches, flashers and conflict monitors) shown on the Plans or specified in the Special Provisions.

**209-5.5.11.6 Arrow LED Signal Modules.** Arrow LED signal modules shall conform to Section 9.01 of the ITE VTCSH for arrow lenses. In addition LED's shall be spread evenly across the illuminated portion of the arrow area. Each arrow LED signal section indication shall provide an average luminous intensity of 5500cd/m<sup>2</sup> (511 cd/ft<sup>2</sup>). Measurements shall be performed at the rated operating voltage of 120VAC.

**209-5.5.11.7 Testing Requirements.** LED signal modules tested or submitted for testing shall be representative of typical average production units. Circular LED signal modules shall be tested in conformance with the requirements in California Test 604. Optical testing shall be performed with the LED signal module mounted in a standard traffic signal section but without a visor or hood attached to the signal section. The number of units tested (sample size) shall be determined by the quantity of each models in the shipment. The sample size shall conform to the American National Standard Institute/Acceptance Sampling in Quality Control, ANSI/ASQC Z1.4.

Sampling parameters to be used for the random sample testing, if any, shall be as specified in the Special Provisions. Specified parameters may be tested on the sample.

Acceptance or rejection of the shipment shall conform to ANSI/ASQC Z1.4 for shipments which are sampled randomly. Upon rejection of a shipment the Contractor shall arrange for pick-up of the rejected shipment at no cost to the Agency.

**209-5.5.11.7 Certificate of Compliance.** The Contractor shall submit a Certificate of Compliance from the manufacturer conforming to 4-1.5 in accordance with 2-5.3. The certificate shall certify that the LED signal modules comply with the requirements in these Specifications. The certificate shall also include a copy of the applicable test reports on the LED signal modules.

#### **209-5.5.12 Programmed Visibility Vehicle Signal Sections.**

**209-5.5.12.1 General.** Programmed visibility vehicle signal sections shall provide a nominal 300 mm (11-3/4 inch) diameter circular or arrow indication. Color and arrow configuration shall conform to ITE Publication ST-008B. Each signal section shall be provided with:

- a) A cap visor.
- b) An adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mounting. Terminal connections shall permit external adjustments about the mounting axis in 5 degree increments.

Signal sections shall be mountable with ordinary tools and capable of being serviced without tools.

Adjustments shall be preset at 4 degrees below the horizontal, unless otherwise specified in the Special Provisions.

**209-5.5.12.2 Programmed Visibility.** The Contractor shall program the signal section as recommended by the manufacturer, shown on the Plans or specified in the Special Provisions. The visibility of each indication shall be capable of adjustment or programming within the section. When programmed, the indication shall be visible only in those areas or lanes to be controlled, except that during dusk and darkness a faint glow to each side will be permissible.

Prior to programming, each signal section with a yellow indication shall provide:

- a) A minimum luminous intensity of 2500 cd on the optical axis.
- b) A maximum intensity of 100 cd at 15 degrees at from 0.5 to 2 degrees horizontal from the axis.
- c) A maximum of 10 cd at from 2 to 15 degrees horizontal from the axis.

Under the same conditions, the intensity of the red indication and the green indication shall be a minimum of 19 to 38 percent, respectively, of the yellow indication.

Each signal face or each signal section shall include integral means for regulating its luminous intensity between limits in proportion to the individual background luminance. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 10,000 lux and shall reduce to  $15 \pm 2$  percent of maximum intensity at less than 10 lux. The dimming device shall operate over an applied voltage range of 95 to 135 V, 60 Hz and a temperature range of  $-40^{\circ}\text{C}$  ( $-42^{\circ}\text{F}$ ) to  $74^{\circ}\text{C}$  ( $165^{\circ}\text{F}$ ).

### **209-5.6 Pedestrian Signal Sections.**

**209-5.6.1 General.** Pedestrian signal sections shall be as shown on the Plans or as specified in the Special Provisions. Message symbols shall be white "WALKING PERSON" and Portland orange "UPRAISED HAND" conforming to the requirements in the ITE "Pedestrian Traffic Control Signal Indications" and the "Manual of Uniform Traffic Control Devices. The height of each symbol shall be not less than 250mm (9-3/4 inches) and the width of each symbol shall not be less than 165mm (6-1/2 inches). Each housing including the front screen, shall have maximum overall dimensions of 470mm (18-1/2 inches) wide, 483mm (19-1/64 inches) high and 292mm (11-1/2 inches) deep. All new pedestrian signal sections installed at any one intersection shall be the same manufacturer and type.

The luminance of the "UPRAISED HAND" symbol shall be  $3750 \text{ cd/m}^2$  ( $348.56 \text{ cd/sf}$ ) minimum and the luminance of the "WALKING PERSON" symbol shall be  $5300 \text{ cd/m}^2$  ( $492.64 \text{ cd/sf}$ ), minimum, when tested in conformance with California Test 606. The uniformity ratio of an illuminated symbol shall not exceed 4 to 1 between the highest and the lowest luminance area. The luminance difference between a nonilluminated symbol and the background around the symbol shall be less than 30 percent when viewed with the visor and front screen in place and at a low sun angle.

Brightness measurements for pedestrian signal sections designed for an incandescent lamp shall be made when the signal is equipped with an A-21 traffic signal lamp operated at a voltage to produce 665 lm.

Each housing including the front screen, shall have maximum overall dimensions of 470mm (18-1/2 inches) wide, 483mm (19-1/64 inches) height and 292mm (11-1/2 inches) deep.

All new pedestrian signal sections installed at any one intersection shall be the same manufacturer and model.

### **209-5.6.2 Components.**

**209-5.6.2.1 General.** Each pedestrian signal section shall consist of a housing, two-color message plate, a reflector assembly, one incandescent lamp or one LED module conforming to 209-5.5.11, with sockets and a front screen.

**209-5.6.2.2 Message Plate.** Each message plate shall be one piece and shall be made of 3mm (1/8 inch) minimum thickness, ultraviolet stabilized polycarbonate plastic or 4.7mm (3/16 inch) tempered glass. The symbols shall be applied to the inside smooth surface of the message plate.

**209-5.6.2.3 Reflector Assembly.** Each reflector assembly shall consist of a double reflector or 2 single reflectors. Reflectors shall conform to ITE Publication ST-008B. Reflectors shall be made of either aluminum or plastic. Each completed reflector shall, when operated with the appropriate lamp and lens, provide the message brightness specified.

Plastic reflectors shall consist of molded or vacuum-formed plastic, with a vacuum-deposited aluminum reflecting surface. The plastic used shall not distort when the reflector is used with the lamp

of the wattage recommended by the manufacturer of the section. In addition, the UL nonmechanical loading temperature of the material shall not be exceeded by more than 10°C (50°F) in conformance with UL 746B.

**209-5.6.2.4 Front Screens.** Front screens shall be provided on each signal face as shown on the Plans or specified in the Special Provisions. The front screen shall not fracture, separate at the welds or compress more than 3mm (1/8 inch) when a 75 mm (2-15/16 inch) diameter, 1.8kg (4 lb) ball is dropped onto the screen from a height of 1.2m (3 feet 11-1/4 inches). The screen will be lying in a horizontal position and supported on its edges for this test. The message plate will be removed from the pedestrian signal housing, when the pedestrian housing is used to support the front screen during the test, so there will be no back support for the screen.

The screen and frame shall be fabricated from aluminum anodized flat black, or finished with lusterless black exterior grade latex paint formulated for application to properly prepared metal surfaces, or shall be fabricated from flat black plastic.

One of the following types of screens shall be provided as specified in the Special Provisions:

a) Honeycomb Screens. Honeycomb screen shall consist of:

1. Aluminum 5mm (3/16 inch) hexagon cells, 10mm (3/8 inch) thick or,
2. Plastic 10mm (3/8 inch) squares, 13mm (1/2 inch) thick with a wall thickness of 1.5mm (1/16 inch).
3. A clear front cover of 3mm (1/8 inch) minimum thickness acrylic plastic sheet or 1.5mm (1/16 inch) minimum thickness polycarbonate plastic.

Honeycomb screens shall be installed tilting downward, at an angle of  $15 \pm 2$  degrees, out from the top. Honeycomb screens shall completely cover the message plate. The honeycomb screen and cover shall be held firmly in place by stainless steel or aluminum clips or stainless steel metal screws.

b) Eggcrate or Z-crate Screens. Eggcrate or Z-crate screens shall consist of:

1. 38mm (1-1/2 inch) deep eggcrate or Z-crate screen of 0.8mm (1/32 inch) nominal thickness polycarbonate. The eggcrate or Z-crate screen shall be mounted in a frame constructed of 1mm (1/32 inch) minimum thickness aluminum alloy or polycarbonate.

Eggcrate or Z-crate screens shall be installed parallel to the face of the message plate and shall be held in place by stainless steel screws. The visor described in 209-5.6.2.6 is not required with this type screen.

**209-5.6.2.5 Housing.** Pedestrian signal housings shall conform to 209-5.5.3.

**209-5.6.2.6 Visors.** Visors shall be constructed of a material similar to the housing. The top of the visor shall extend a minimum length of 150mm (5-7/8 inches) at the top and 125mm (4-7/9 inches) at the bottom when measured from the front surface of the housing. The front shall be normal to the top.

**209-5.6.3 Finish.** The exterior of each housing and visor and the interior of the visors shall be painted in conformance with 210 or as specified in the Special Provisions.

**209-5.6.4 Controls.** Pedestrian signals sections shall be capable of being controlled by solid-state switching devices specified for traffic signal controller assemblies.

**209-5.6.5 Terminal Blocks.** Each pedestrian signal section shall be provided with a terminal block conforming to 209-4.3.3 or as specified in the Special Provisions. All field wiring shall connect to this terminal block.

**209-5.6.6 LED Pedestrian Signal Section "Upraised Hand" Module.**

**209-5.6.6.1 General.** In addition to the requirements in 209-5.5.11 these LED modules shall conform to the following specifications. The installation of the LED modules shall not require modification of a standard lamp socket or reflector. LED modules shall be designed as retrofit replacements for existing optical units and shall not require special tools for installation.

Maximum power consumption requirements for these LED modules shall be 15.0W at 25°C (77°F) and 18.0W at 74°C (165°F).

The luminance of the "Upraised Hand" symbol shall be a minimum of 3,750 cd/m<sup>2</sup> (348 cd/ft<sup>2</sup>). The color of the "Upraised Hand" shall be Portland orange conforming to the requirements of ITE "Pedestrian Traffic Control Signal Indications" and the MUTCD. The height of each symbol shall be not less than 250mm (9-27/32 inches) and the width of each symbol shall not be less than 165mm (6-1/2 inches).

The uniformity ratio of an illuminated symbol shall not exceed 4 to 1 between the highest luminance area and the lowest luminance area.

LED modules shall be rated for a minimum useful life of 48 months.

**209-5.6.6.2 Physical and Mechanical Requirements.** In addition to the requirements in 209-5.5.11 the physical and mechanical requirements for these LED modules shall conform to the following specifications.

LED modules shall not require a specific mounting orientation or have a variance in light output, pattern or visibility for any mounting orientation. Installation of LED pedestrian signal modules shall only require removal of the lamp.

LED modules shall be rated for use in the operating temperature range of -40°C to +74°C (-42°F to 165°F).

**209-5.6.6.3 Photometric Requirements.** The minimum initial luminous intensity values shall be 3750 cd/m<sup>2</sup> (347.22 cd/ft<sup>2</sup>). Luminous intensity values shall meet or exceed 85 percent of 3750 cd/m<sup>2</sup> (347.22 cd/ft<sup>2</sup>) after 48 months of continuous use over the temperature range of -40°C to +74°C (-42°F to 165°F) in a traffic signal operation.

The measured chromaticity coordinates shall conform to 5.3.2.1 and Figure C of the ITE VTCSH while operating throughout the temperature range of -40°C to +74°C (-42°F to 165°F).

**209-5.6.6.4 Electrical Requirements.** Electrical requirements for LED modules shall conform to 209-5.5.11.4 or as specified in the Special Provisions.

**209-5.6.6.5 Testing.** The LED pedestrian signal modules tested or submitted for testing shall be representative of the typical average production units. Modules shall be tested in accordance with California Test 606. Optical testing shall be performed with the module mounted in a housing as specified in the Special Provisions or on the Plans but without a visor or hood attached to the housing.

**209-5.6.6.6 Quality Assurance Testing.** Quality assurance testing may be performed by the Agency on each new light emitting diode pedestrian signal module. The number of units tested (sample size) shall be determined by the quantity of each model in the shipment. The sample size shall

conform to the requirements in the American National Standard Institute/Acceptance Sampling in Quality Control. ANSI/ASQC Z1.4.

The Engineer will determine the sampling parameters to be used for the random sample testing. The parameters specified in the Special Provisions may be tested on each sample.

The basis of acceptance or rejection of the shipment shall be the criteria specified in ANSI/ASQC Z1.4 for shipments that are sampled randomly. Upon rejection of the shipment the Contractor shall arrange for pick-up of the shipment at no cost to the Agency.

**209-5.6.6.7 Certificate of Compliance.** A Certificate of Compliance shall be submitted in conformance with 209-5.5.11.7.

**209-5.7 Signal Mounting Assemblies.** Signal mounting assemblies shall consist of Size 41 standard steel pipe or galvanized conduit, necessary fittings, slip-fitters and terminal compartments. Pipe fittings shall be ductile iron, galvanized steel, aluminum alloy Type AC-84B No. 380, or bronze. Mast arm slip-fitters, post top slip-fitters and terminal compartments shall be cast bronze or hot-dip galvanized ductile iron. After installation, any exposed threads of galvanized conduit brackets and areas of the brackets damaged shall be cleaned with a wire brush and painted with 2 applications of an approved unthinned zinc-rich primer (organic vehicle type) conforming to 210. Aerosol cans shall not be used.

Each terminal compartment shall be fitted with a terminal block containing a minimum of 12 poles, each with 2 screw type terminals. Each screw type terminal shall be designed to accommodate at least five No. 14 conductors. A cover shall be provided on the compartment to give ready access to the terminal block. Where used to bracket mount signals, the terminal compartment shall be designed to bolt securely to a pole or standard.

The horizontal dimension of the mounting assembly members between the vertical centerline of the terminal compartment or slip-fitter and the vertical centerline of each signal face shall not exceed 280 mm (11-1/32 inches), except where required to provide proper signal face alignment or permit programming of programmed visibility signal faces unless otherwise directed by the Engineer. Mounting assemblies shall be watertight and free of sharp edges or protrusions which might damage conductor insulation. Mounting assembly members shall be either plumb or level, symmetrically arranged and securely assembled. Each mounting assembly shall be provided with positive locking, serrated fittings that, when mated with similar fittings on the signal faces shall prevent the faces from rotating. Fitting shall permit fastening at increments of not more than 7 degrees. Construction shall be such as to permit all conductors to be concealed.

For post-top mounting of signals, a slip-fitter shall be used. The slip-fitter shall fit over a 115mm (4-1/2 inches) outside diameter pipe or tapered standard end. Each slip-fitter shall be provided with cadmium-plated steel set screws, arranged as shown on the plans. Each slip-fitter used to post-top mount signals with brackets shall be provided with an integral terminal compartment.

Each mounting assembly shall be oriented to provide maximum horizontal clearance to the adjacent roadway.

#### **209-5.8 Detectors.**

**209-5.8.1 General.** Vehicle detectors shall be the type or types shown on the Plans. All sensor units, control units and amplifiers shall conform to the specifications in the Special Provisions. The units shall not be affected by transient voltages when tested in conformance with the requirements in

California Test 667. After a power interruption the units shall return to normal operation within one minute.

Each unit shall be provided with a light or meter, for each output circuit, to indicate when the detector is detecting a vehicle. Each detector shall operate over the range of voltages from 100V to 135V at 60 Hz.

Circuitry shall be solid-state, except relays with normally closed contacts may be used for the output circuit. Units shall use printed circuit boards designed to facilitate identification of components. This shall be done by either part identification markings or by providing a pictorial diagram showing the physical location and identification of each component. Each printed circuit board shall conform to the following minimum quality requirements:

- a) NEMA FR-4 glass cloth base epoxy resin board, 1.5mm (1/4 inch) minimum thickness,
- b) Organic masking,
- c) Gold plated contacts.

Units shall be designed to provide vehicle detection without readjustment from  $-18^{\circ}\text{C}$  to  $71^{\circ}\text{C}$  ( $0^{\circ}\text{F}$  to  $160^{\circ}\text{F}$ ).

#### **209-5.8.2 Inductive Loop Detectors.**

**209-5.8.2.1 General.** The term "inductive loop detector" shall be defined as a complete installation consisting of a loop or group of loops installed in the roadway, as shown on the Plans, lead-in cable and sensor unit with a power supply installed in a controller cabinet.

**209-5.8.2.2 Sensor Unit Construction.** "Card" type sensor units shall conform to the requirements in "Traffic Signal Control Equipment Specifications" issued by the State of California Department of Transportation, and all addenda thereto current at the time of advertising the Contract. Shelf mounted sensor units shall conform to the requirements in Section 11 of the NEMA Standards Publication No. TS.1.

Capacitors or inductors necessary for loop tuning shall not be mounted external to the sensor unit.

**209-5.8.2.3 Construction Materials.** Conductor for inductive loop detectors shall be continuous and unspliced and shall conform to the Special Provisions or the following:

- a) Type 1 loop wire shall be Type RHW-USE neoprene-jacketed or Type USE cross-linked polyethylene insulated No. 12 stranded copper wire. The minimum insulation thickness at any point shall be 1.0mm (1/32 inch) or.
- b) Type 2 loop wire shall consist of a conductor inside of plastic tubing. The conductor shall be Type THWN or Type XHHW, No. 14 stranded copper wire. The tubing shall be polyethylene or vinyl, rated for use at  $105^{\circ}\text{C}$  ( $221^{\circ}\text{F}$ ) and shall be resistant to oil and gasoline. The tubing shall have a maximum outside diameter of 7mm (1/4 inch) and a minimum wall thickness of 0.71mm (1/32 inch). The conductors shall not be spliced inside the tubing.

Conductor for loop detector lead-in cable shall be 2 No. 16 (19 x 29) stranded tinned copper. Loop detector lead-in cable shall conform to the calculated cross sectional area of ASTM Designation B 286, Table 1. The lead-in cable shall conform to the Special Provisions or the following:

- a) Type B lead-in cable shall be insulated with 0.5 mm (1/64 inch) of high-density polyethylene. The conductors shall be twisted together with at least 6 turns per meter (3 feet 3-3/8 inches) and the twisted pair shall be protected with a copper or aluminum polyester shield. A No. 20,

minimum, copper drain wire shall be provided and connected to the equipment ground within the cabinet. The cable shall be provided with a high-density polyethylene or high-density polypropylene outer jacket with a nominal thickness of 0.8mm (1/32 inch). An amorphous interior moisture penetration barrier of nonhydroscopic polyethylene or polypropylene fillers shall be provided or.

- b) Type C lead-in cable shall conform to the International Municipal Signal Association's (IMSA) Specifications No. 50-2. A No. 20 minimum copper drain wire shall be provided and connected to the equipment ground within the cabinet.

All detector lead-in cable connections and/or terminations shall be soldered.

**209-5.8.2.4 Sealants.** The sealant for filling slots shall conform to one of the following:

- a) Elastomeric Sealant.

Elastomeric sealant shall be a polyurethane material of a composition that will within its stated shelf life, cure only in the presence of moisture. Sealant shall be suitable for use in both asphalt concrete and portland cement concrete. The cured sealant shall have the performance characteristics shown in Table 209-5.8.2.4(A).

**TABLE 209-5.8.2.4(A)**

Specifications	ASTM Designation	Requirement
Hardness (indentation) at 25°C (77°F) and 50% relative humidity (Type A Model 1700 only)	D2240 Rex.	65-85
Tensile Strength, pulled at 508 mm (20 in) per minute	D412 Die C	3.45 MPa ( 0.50 psi) min.
Elongation: pulled at 508 mm per minute	D412 Die C	400%, min.
Flex at -40°C (-40°F): 0.6 mm Free Bend (180°) over a 13 mm (1/2 inch) Mandrel.	—	No cracks
Weather Resistance: Weatherometer 350 h cured 7 days at 25°C (77°F) @ 50% relative humidity.	D822	Slight chalking
Salt Spray Resistance: 28 days at 38°C (100°F) with 5% NaCl, Die and pulled at 508 mm(20 inch) per minute.	B117	3.45 MPa ( 518 psi) min. tensile, 400% min. elongation
Dielectric Constant over a temperature range of -30°C (-22°F)	D 150	Less than 25% change

- b) Asphaltic Emulsion Sealant.

Asphaltic emulsion sealant shall conform to the State of California's Specification 8040-41A-15 and shall only be used for filling slots in asphalt concrete pavement. This material shall not be used in slots which exceed 16 mm (5/8 inch) in width or where the slope causes the material to run from the slot. The material shall not be thinned in excess of the manufacturer's recommendations and shall not be placed when the air temperature is less than 7°C (45°F).

- c) Hot-Melt Rubberized Asphalt Sealant.

Hot-melt rubberized asphalt sealant shall be in solid form at room temperature and fluid at an application temperature of 190°C (374°F) to 205°C (401°F). Fumes from the material shall be non-toxic. Sealant shall be suitable for use in both asphalt concrete and portland cement concrete.

Performance characteristics of the cured hot-melt rubberized asphalt sealant shall be as shown in Table 209-5.2.4(B).

TABLE 209-5.8.2.4(B)

Specification	ASTM Designation	Requirement
Cone Penetration, 25°C (77°F) 150g (5.3 oz), for 5 sec.	D3407, Sec. 5	3.5 mm (1/8 inch) max.
Flow, 60°C (140°F)	D3407, Sec. 6	5 mm (3/16 inch) max.
Resilience, 25°C (77°F)	D 3407, Sec. 8	25% min.
Softening Point	D 36	82°C (180°F) min.
Ductility, 25°C (77°F) 50 mm/min. (2 inch) min.	D113	300 mm (11 13/16 inches) min.
Flash Point, Cleveland Open Cup, °C (°F)	D92	288°C (550°F)
Viscosity, Brookfield Thermosel, No. 27 Spindle, 20 rpm, 190°C (374°F)	D4402	2.5-3.5 Pa·s

### 209-5.8.3 Magnetic Detectors.

**209-5.8.3.1 General.** Each magnetic detector amplifier shall be a low noise, high gain amplifier designed for use with all types of magnetic detector sensing units as specified by the Agency in the Special Provisions. Sensitivity of units shall be readily adjustable by a knob on the front panel. An indicator light shall be provided to indicate detector operation.

The sensing elements shall be no larger than 58mm (2-14 inches) in diameter and shall contain no moving parts or transistors. The element casing shall be constructed of non-ferrous materials suitable for use in the environment that it will operate in and shall be sealed to prevent the entrance of moisture. The element shall be shaped to facilitate pushing into conduit and shall not have any sharp edges along its length. The overall length of the sensing elements shall not exceed 530mm (20-7/8 inches).

**209-5.8.3.2 Performance Characteristics.** Each magnetic detector shall be capable of being activated by a voltage induced in the coil of the sensing element by the passage of a vehicle at any speed from 5 to 130km/hr (3 to 81 mph). Any vehicle passing within 450mm (17-3/4 inches) of either end of the sensing elements shall provide an output closure.

**209-5.8.3.3 Amplifier Unit Construction.** Each amplifier shall be provided with an integral power supply. Each amplifier shall be designed to provide ease of maintenance with all electronic components readily accessible. All input and output circuits for each amplifier shall enter via a single MS connector. Connector circuitry for the amplifiers shall be as shown in the Table 209-5.8.3.3(A).

Table 209-5.8.3.3(A)

MS Connector Circuit	18 – 8 Pin
Magnetic Detector (-)	A
Magnetic Detector (+)	B
120 V, (ac+)	C
Chassis Ground	D
Detector Common	F
Output N.O.	F
Output N.C.	G
Grounded Conductor, (AC-)	H

All controls, indicator lights, fuse holders and connectors shall be mounted on the front of the amplifier.

**209-5.8.3.4 Construction Materials.** The cable from the pull box adjacent to the magnetic detector sensing element to the field terminals in the controller cabinet shall be the type specified for inductive loop detectors.

**209-5.9 Pedestrian Push Button Assemblies.** Pedestrian push button assembly housings shall be either die-cast or permanent mold cast aluminum or, when specified in the Special Provisions, shall be ultraviolet stabilized, self-extinguishing, structural plastic. Plastic housings shall be black matching Color No. 17038, 27038 or 37038 of Federal Standard No. 595B or as specified by the Agency in the Special Provisions and shall be colored throughout. Assemblies shall be rainproof and shockproof in any weather conditions.

Switches shall be the phenolic enclosed precision snap-acting type, single-pole, double-throw, switching unit, with screw type terminals, rated 15A at 125VAC, and shall conform to the following:

- a) Have a stainless steel plunger actuator and be provided with a U-frame to permit recessed mounting in the push button housing.
- b) Have an operating force of 2.5N (9oz) to 3.6N (13oz) and a minimum release force of 1N (4oz).
- c) Pre-travel shall be 0.4mm (1/64 inch) maximum.
- d) Overtravel shall be 0.6mm (1/32 inch) minimum.
- e) Differential travel shall be 0.01mm to 0.05mm.
- f) The actuator shall have a minimum diameter of 50mm (1-31/32 inches).

Pedestrian push button signs shall be porcelain enameled metal or structural plastic.

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REVISE THE SIXTH LINE OF 213-1.5.5 TO READ:

2°C (4°F). Asphalt cement shall be PG 64-10. Specimen hanging rack shall consist of a

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REVISE 302-1 TO READ:

**302-1 COLD MILLING OF EXISTING PAVEMENT.**

**302-1.1 General.** The Contractor shall cold mill existing pavement as shown on the Plans and specified in the Special Provisions. The type of pavement and depth to be cold milled shall be as shown on the Plans or specified in the Special Provisions. The presence of pavement fabric, rubberized material (i.e. ARHM, REAS, ARAM's, etc.), or steel reinforcement within the depth to be cold milled shall be noted on the Plans or in the Special Provisions. The surface after cold milling shall be uniformly grooved or ridged unless otherwise specified in the Special Provisions. The outside lines of the milled pavement shall be neat and uniform.

The milled pavement shall be true to grade and cross section. When the straightedge specified in 302-5.6.2 is laid on the finished surface parallel to the centerline of the roadway, the surface shall not vary from the edge of the straightedge more than 10mm (3/8 inch) at any point, except at intersections or at changes of grade. Any areas that are not within tolerance shall be brought to grade within 1 working day following initial cold milling.

Cold milling operations shall be performed without damage to the remaining pavement. Whenever cold milling is adjacent to existing Portland cement concrete curbs, gutters or pavement, the Contractor shall protect these improvements from damage. Any Portland cement concrete curbs, gutters or pavement damaged during cold milling operations shall be repaired as directed by the Engineer at the Contractor's

expense. Any Portland cement concrete curbs, gutters or pavement that is cracked or displaced shall be removed and replaced at the Contractor's expense. Replaced sections of Portland cement concrete curb, gutter or pavement shall be a minimum of 1.52m (5 feet) in length or to the next joint.

**302-1.2 Milling Machine.** Milling machines shall be specially designed for cold milling of asphalt concrete, Portland cement concrete, or a combination of asphalt and Portland cement concrete pavement. Milling machines shall conform to the following:

- a) The cutting drum shall be a minimum of 1500 mm (60 inches) wide and shall be equipped with carbide-tipped cutting teeth placed in a variable pattern to produce the desired finish.
- b) Be self-propelled and capable of removing the pavement to the depth shown on the Plans.
- c) Be equipped with a conveyor system that will immediately convey the milled material into a transport vehicle for disposal as specified in the Special Provisions.
- d) Have the capability of spraying water at the cutting drum to minimize dust.
- e) Be designed so that the operator can observe the milling operation, at all times, without leaving the controls.
- f) Be adjustable for slope and depth.
- g) Be able to deep cut, in one pass, to the maximum depth recommended by the manufacturer without producing fumes or smoke.

The Contractor shall provide smaller machines if required to cold mill areas that are inaccessible to the larger machine and to provide the surface specified in the Special Provisions.

### **302-1.3 Cold Milling to Specified Elevations.**

**302-1.3.1 General.** Milling to specified elevations is the controlled removal of a portion of the existing pavement and underlying base or substrate. The finished elevations and depth of cut shall be as shown on the Plans or specified in the Special Provisions.

**302-1.3.2 Milling Machine.** Milling machines used for milling to specified elevations shall conform to 302-1.2. The machines shall also be equipped with automatic grade controls that reference the existing pavement elevations or independent grade references. The references shall be those required to achieve the specified elevations shown on the Plans.

### **302-1.4 Profile Milling.**

**302-1.4.1 General.** Profile milling is the controlled removal of a portion of the existing pavement to a nominal depth using longitudinal grade controls to remove surface irregularities in the pavement and improve ride ability. The grade shall be as shown on the Plans.

**302-1.4.2 Equipment.** Milling machines used for profile milling operations shall conform to 302-1.2. The Contractor shall also use a minimum 6m (20 foot) paving ski with spring loaded feet attached to the bottom at not more than 0.5m (18 inch) increments. The upper portion of the ski shall be one-piece and manufactured such that the ski does not flex or bend by more than 5mm (3/16 inch) when supported off of the surface of the pavement by an attachment located at the ski's longitudinal center of gravity. The grade control system of the milling machine shall be referenced to the center of the ski. During profile milling operations, the center of the ski shall be on a line coincident with the transverse centerline of the milling machine's cutting drum. A ski shall be attached to each side of the milling machine cutting drum during the first pass, and on one side of the milling machine on subsequent, adjacent passes with a joint matching grade control on the other side.

The resultant milled surface shall not deviate from the grade shown on the Plans, using the straight edge specified in 302-5.6.2, by more than 6mm (1/4 inch) at any point.

### **302-1.5 Full Depth Milling.**

**302-1.5.1 General.** Full depth milling is the removal of the full depth of the existing pavement as shown on the Plans or specified in the Special Provisions. When full depth milling is specified, the Contractor shall continuously control the depth of milling to stay no more than 13mm (1/2 inch) below the full depth of the existing pavement. In areas of resurfaced trenches, individual excavations or bore holes, the required depth of milling shall be the same as that of the adjacent pavement. The Contractor shall remove existing asphalt concrete overlay from gutters adjacent to any area specified to be cold milled, as directed by the Engineer.

**302-1.5.2 Equipment.** Milling machines used for full depth milling of pavement shall conform to 302-1.2 and be capable of milling a minimum depth of 250mm (10 inches) in a single pass.

**302-1.6 Cold Milling of Composite Pavements.** Composite pavements are pavements that consist of more than one material overlaid with another (e.g. Portland cement concrete overlaid with asphalt concrete). The thickness of each existing pavement material shall be shown on the Plans. The area and depth of a composite pavement to be cold milled shall be as shown on the Plans.

**302-1.7 Work Site Maintenance.** Work site maintenance shall conform to 7-8. A motorized street sweeper shall follow within 15 m (50 feet) of the cold milling machine unless otherwise approved by the Engineer.

**302-1.8 Disposal of Millings.** Unless otherwise specified in the Special Provisions all material removed shall be considered the property of the Contractor and shall be disposed of by the Contractor.

**302-1.9 Traffic Signal Loop Detectors.** The Contractor shall not mill within 300mm (12 inches) of any existing loop detectors that are shown to be protected in place on the Plans or in the Special Provisions. Traffic signal loop detectors that were shown to be protected in place but are damaged or removed shall be replaced in conformance with 7-9.

**302-1.10 Pavement Transitions.** Structures and vertical joints within the cold-milled areas that are transverse to through traffic shall be ramped in conformance with 7-10 and 306-1.5.1. Ramps shall be constructed the same day as the existing pavement is cold milled and removed prior to placement of the permanent paving.

**302-1.11 Measurement.** Cold milling will be measured by the linear meter (foot) along the edge of the transverse joint lines, adjacent curb, gutter, or cross gutter, or by the square meter (square foot) as shown in the Bid. The amount of each type of pavement cold milled (asphalt, concrete, or composite pavement) shall be measured separately.

### **302-1.12 Payment.**

The Contract Unit Price for cold milling each type of pavement shall include cold milling, construction and removal of pavement transitions, disposal of millings, and all other necessary work.

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DELETE 302-5.2 AND REPLACE WITH THE FOLLOWING:

302-5.2 (Not Used.)

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REVISE 302-5.4 TO READ:

**302-5.4 Tack Coat.** If the asphalt concrete pavement is being constructed directly upon an existing hard-surfaced pavement, a tack coat of PG 64-10 paving asphalt at an approximate rate of  $0.25 \text{ L/m}^2$  (0.05 gallon per square yard) or SS-1h emulsified asphalt at an approximate rate of  $0.25 \text{ L/m}^2$  to  $0.45 \text{ L/m}^2$  (0.05 to 0.10 gallon per square yard) shall be uniformly applied upon the existing pavement preceding the placement of the asphalt concrete. The surface shall be free of water, foreign material, or dust when the tack coat is applied. To minimize public inconvenience, no greater area shall be treated in any one day than is planned to be covered by asphalt concrete during the same day, unless otherwise approved by the Engineer.

A similar tack coat shall be applied to the surface of any course, if the surface is such that a satisfactory bond cannot be obtained between it and a succeeding course.

The contact surfaces of all cold pavement joints, curbs, gutters, manholes, and the like shall be painted with either SS-1h emulsified asphalt or PG 64-10 paving asphalt immediately before the adjoining asphalt concrete is placed.

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REVISE THE FIRST LINE OF 302-7.2.2 TO READ:

**302-7.2.2 Tack Coat.** The tack coat shall be PG 64-10 paving asphalt.

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REVISE 400-1.1.2 TO READ

**400-1.1.2 Source.** Before beginning portland cement concrete and asphalt concrete work, the Contractor shall submit the name of the supplier to the Engineer as specified in 2-5.3. The supplier shall have on file with the Agency mix designs for portland cement concrete conforming to 201-1.1.1, and asphalt concrete conforming to 203-6.2, when required by the Specifications.

The Contractor or supplier shall resubmit required information when any change is made.

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REVISE 400-4.1 TO READ:

**400-4.1 General.** Asphalt concrete shall be a mixture of mineral aggregate and up to 15 percent reclaimed asphalt pavement (RAP) with paving asphalt conforming to 203-6.1 at a central mixing plant. RAP shall conform to 203-7.2.2, except the viscosity of RAP asphalt recovered in accordance with ASTM D 1856 (Absorption Recovery Method) will not be required. RAP asphalt content may be determined in accordance with Calif. Test 382 except the aggregate correction factor shall not be applied.

This material will be designated by the type of asphalt concrete, class and grade, i.e., "III-B2-PG 64-10". Unless otherwise specified on the Plans or in the Special Provisions, III-B3-PG 64-10 shall be used. Asphalt concrete containing up to 15 percent RAP shall be identified by adding the suffix "RAP" to the class and grade, i.e., "III-B2-PG 64-10 RAP".

Acceptance of asphalt concrete shall conform to 203-6.4.1.

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ADD THE FOLLOWING TO 500-1.1.7:

- e) **End Seals.** The beginning and end of the new pipe liner shall be sealed to the host pipe with an epoxy or other material. The epoxy or other material shall conform to 211-2 and be submitted for approval to the Engineer in conformance with 2-5.3. The approved epoxy or other material shall be compatible with the lining material and host pipe and shall provide a watertight seal. The finished liner shall protrude a minimum of 25mm (1 inch) and a maximum of 50mm (2 inches) into the manhole, unless otherwise shown on the Plans or specified in the Special Provisions. Liner material shall be cut smooth and parallel with the manhole wall. The interface between the host pipe and the pipe liner shall be sealed 360 degrees. When the pipe liner extends through the manhole it shall be sealed as shown on the Plans and as specified in the Special Provisions.

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REVISE THE HEADING FOR 500-1.3 TO READ:

**500-1.3 HDPE Solid-Wall Pipe Liner.**

## — PAGE 409 —

REVISE THE HEADING FOR 500-1.3.8 TO READ:

**500-1.3.8 Service Connections and End Seals.**

REVISE THE HEADING FOR 500-1.4 TO READ:

**500-1.4 Cured-In-Place Pipe Liner.**

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REVISE THE HEADING FOR 500-1.4.7 TO READ:

**500-1.4.7 Service Connections and End Seals.**

REVISE THE HEADING FOR 500-1.5 TO READ:

**500-1.5 PVC Pipe Lining System.**

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REVISE THE HEADING FOR 500-1.5.8 TO READ:

**500-1.5.8 Service Connections and End Seals.**

— PAGE 414 —

REVISE 500-1.7.7 TO READ:

**500-1.7.7 Service Connections and End Seals.** Existing service connections shall be reinstated through the use of a remote control unit or excavation. Service connections and end seals shall conform to 500-1.1.7.

The beginning and end of the new HDPE pipe liner shall be sealed to the rehabilitated host pipeline. If sealing material is required, it shall be compatible with the HDPE pipe and shall provide a watertight seal.

DELETE 500-1.7.8

REVISE THE HEADING FOR 500-1.7.9 TO READ:

**500-1.7.8 Repair and Rejection.**

REVISE THE HEADING FOR 500-1.8 TO READ:

**500-1.8 CCFRPM Liner Pipe.**

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REVISE 500-1.8.8 TO READ:

**500-1.8.8 Service Connections and End Seals.**

Service Connections and end seals shall conform to 500-1.1.7.

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REPLACE "FLEXIBLE" WITH "FLEXURAL" IN THE EIGHTH LINE OF 500-1.10.3 (f), 6).

REVISE 500-1.10.4 TO READ:

**500-1.10.4 Service Connections and End Seals.** Service connections and end seals shall conform to 500-1.1.7.

DELETE 500-1.10.5.

REVISE THE HEADING FOR 500-1.10.6 TO READ:

**500-1.10.5 Repair and Rejection.**

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REVISE 500-1.11.9 TO READ:

**500-1.11.9 Service Connections and End Seals.** Service connections shall be exposed and connected to the liner pipe by use of a saddle approved by the Engineer as specified in 2-5.3. Service connections and end seals shall conform to 500-1.1.7.

REVISE THE HEADING FOR 500-1.12 TO READ:

**500-1.12 PVC Closed Profile Liner Pipe.**

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REVISE 500-1.12.8 TO READ:

**500-1.12.8 Service Connections and End Seals.** Service connections and end seals shall conform to 500-1.1.7.

REVISE THE HEADING FOR 500-1.13 TO READ:

**500-1.13 Machine Spiral Wound PVC Pipe Liner.**

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REVISE 500-1.13.7 TO READ:

**500-1.13.7 Service Connections and End Seals.** Service connections and end seals shall conform to 500-1.1.7.

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ADD 500-2.5 TO READ:

**500-2.5 Epoxy Mastic and Flexible PVC Liner System.**

**500-2.5.1 General.** This subsection describes the installation of the mastic primer and epoxy mastic that bonds to the cleaned, repaired and prepared interior concrete substrate, then follows with the mechanical locking of the flexible PVC liner into the epoxy mastic. The integral locking extensions in the flexible PVC liner are embedded to their full depth into the epoxy mastic.

**500-2.5.2 Materials.**

**500-2.5.2.1 Plastic Liner.** The liner shall be manufactured from a PVC compound in accordance with 210-2. The plastic liner shall be a flexible PVC Liner with a minimum thickness of 1.65 mm (1/16 inch) and conform to 210-2.4.

**500-2.5.2.2 Mastic Primer.** The epoxy mastic primer shall be a two-part coating that is applied to the prepared concrete substrate.

**500-2.5.2.3 Epoxy Mastic.** The epoxy mastic shall be a two-part 100% epoxy coating for bonding and filling voids in properly prepared concrete substrate.

**500-2.5.3 Locking Extensions.** All liner to be embedded in the epoxy mastic shall have integral locking extensions and meet the requirements of 210-2.2.4 except for the dimensions requirement. The locking extensions shall have a shape, height, web thickness, and spacing that will allow the liner to be held permanently in place and be able to meet the pull-out requirements of 500-2.5.9.

**500-2.5.4 Chemical Resistance and Physical Property Testing.** The plastic liner sheet and accessories shall conform to 211-2 and 210-2.4.

**500-2.5.5 Preparation and Repair of Substrate.** Prior to applying the mastic primer, the structure shall be cleaned and prepared in accordance with 311-1.6 and repaired in accordance with 311-1.9.

**500-2.5.6 Installer Qualifications.** Applicators and welders of the plastic liner shall be qualified in accordance with 311-1.2.

**500-2.5.7 Installation.**

**500-2.5.7.1 Priming.** The mastic primer shall be applied to 76  $\mu\text{m}$  (3 mils) minimum to 127  $\mu\text{m}$  (5 mils) maximum thickness. The primer shall be allowed to dry before applying the epoxy mastic.

**500-2.5.7.2 Epoxy Mastic Application.** A finishing trowel or other suitable tool shall be used to apply the epoxy mastic to a uniform minimum thickness of 6.4 mm (1/4 inch).

**500-2.5.7.3 Plastic Liner Application.** The plastic liner shall be placed while the wetting ability of the epoxy mastic is at its optimum, be pressed into the mastic, and rolled to remove any trapped air. The lining system shall be allowed to cure for the amount of time recommended by the lining manufacturer. The average dry film thickness of the cured lining system, including the liner sheets and the applied epoxy mastic, when completed shall not be less than 8 mm (315 mils).

**500-2.5.8 Field Jointing of Liner.**

**500-2.5.8.1 General.** The Contractor shall utilize the maximum size plastic liner sheet that is practical and will provide the minimum number of seams. Vertical and horizontal seams shall overlap a minimum of 13 mm (1/2 inch) and shall be welded with 25 mm (1 inch) weld strips. Corner strips may be used at inside and outside corners, or liner may be wrapped around corners. The Contractor shall be allowed to heat the liner to facilitate turning corners. Excessive heating of the liner material to facilitate turning corners shall be avoided.

**500-2.5.8.2 Field Joints in Manhole and Structure Rehabilitation.** Field joints in the liner shall be Type AL-2 unless AL-1 or AL-3 is approved by the Engineer.

- a) Type AL-1 joint shall consist of a 100 mm (4 inch) wide joint strip centered over a 25 mm (1 inch) maximum gap between sheets and securely welded along each edge of adjacent liner with a 25 mm (1 inch) welding strip.
- b) Type AL-2 joints shall be made with integral joint flaps with locking extensions removed 25 mm (1 inch) from one side per 210-2.2.6. The flap shall be overlapped a minimum of 13 mm (1/2 inch) and the overlap secured to the adjacent liner by means of a 25 mm (1 inch) welding strip.
- c) Type AL-3 joints shall consist of a 25 mm (1 inch) wide weld strip centered over a 6 mm (1/4 inch) maximum gap between sheets and securely welded along each edge of adjacent liner.

**500-2.5.8.3 Installation of Welding Strips.** Installation of welding strips shall conform to 311-1.5.4.

**500-2.5.9 Pull Test for Locking Extensions.** Liner locking extensions embedded in epoxy mastic shall withstand a test pull of at least 3.5N per linear mm (20 pounds per linear inch), applied perpendicularly to the concrete surface for a period of 1 minute without rupture of the locking extensions or withdrawal from the epoxy mastic or delaminating of the mastic from the concrete substrate. This test shall be made at a temperature between 21°C to 27°C (70°F to 80°F).

**500-2.5.10 Inspection.** After installation of the protective lining system, the surface of the liner shall be cleaned and prepared by the Contractor and then inspected by the Engineer. Field testing shall be in accordance with 311-1.10.

**500-2.5.11 Repair of Defects and Holidays.** The Contractor shall repair all defects and damage in the plastic liner in accordance with 311-1.9.

— PAGE 436 —

REVISE THE FIRST LINE OF 600-4.2.1 TO READ:

**600-4.2.1 Asphalt Rubber.** Paving asphalt used for asphalt rubber shall be PG 64-10 conforming to 203-

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Office of Design A

FOR CONTRACT NO.: 07-2159C4

# INFORMATION HANDOUT

## **MATERIALS INFORMATION**

Los Angeles County Sanitary District Amendments, 2006

Amendments to  
Standard Specifications for  
Public Works Construction  
2006 Edition  
&  
Standard Drawings for Construction

**ROUTE: 07-LA-5, KP 2.9/4.9**

AMENDMENTS TO THE STANDARD  
SPECIFICATIONS FOR PUBLIC WORKS  
CONSTRUCTION, 2006 EDITION

AND

STANDARD DRAWINGS  
FOR CONSTRUCTION



COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

AMENDMENTS TO THE STANDARD SPECIFICATIONS  
FOR PUBLIC WORKS CONSTRUCTION  
2006 EDITION

- A. Provisions contained in this document amend the "Standard Specifications For Public Works Construction" (SSPWC), 2006 Edition.
- B. The provisions have been arranged in a format and sequence that parallels the SSPWC. As a reference convenience, page numbers of the sections and subsections in the SSPWC to be amended are provided. These page numbers indicate the page on which a particular section or subsection begins and may not necessarily be the page on which the amendment occurs. An amendment may occur on a page subsequent to that referenced if the section or subsection being amended appears on multiple pages of the SSPWC.
- C. A vertical line in the margin denotes a change in the text adopted by the Board of Directors of the Districts since Amendments dated December 2003. This is done as a courtesy to the user of this document. The Districts do not guarantee that all changes are marked. The user should compare these Amendments with the previous edition and should not rely on the accuracy of the lines in the margins. The Districts declaim any responsibility or liability for any errors or omissions.

Approved \_\_\_\_\_

*Stephen R. Maguin*

STEPHEN R. MAGUIN  
CHIEF ENGINEER  
C.E. NO. 23089



Whenever any one or more of the County Sanitation Districts of Los Angeles County construction projects are to be constructed pursuant to "Standard Specifications for Public Works Construction," the amendments herein contained shall apply to said Standard Specifications. Reference to "Standard Specifications for Public Works Construction" is the 2006 Edition of said specifications.

The section numbering used herein is identical to that in said Standard Specifications.

**-PAGE 1-**

IN 1-2 **DEFINITIONS, Agency**, DELETE THE SENTENCE AND REPLACE WITH THE FOLLOWING:

"The District or Districts for which the Work is being performed. The discretion conferred upon the Agency by the Specifications or District Amendments, whether designated Agency, District or Districts, may be exercised by the Engineer."

IN 1-2 **DEFINITIONS, Contractor**, ADD THE FOLLOWING TO THE END:

"The term "General Contractor" shall mean Contractor."

IN 1-2 **DEFINITIONS, Service Connection**, ADD THE FOLLOWING TO THE END:

", including House Connection Sewer"

IN 1-2 **DEFINITIONS**, ADD THE FOLLOWING TO THE LIST:

"**District or Districts** - See **Agency**."

**Equipment Manufacturer, Vendor, Equipment Supplier or Supplier** - Any person, firm, corporation, partnership, or any combination thereof, which enters into a contract with the Contractor to supply specified materials or equipment and/or install equipment, or provide services as part of the Work of the Contract.

**Fiberglass Liner Pipe** - Centrifugally Cast Fiberglass Reinforced Plastic Mortar (CCFRPM) Liner Pipe.

**Major Bid Item** - a single Contract item constituting 10 percent or more of the original Contract Price."

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IN 1-3.2 **Common Usage**, ADD THE FOLLOWING TERMS TO THE LIST:

"CMP.....Corrugated Metal Pipe.

FRP.....Fiberglass reinforced plastic.

ESRP .....Emergency Spill Response Plan.

FRPM.....Fiberglass reinforced plastic mortar.

HDPE .....High density polyethylene.

LCRS.....Leachate collection and removal system

RGRCP...Rubber Gasket Reinforced Concrete Pipe

SDIs.....Storm drain inlets"

-PAGE 8-

IN 1-3.3 Institutions, ADD THE FOLLOWING TO THE LIST:

"ACI.....American Concrete Institute"

-PAGE 9-

IN 2-1 AWARD AND EXECUTION OF CONTRACT, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Proposals shall be submitted on the proposal forms prepared and furnished for the purpose, which may be obtained at the office of the Engineer at the address indicated on the Notice Inviting Bids. When presented they must be completely made out in the manner and form indicated therein, showing the proposed prices clearly and legibly, and must be properly signed by the bidder, whose address, telephone number, and California contractor's license number shall also be shown.

Each proposal submitted, together with the required proposal guaranty prescribed, shall be presented under sealed cover and must be filed prior to the time, and at the place, designated in the Notice Inviting Bids. A proposal may be withdrawn by the bidder, provided the request therefore is made in writing and is filed with the Board Secretary prior to the time fixed for the opening of bids. No proposals received after the time set for opening of the proposals will be considered. All proposals will be publicly opened and read at the time and place indicated in the Notice Inviting Bids.

The Plans and Specifications to which the proposal forms refer are on file and open to inspection in the office of the Engineer. Copies of the Plans, Standard Drawings, amendments to the Standard Specifications for Public Works Construction, Special Provisions, and Subsurface Investigation Report, if any, may be obtained at said office without cost unless a non-refundable fee is specified in the Notice Inviting Bids.

The quantities shown on the proposal form are to provide a basis for comparison of bids; they are based on the Plans and Specifications and on other information which is also available to the bidder. They are in some cases estimates and do not necessarily indicate the exact quantities that may be involved.

Each proposal submitted must be accompanied either by a certified or cashier's check, or a surety bond, payable to the District, in an amount equivalent to at least ten percent of the total aggregate bid price of such proposal, as a guarantee that the bidder, if his proposal be accepted, will enter into and execute the awarded contract; and no proposal will be accepted unless such check or surety bond is enclosed therewith. If the bidder desires to submit a bond with a proposal instead of a certified or cashier's check, the bidder must comply with all applicable laws including Code of Civil Procedure, Section 995.630.

Should any bidder to whom an award is made fail to properly enter into and execute the awarded contract, the amount of the check or bond submitted shall be presumed to be the amount of damage sustained by the District by reason thereof and shall be retained by, or the security shall inure to the benefit of the District. In such case, it is recognized that actual damage would be impracticable or extremely difficult to fix.

More than one proposal for the same work from any individual, firm, partnership, corporation or association under the same or different name will not be accepted, and reasonable ground for believing that any bidder is interested as a prime contractor in more than one proposal for the work will be cause for

rejecting all proposals in which such bidder is interested. Apparent collusion among the bidders will likewise be sufficient cause for rejecting any or all bids, and the participants in collusion may be barred from future bidding.

Proposals in which the unit prices are unbalanced, and those which are incomplete or show any alteration of form, erasures, or irregularities of any kind, or contain any additions of conditional or alternate bids that are not called for or otherwise permitted, may be rejected.

Bidders must be thoroughly competent and capable of satisfactorily performing the work covered by the proposal; and when requested, shall furnish such statements relative to previous experience on similar work, and plan of procedure proposed, and the organization, machinery, plant and other equipment, available for the contemplated work, and the financial condition and resources of the bidder, as may be deemed necessary by the District in determining such competence and capability.

The right is reserved to reject all bids and to waive technical defects as the interest of the District may require. In the event of any such rejection, the District shall not be liable for any costs incurred in connection with the preparation and submittal of a bid.

Proposals will not be accepted from bidders who are not licensed as Contractors under the provisions of Chapter 9 of Division 3 of the Business and Professions Code at the time of bid, unless legally exempted from such requirement.

If an award is made, it will be to the responsible bidder submitting the lowest responsive bid.

Unless otherwise specified in the bid documents, the bidder shall within 15 calendar days after the agreement has been received by the bidder or bidder's authorized agent, sign, date, and return to the District the agreement for the doing of the work, and furnish good and sufficient bonds as specified in the Specifications, subject to the approval of the District, for the faithful performance of the agreement and for the payment of all labor performed and materials used on the Work. The agreement shall be effective from the execution date inserted thereon by the bidder. In the event the bidder does not return the signed agreement and bonds within the calendar days specified, a day will be subtracted from the completion time specified for each working day beyond the calendar days specified, until the agreement and bonds are executed, dated and returned. Alternatively unless otherwise provided in the Special Provisions, the District may at any time after 15 calendar days after the agreement has been received by the bidder or bidder's authorized agent, give written notice to the bidder that it is in default. Unless the bidder within five days of its receipt or its authorized agent's receipt of said notice, signs, dates and returns to the District the agreement and required bonds, the bid bond or other form of bid security shall be paid to the District as liquidated damages."

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IN **2-3.2 Additional Responsibility**, DELETE THE LAST TWO PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"The Contractor shall perform, with its own organization, Contract work amounting to at least 50 percent of the Contract Price."

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IN **2-4 CONTRACT BONDS**, FOURTH PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"The "Performance Bond" shall remain in full force and effect through the guarantee period."

IN **2-5.1 General**, AFTER THE SECOND PARAGRAPH, ADD THE FOLLOWING:

"Every part of the work as specified and shown in the Contract Documents shall be completed and approved. The Engineer has the right to reject any deviation or exception to the Plans, Specifications or related documents proposed by the Contractor or equipment manufacturers. The Plans have been drawn to the indicated scales, except where otherwise noted. Dimensions indicated by figures or numerals shall govern in all cases whether drawn to scale or not. On any drawings where a portion of the work is drawn out or detailed and the remainder is indicated in outline, the drawn out or detailed parts shall apply in all cases. Any bills of material, material take-offs, or lists of bulk material quantities as listed in the Contract Documents are estimated quantities subject to final take-offs by the Contractor. Changes in these quantities due to final definitive take-offs by the Contractor shall not be grounds for an extra work request."

IN **2-5.1 General**, AFTER THE FIFTH PARAGRAPH, ADD THE FOLLOWING:

"Each bidder shall be responsible for visiting the site of the Work prior to submitting a bid, examining all the existing conditions and ascertaining all necessary work entailed by the Plans and Specifications. By submitting a bid for this Work, the bidder shall be deemed to have made such examination, and that he is familiar with and accepts all conditions of the jobsite.

The dimensions and elevations of existing structures and locations of existing equipment, pipelines and grades shown on the Plans were taken, for the most part, from original plans and are not guaranteed for accuracy. It shall be the responsibility of the Contractor to check dimensions and elevations of existing structures, pipelines, grades or other existing items affected by or affecting the work under this Contract, prior to the start of construction or ordering of materials and equipment affected thereby. Delay or extra expense to the Contractor which is due to encountering construction, piping, or grades not shown or in locations different from those indicated on the Plans, and which could have been avoided by the required field check, shall not constitute a claim for extra work, additional payment, time extension, or damages. The Contractor shall be solely responsible for determining the extent and cost of removal and salvage operations."

IN **2-5.1 General**, LAST PARAGRAPH, LAST SENTENCE, ADD THE FOLLOWING TO THE END:

"who will issue instructions on the method to proceed. If the Contractor proceeds with the work so affected, without instructions from the Engineer, the incorrect work shall be removed at no cost to the Districts, and such an action shall not be grounds for delay or time extension claims by the Contractor. The necessary corrections shall be made to comply with the Engineer's instructions. Except for the foregoing, compensation will be made for legitimate extra work."

IN **2-5.2 Precedence of Contract Documents**, FIRST PARAGRAPH, FIRST SUBPARAGRAPH, DELETE THE WORD "regulatory".

IN **2-5.2 Precedence of Contract Documents**, LAST PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Detailed plans and detailed notes on Plans shall have precedence over general plans and general requirements of the Special Provisions. Within each category of the documents, if there is any conflict, the most stringent requirement shall control. Changes made by the Districts to the document that is highest in priority shall be considered adequate to convey scope of work since lower priority documents may not be changed by the Districts. The Contractor shall be responsible for all necessary cross-checking."

IN 2-5.3 Submittals, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Shop drawings shall be prepared by the manufacturer, fabricator, or Subcontractor and submitted by the Contractor. Shop drawings are drawings showing details of manufactured or assembled or shop fabricated products to be incorporated into the Work. Where the manufactured item is designed by the manufacturer, fabricator, Subcontractor, consultant or designee, the drawings and supporting calculations shall be stamped by an engineer registered by the State of California executing the design within the scope of his registration. Working drawings are drawings showing details not shown on the Plans which are required to be designed by the Contractor. Working drawings shall be of a size and scale to clearly show all necessary details.

When working drawings, shop drawings, other drawings, or submittals are required by the Plans or Specifications, or requested by the Engineer, they shall be prepared in accordance with current modern engineering practice at the Contractor's expense. Drawings shall be of size and scale to show clearly all necessary details. Materials shall not be furnished or fabricated nor any work done for which drawings or submittals are required, before approval of the drawings or submittals. Any submittals reviewed and processed by the Districts prior to issuance of the Notice to Proceed are done to expedite the schedule and as a courtesy to the Contractor. The Contractor shall assume full responsibility and risks should he decide to proceed with the ordering and/or purchasing of any of the approved materials prior to the Districts' issuance of the Notice to Proceed.

Engineering data covering all equipment and fabricated materials to be furnished shall be submitted to the Districts for approval. Working drawings, shop drawings or other drawings and supporting calculations are required in, but not limited to, the sections shown in Table 2-5.3(A):

TABLE 2-5.3 (A)

Item	Section Number	Title	Subject
1	7-10.4.1	Safety Orders	Shoring and Excavation Plan
2	207-2.1	General	Reinforced Concrete Pipe
3	207-2.5	Joints	Reinforced Concrete Pipe
4	207-8.4	Joints	Vitrified Clay Pipe
5	207-10.2	Fabricated Steel Pipe	Steel Pipe
6	207-25	Precast Manhole Shafting	Precast Manholes
7	300-3.2	Cofferdams	Structure Excavation and Backfill
8	303-1.7	Placing Reinforcement	Concrete Structures - Working or Shop*
9	303-3.1	General	Prestressed Concrete Construction
10	304-1.1.1	Shop Drawings	Structural Steel
11	304-2.1	Metal Hand Railings	Metal Railings
12	306-1.1.8	Dewatering	Dewatering Plan
13	306-2	Jacking Operations	Underground Conduit Construction
14	306-3	Tunneling Operations	Underground Conduit Construction

Item	Section Number	Title	Subject
15	306-3.4	Tunnel Supports	Tunneling Operations
16	306-8	Microtunneling Operations	Underground Conduit Construction
17	500-1.1.7(e)	Bypassing Requirements	Flow Bypass Plan

\*Drawings, Bend and Bar Lists

Working or shop drawings and calculations for Items 1, 7, 9, 10, 11, 12, 13, 14, 15, and 16 listed above shall be prepared, stamped, and signed by a Civil or Structural Engineer currently registered by the State of California. In addition, dewatering plan shall be reviewed and stamped by a Geotechnical Engineer currently registered by the State of California.

Unless otherwise approved by the Engineer, data shall be submitted only by the prime Contractor who shall indicate by a signed stamp on the drawings, or other approved means, that he (the Contractor) has checked the data, and that the work shown is in accordance with contract requirements and has been checked for dimensions and relationship with work of all other trades involved. The practice of submitting incomplete or unchecked data to the Engineer for approval will not be acceptable. The data which, in the opinion of the Engineer, are incomplete or have not been checked by the Contractor or are illegible will be considered as not complying with contract requirements and will be returned to the Contractor for resubmittal in the proper form. The Districts may make this determination at any time during the review period. The Contractor is totally responsible for any impacts on his schedule due to incomplete submittals, submittals returned marked NOT APPROVED, and submittals not complying with the requirements above or the format below.

Data shall be submitted in a format similar to the arrangement of the applicable section(s) of the Specifications unless otherwise specified in the individual section(s). Any submittal not following the format specified, and not conforming with the requirements listed below, will be returned for resubmittal without review.

- 1) Data shall include drawings and descriptive information in sufficient detail to show the kind, size, arrangement, and operation of component materials and devices; the external connections, anchorages, and supports required; performance characteristics; dimensions needed for installation and correlation with other materials and equipment, and all additional information as required in the detailed section(s) of the Specifications.
- 2) Calculations to support the adequacy of the design in meeting specified performance ratings or requirements shall be submitted when required by the Specifications.
- 3) Each drawing or data sheet shall be clearly marked with the name of the project, the Contractor's name, and references to applicable Specification paragraphs and Plan sheets. Submittals containing multiple drawings or data sheets shall be collated prior to submittal for approval.
- 4) Data sheets, catalog cuts or drawings showing more than the particular item under consideration shall be marked to cross out all but the applicable information.
- 5) Data submitted shall include drawings showing wiring and piping layouts. Any changes proposed by the Contractor shall be stated in a cover letter and essential details of such changes shall be clearly shown in the data submitted.

Submittals shall be accompanied by a standard Districts' transmittal form. The Districts will furnish one copy of the transmittal form to the Contractor and the Contractor shall be responsible for reproducing any additional copies required. Any submittal not accompanied by such a form, or where all applicable items on the form are not completed, will be returned for resubmittal. A separate transmittal form shall be used for each specific item or class of material or equipment for which a submittal is required. Transmittal of shop drawings on various items using a single transmittal form will be permitted only when the items taken together constitute a manufacturer's "package" or are so functionally related that expediency indicates review of the group or package as a whole. Submittals transmitted by a facsimile machine will not be accepted.

The Contractor shall assign a unique and individual sequential number on each submittal package. The submittal number shall be clearly written in the space provided on the transmittal form. The Contractor shall use the individual submittal number in all correspondence to the Districts in reference to a particular submittal. The Contractor shall be responsible for not assigning the same submittal number to different submittal packages. Resubmittals shall incorporate the original submittal number followed by the revision number. Submittals improperly numbered will be returned without review.

The Contractor shall indicate by checking the appropriate box on the transmittal form that either no exceptions to the Specifications are taken or deviations are submitted. If deviations are indicated, then all deviations shall be listed with the transmittal form. Failure to list all deviations shall be grounds for rejection of a submittal or return of the submittal without review, at the Districts' option. The Contractor shall be solely responsible for any deviations not listed. Any transmittal form not conforming with this requirement will be returned with the engineering data for resubmittal without review. Consequences of such delays shall be borne fully by the Contractor.

Unless otherwise specified, the total number of copies submitted shall be four plus the number the Contractor desires to be returned stamped with the Engineer's approval. Four copies will be retained for the Districts' use.

The Engineer's review of drawings and data submitted by the Contractor will cover only general conformity to the Plans and Specifications. The Engineer's approval of drawings returned marked APPROVED or APPROVED SUBJECT TO CORRECTIONS SHOWN IN RED will not constitute a blanket approval of dimensions, quantities, and details of the material, equipment, device, or item shown, and does not relieve the Contractor from any responsibility for errors, omissions or deviations from the contract requirements. The Contractor shall be responsible for the correctness of the drawings, for shop fits and field connections, and for the results obtained by use of such drawings. The Districts reserve the right to subsequently reject any previously approved equipment, material, and/or construction method which deviates from the Contract Documents when said deviations were not listed in the transmittal form for the approved submittal. When the drawings and data are returned marked NOT APPROVED or RESUBMITTAL REQUIRED, the corrections shall be made as noted thereon and as instructed by the Engineer; resubmittal shall be made in the same manner as the original submittal.

The Contractor shall allow 20 working days for the Districts to review each required submittal or resubmittal. The review period shall commence on the day the submittal is received by the Districts. The Districts will notify the Contractor in writing if a longer period is required to review complicated submittals and this request for added time shall not be the basis for a claim for extra time or monetary compensation by the Contractor. If submittals are rejected by the Districts, the Contractor is responsible for any subsequent time delays without any additional compensation from the Districts.

Subject to the requirements above, drawings and data, after final processing by the Engineer, shall become a part of the Contract Documents, and the work shown or described thereby shall be performed in conformity therewith unless otherwise required by the Engineer. In the event of conflict between approved submittal and the other Contract Documents, the most stringent requirements shall apply unless the Districts have agreed to a reduction in requirements in response to a deviation listed on a submittal transmittal form.

In addition to shop drawings and working drawings, the Contractor shall submit the following information along with submittals or as separate submittals when applicable:

- 1) Certification per 4-1.5.
- 2) Construction Schedule per 6-1.
- 3) Confined Space Entry Program per 7-10.4.4
- 4) Concrete mix designs per 201-1.1.
- 5) Asphalt concrete mix designs per 203-6.2.
- 6) Data, including, but not limited to, catalog sheets, manufacturer's brochures, technical bulletins, specifications, diagrams, product samples, and other information necessary to describe a system, product or item. This information is required for irrigation systems, street lighting systems, and traffic signals, and may also be required for any product, manufactured item, or system
- 7) Equipment anchorage details and supporting calculations prepared, stamped, and signed by a Civil or Structural Engineer currently registered by the State of California executing the design within the scope of his registration.
- 8) Dewatering plan, including but not limited to procedures, plan and section drawings, location of wells, piping and routing, pumping equipment, metering, silt removal, water quality monitoring, discharge and necessary permits.

All resubmittals shall include a copy of the Districts' response letter to the previous submittal. The Contractor shall place a check mark (✓) next to each comment on the Districts response letter where the resubmittal is in full compliance. The Contractor shall underline each comment on the Districts' response letter where the resubmittal still has deviations or missing information. The Contractor shall sequentially number each underlined comment in the right hand margin, and shall include in the resubmittal a corresponding detailed written justification for each deviation or missing information. Failure to include a copy of the Districts' response letter properly marked up along with a justification for each deviation or missing information will result in the resubmittal being returned without review. Consequences of resulting delays shall be borne fully by the Contractor."

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IN **2-7 SUBSURFACE DATA**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"Copies of soil test reports for test holes which have been drilled will be made available to bidders upon request."

IN **2-8 RIGHT OF WAY**, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"Unless otherwise approved by the Engineer, the Contractor shall limit construction activities and storage of equipment and materials, and parking of vehicles including employees' private vehicles to within the limits of the Districts' easements and occupational right of ways. The equipment and materials to be stored at a location are limited to those that will be in actual and immediate use for work within that location. In addition, if the Contractor elects not to use the occupational right of way area provided at a location, the Contractor shall be deemed to have waived his rights to the occupational right of way obtained for that location. Unless otherwise specified or directed by the Engineer, construction within

private properties shall be restricted to the hours between 7:00 a.m. and 3:30 p.m., Monday through Friday, no holidays. The Contractor shall be solely responsible for the protection and safekeeping of his equipment and materials and shall make no claim against the property owner or lessee by reason of any act of an employer or trespasser. Any existing fence or gate disturbed shall be restored and/or replaced during the same day. The Contractor shall, as the first order of work, install a temporary 6-foot high chain link fence to isolate the occupational right of way from the remainder of the property. The time accounting for work in a right of way shall start with the erection of the temporary fence. In the event that the Districts are unable to secure the easement or occupational right of way from the property owner, the Districts shall have the authority to direct the Contractor to proceed with the remaining contract work and reschedule and complete the work at that property at a later date. If rescheduling of the work delays the overall project completion, the Districts may extend the working days allowed. However, no additional monetary compensation will be granted due to such directive. When authorized in writing by the Engineer, the Contractor at his expense may remove improvements within the right of way (either through private right of way or Districts' property) shown on the Plans, but he shall replace same to their original condition at his expense. Payment for losses or damages to crops, within the occupational right of way shown on the Plans, will be made by the Districts unless otherwise stated. Upon completion of work within a location, the Contractor shall remove all the equipment and materials, including all temporary facilities, off that location and restore and resurface all disturbed areas in accordance with 7-9."

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IN **2-9.1 Permanent Survey Markers**, FIRST PARAGRAPH, THIRD SENTENCE, AFTER THE WORDS "lot stakes", ADD THE WORDS "or marks".

IN **2-9.1 Permanent Survey Markers**, FIRST PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Replacement will be performed by the Engineer, but the Engineer may direct the Contractor to replace monuments removed during construction, with the Districts providing the necessary survey. If the Districts direct the Contractor to remove and replace a survey monument, the Contractor shall file a Corner Record Form with the Office of the County Surveyor prior to removal of the monument. The Contractor shall file a new Corner Record Form with the County Surveyor office for each monument disturbed during construction. The Contractor shall invoice the Districts for this cost and the Contractor will be paid by purchase order."

IN **2-9.2 Survey Services**, FIRST PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "adequate for construction" AND REPLACE WITH THE WORDS "which will be provided as described below".

IN **2-9.2 Survey Services**, SECOND PARAGRAPH, FIRST SENTENCE, DELETE THE NUMBER "2" AND REPLACE WITH THE NUMBER "5".

IN **2-9.2 Survey Services**, SECOND PARAGRAPH, LAST SENTENCE, DELETE THE WORDS "line and grade stakes" AND REPLACE WITH THE WORDS "the required survey".

IN **2-9.2 Survey Services**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Stakes will be set and stationed by the Engineer for curbs and headers; sewers, storm drains and all other underground conduits 3 inches and larger; rough grade and a corresponding cut or fill to finish grade on 50 foot centers for both earthwork and paving indicated on a grade sheet; and cut or fill to finish grade for flow lines indicated on a grade sheet. The Engineer will furnish boundary surveys and establish major exterior wall lines in the areas of buildings and establish major exterior and major interior wall lines in the areas of structures and will provide a minimum of two bench marks and a maximum number of bench marks as determined by the Engineer adjacent to the work site."

IN **2-10 AUTHORITY OF BOARD AND ENGINEER**, LAST PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "execution," AND "or sequence".

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AFTER **2-11 INSPECTION**, ADD THE FOLLOWING:

**"2-12 CORRESPONDENCE.** The use of facsimile (fax) machines for the transmittal of routine correspondence, including submittals, shall not be allowed except when specifically requested by the Engineer. The use of electronic mail (e-mail) will not be allowed for the transmittal of any correspondence. The Districts will allow the use of fax machines for urgent matters such as notification of changed conditions. Unless otherwise allowed by the Engineer, all faxes shall be directed to the Districts' Field Engineering Section to the attention of the Resident Engineer. The fax number for the Field Engineering Section will be provided to the Contractor at the pre-construction meeting or upon request by the Contractor. Faxes sent to fax numbers other than those designated by the Engineer will not be accepted. Faxes received after 2:00 p.m. shall be considered as being received the following working day. All faxes shall be followed up with a copy that is mailed to the Districts on the same day that the fax is forwarded. The Districts will not accept any illegible faxed correspondence."

IN **3-1 Changes Requested by the Contractor**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**"3-1.1 General.** Changes in specific methods of construction may be made at the Contractor's request when approved in writing by the Engineer.

Changes in the Plans and Specifications requested by the Contractor shall be in writing. Changes in the Plans and Specifications that do not materially affect the Work and are not detrimental to the Work or to the interests of the Districts, may be granted to facilitate the Work, when approved in writing by the Engineer. The Contractor shall allow a minimum of 20 working days for the Districts to review such changes. Regardless of whether a requested change is approved or not approved by the Engineer, the Contractor shall not be excused from any scheduled completion date provided by the Contract and shall proceed with all work to be performed under the Contract.

**3-1.2 Payment for Changes Requested by the Contractor.** If such changes are granted, they shall be made at a reduction in cost or at no additional cost to the Districts. Nothing herein shall be construed as granting a right to the Contractor to demand such changes."

IN **3-2.1 General**, AFTER THE FIRST PARAGRAPH, ADD THE FOLLOWING:

"For changes involving specialized type of work, the Engineer shall have the authority to direct the Contractor to use a Subcontractor specializing in that type of work.

Nothing herein shall be construed as granting a right to the Contractor to stop work or refuse to perform work, irrespective of the total arithmetic dollar value of all changes. Under no circumstances will the Districts pay additional compensation for costs incurred as a result of the Contractor's failure to proceed with the work in a timely manner."

IN **3-2.2.1 Contract Unit Prices, General**, SECOND PARAGRAPH, FIRST SENTENCE, IN THE FIRST LINE, DELETE THE WORDS "Contract Unit Price" AND REPLACE WITH "Major Bid Item".

IN **3-2.2.1 Contract Unit Prices, General**, AFTER THE SECOND PARAGRAPH, ADD THE FOLLOWING:

"Changes in quantities for those bid items including Major Bid Items, for which quantities could not be accurately estimated prior to construction, including bid items for unsuitable subbedding, unsuitable backfill, relaying and/or protection and support of house connection sewers, temporary resurfacing, placement of slurry seal, drilling of wells, construction of subsurface barriers, removal and replacement of unsuitable foundation materials, removal of concrete overpours, removal of debris from sewer, etc., shall not be considered as changes initiated by the Districts and the limitation of 25 percent indicated in the above paragraph shall not apply or constitute extra work under 3-3. The Districts reserve the right to adjust payment per 3-2.4 when the total of a bid item listed in this paragraph increases by more than 25 percent relative to the original quantity."

IN **3-2.2.2 Increases of More Than 25 Percent**; FIRST PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "Contract Unit Price" AND REPLACE WITH "Major Bid Item".

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IN **3-2.2.3 Decreases of More Than 25 Percent**; FIRST PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "Contract Unit Price" AND REPLACE WITH "Major Bid Item".

IN **3-2.3 Stipulated Unit Prices**; SECOND SENTENCE, DELETE THE WORDS "when so specified in the Special Provisions".

IN **3-2.4 Agreed Prices**, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"The Contractor shall submit to the Engineer a detailed breakdown of all costs attributable to the change in work and a schedule analysis. The cost breakdown shall include unit costs for each separate work item showing quantities of material, manhours of labor, rental of equipment and other expenditures contributing to the cost. In the event that extra work which is most appropriately performed on a lump sum basis, as determined by the Engineer, must be started before a cost breakdown can be prepared by the Contractor, the Districts may direct the work to be performed on a time-and-material basis in accordance with 3-3 until such time that a lump sum cost breakdown is submitted by the Contractor and approved by the Districts."

IN **3-3.2.2 Basis For Establishing Costs, (a) Labor**, LAST PARAGRAPH, AFTER THE WORD "superintendence", ADD THE WORDS "(including, but not limited to, Superintendent, Project Manager, Project Engineer, Estimator, etc.)".

IN **3-3.2.2 Basis For Establishing Costs, (c) Tool and Equipment Rental**, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Regardless of ownership, the rates to be used in determining equipment rental costs shall not exceed those listed in the current edition of the Rental Rate Blue Book for Construction Equipment (published by Dataquest) at the time the work is performed. The hourly rate allowed shall be calculated by dividing the listed monthly rental rate by 176 and adding the estimated operating cost/hour (if listed). The listed monthly, daily and hourly rates, rate adjustment tables and regional adjustment maps shall not be utilized. Payment for multiple shifts shall not exceed 75 percent of the calculated hourly rate for double shifts (16 hours) and 67 percent of the calculated hourly rate for triple shifts (24 hours). Standby rates shall be 50 percent of the calculated hourly rate, less the estimated operating cost/hour. Payment for standby shall not exceed 8 hours per day, 40 hours per week and 176 hours per month. If the equipment is not listed, the rate allowed shall be that calculated for a comparable item."

IN **3-3.2.2 Basis for Establishing Costs, (e) Invoices**, LAST SENTENCE, ADD THE FOLLOWING TO THE END:

"except equipment rental which will be calculated per 3-3.2.2(c)".

IN 3-3.2.3 Markup, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"(a) **Work by Contractor.** The following percentages shall be added to the Contractor's costs and shall constitute the markup for all overhead, insurance, interest, and profits:

- |                                 |    |
|---------------------------------|----|
| 1) Labor                        | 20 |
| 2) Materials                    | 15 |
| 3) Equipment Rental             | 15 |
| 4) Other Items and Expenditures | 15 |

To the sum of the costs and markups provided for in this subsection, 1 percent shall be added as compensation for bonding to the extent actually paid. The 1 percent shall be the maximum total compensation for both the Contractors' and Subcontractors' bonding cost.

(b) **Work by Subcontractor.** When all or any part of the extra work is performed by a Subcontractor, the markup established in 3-3.2.3(a) shall be applied to the Subcontractor's actual cost of such work. A markup of 10 percent on the first \$5,000 of the subcontracted portion of the extra work and a markup of 5 percent on work added in excess of \$5,000 of the subcontracted portion of the extra work may be added by the Contractor.

(c) In the case of a joint venturer acting as a Subcontractor and regardless of the arrangements among the joint venturers themselves, each joint venturer is considered a Prime Contractor; therefore, negotiated direct expenses, overhead and profit shall be allowed only once on subcontract work undertaken by a joint venturer.

(d) For a change in work that includes both additions and deletions and which result in a net price increase, markup values shall be applied on the net increase.

(e) Should work be deleted which is not covered by a contract unit price, the credit due to the Districts shall be established by the fair value of the work at the time the Contract was bid, minus actual costs incurred by the Contractor prior to notification of such deletion. The Contractor shall submit a clear and complete cost breakdown in order to establish the fair value of any credit. Fair value shall include the direct expenses which will not be incurred as a result of the deletion and all anticipated profit attributable to the deleted work. The same markups for Contract increases shall be applied to any credit due to the Districts."

IN 3-3.3 Daily Reports by Contractor, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Districts failure to attempt reconciliation or to prepare notes regarding disagreements is not a waiver of Districts' right to dispute the accuracy of the Contractor's report. The Contractor shall maintain records in sufficient detail to distinguish the cost of extra work from the cost of other operations."

AFTER 3-3.3 Daily Reports by Contractor, ADD THE FOLLOWING:

**"3-3.4 Notification by Contractor.** The Contractor shall inform the Districts' inspector(s) prior to performing any work the Contractor considers extra work. The Contractor shall submit daily reports in accordance with 3-3.3."

**IN 3-4 CHANGED CONDITIONS, AFTER THE FOURTH PARAGRAPH, ADD THE FOLLOWING:**

"Under no circumstances will the Districts pay additional compensation based on a claim that the Contractor incurred additional cost because he encountered soil conditions different from those anticipated at the time of bid submittal. This paragraph does not apply to changed condition 3) noted above."

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**AFTER 3-5 DISPUTED WORK, ADD THE FOLLOWING:**

**"3-6 APPLICABLE PORTION OF PUBLIC CONTRACT CODE 20104-20104.6**

**Article 1.5 Resolution of Construction Claims**

20104. (a) (1) This article applies to all public works claims of three hundred seventy-five thousand dollars (\$375,000) or less which arise between a contractor and a local agency.
- (2) This article shall not apply to any claims resulting from a contract between a contractor and a public agency when the public agency has elected to resolve any disputes pursuant to Article 7.1 (commencing with Section 10240) of Chapter 1 of Part 2.
- (b) (1) "Public work" has the same meaning as in Sections 3100 and 3106 of the Civil Code, except that "public work" does not include any work or improvement contracted for by the state or the Regents of the University of California.
- (2) "Claim" means a separate demand by the contractor for (A) a time extension, (B) payment of money or damages arising from work done by or on behalf of the contractor pursuant to the contract for a public work and payment of which is not otherwise expressly provided for or the claimant is not otherwise entitled to, or (C) an amount the payment of which is disputed by the local agency.
- (c) The provisions of this article or a summary thereof shall be set forth in the plans or specifications for any work which may give rise to a claim under this article.
- (d) This article applies only to contracts entered into on or after January 1, 1991.
- 20104.2. For any claim subject to this article, the following requirements apply:
- (a) The claim shall be in writing and include the documents necessary to substantiate the claim. Claims must be filed on or before the date of final payment. Nothing in this subdivision is intended to extend the time limit or supersede notice requirements otherwise provided by contract for the filing of claims.
- (b) (1) For claims of less than fifty thousand dollars (\$50,000), the local agency shall respond in writing to any written claim within 45 days of receipt of the claim, or may request, in writing, within 30 days of receipt of the claim, any additional documentation supporting the claim or relating to defenses to the claim the local agency may have against the claimant.
- (2) If additional information is thereafter required, it shall be requested and provided pursuant to this subdivision, upon mutual agreement of the local agency and the claimant.

(3) The local agency's written response to the claim, as further documented, shall be submitted to the claimant within 15 days after receipt of the further documentation or within a period of time no greater than that taken by the claimant in producing the additional information, whichever is greater.

(c) (1) For claims of over fifty thousand dollars (\$50,000) and less than or equal to three hundred seventy-five thousand dollars (\$375,000), the local agency shall respond in writing to all written claims within 60 days of receipt of the claim, or may request, in writing, within 30 days of receipt of the claim, any additional documentation supporting the claim or relating to defenses to the claim the local agency may have against the claimant.

(2) If additional information is thereafter required, it shall be requested and provided pursuant to this subdivision, upon mutual agreement of the local agency and the claimant.

(3) The local agency's written response to the claim, as further documented, shall be submitted to the claimant within 30 days after receipt of the further documentation, or within a period of time no greater than that taken by the claimant in producing the additional information or requested documentation, whichever is greater.

(d) If the claimant disputes the local agency's written response, or the local agency fails to respond within the time prescribed, the claimant may so notify the local agency, in writing, either within 15 days of receipt of the local agency's response or within 15 days of the local agency's failure to respond within the time prescribed, respectively, and demand an informal conference to meet and confer for settlement of the issues in dispute. Upon a demand, the local agency shall schedule a meet and confer conference within 30 days for settlement of the dispute.

(e) Following the meet and confer conference, if the claim or any portion remains in dispute, the claimant may file a claim as provided in Chapter 1 (commencing with Section 900) and Chapter 2 (commencing with Section 910) of Part 3 of Division 3.6 of Title 1 of the Government Code. For purposes of those provisions, the running of the period of time within which a claim must be filed shall be tolled from the time the claimant submits his or her written claim pursuant to subdivision (a) until the time that claim is denied as a result of the meet and confer process, including any period of time utilized by the meet and confer conference.

(f) This article does not apply to tort claims and nothing in this article is intended nor shall be construed to change the time periods for filing tort claims or actions specified by Chapter 1 (commencing with Section 900) and Chapter 2 (commencing with Section 910) of Part 3 of Division 3.6 of Title 1 of the Government Code.

20104.4. The following procedures are established for all civil actions filed to resolve claims subject to this article:

(a) Within 60 days, but no earlier than 30 days, following the filing or responsive pleadings, the court shall submit the matter to nonbinding mediation unless waived by mutual stipulation of both parties. The mediation process shall provide for the selection within 15 days by both parties of a disinterested third person as mediator, shall be commenced within 30 days of the submittal, and shall be concluded within 15 days from the commencement of the mediation unless a time requirement is extended upon a good cause showing to the court or by stipulation of both parties. If the parties fail to select a mediator within the 15-day period, any party may petition the court to appoint the mediator.

- (b) (1) If the matter remains in dispute, the case shall be submitted to judicial arbitration pursuant to Chapter 2.5 (commencing with Section 1141.10) of Title 3 of Part 3 of the Code of Civil Procedure, notwithstanding Section 1141.11 of that code. The Civil Discovery Act of 1986 (Article 3 (commencing with Section 2016) of Chapter 3 of Title 3 of Part 4 of the Code of Civil Procedure) shall apply to any proceeding brought under this subdivision consistent with the rules pertaining to judicial arbitration.
- (2) Notwithstanding any other provision of law, upon stipulation of the parties, arbitrators appointed for purposes of this article shall be experienced in construction law, and, upon stipulation of the parties, mediators and arbitrators shall be paid necessary and reasonable hourly rates of pay not to exceed their customary rate, and such fees and expenses shall be paid equally by the parties, except in the case of arbitration where the arbitrator, for good cause, determines a different division. In no event shall these fees or expenses be paid by state or county funds.
- (3) In addition to Chapter 2.5 (commencing with Section 1141.10) of Title 3 of Part 3 of the Code of Civil Procedure, any party who after receiving an arbitration award requests a trial de novo but does not obtain a more favorable judgment shall, in addition to payment of costs and fees under that chapter, pay the attorney's fees of the other party arising out of the trial de novo.
- (c) The court may, upon request by any party, order any witnesses to participate in the mediation or arbitration process.
- 20104.6.(a) No local agency shall fail to pay money as to any portion of a claim which is undisputed except as otherwise provided in the contract.
- (b) In any suit filed under Section 20104.4, the local agency shall pay interest at the legal rate on any arbitration award or judgment. The interest shall begin to accrue on the date the suit is filed in a court of law."

IN **4-1.1 General**, DELETE THE PERIOD AFTER "4-1.1".

IN **4-1.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"No repairs shall be made unless approved by the Engineer."

IN **4-1.1 General**, SECOND PARAGRAPH, FIRST SENTENCE, ADD THE WORDS "Plans and" BETWEEN THE WORDS "the" AND "Specifications".

IN **4-1.3.1 General**, FIRST PARAGRAPH, FIRST SENTENCE, AFTER THE WORDS "protective coating application," ADD THE WORDS "plastic liner, fiberglass tanks, plastic liner pipe,".

IN **4-1.3.1 General**, ADD THE FOLLOWING TO THE END:

"The Contractor shall notify the Engineer at least 48 hours prior to materials manufacture."

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IN **4-1.3.2 Inspection of Materials Not Locally Produced**, ADD THE FOLLOWING TO THE END:

"In lieu of approving an inspector, or accredited testing laboratory, the Engineer may elect to have the inspection performed by a Districts representative. All costs for transportation, meals and lodging shall be borne by the Contractor."

IN 4-1.3.3 **Inspection by the Agency**, FIRST SENTENCE, DELETE THE WORDS "and testing laboratory".

IN 4-1.4 **Test of Materials**, FIRST PARAGRAPH, DELETE THE THIRD, FOURTH AND FIFTH SENTENCES AND REPLACE WITH THE FOLLOWING:

"All initial testing and a reasonable amount of retesting shall be performed under the direction of the Engineer, and at no expense to the Contractor except for the construction soils testing and concrete strength testing for concrete poured at the project site. The Contractor shall provide an independent accredited testing laboratory approved by the Engineer to perform all required soils testing and concrete strength testing. The costs shall be borne by the Contractor. If the Contractor is to provide any additional testing and pay for that testing, the Contract Documents will so state. Frequency of soils testing shall be as specified in 211-5."

IN 4-1.6 **Trade Names or Equals**, SECOND PARAGRAPH, LAST SENTENCE, DELETE THE WORDS "as provided in the contract documents", AND REPLACE WITH THE WORDS "within 35 days from the award of the Contract".

IN 4-1.6 **Trade Names or Equals**, AFTER THE FIFTH PARAGRAPH, ADD THE FOLLOWING:

"If the Contractor is authorized to substitute an equivalent item or material, it shall be with the understanding that there will be no increase in contract price due to the substitution.

If a substitute requested by the Contractor is approved by the Engineer and is subsequently found to be not equal to the specified item or material, the Contractor shall remove and dispose of the substitute at his expense and he shall furnish and install the specified item or material or approved equal. No additional compensation will be made to the Contractor for furnishing and installing the specified item or material."

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IN 5-1 **LOCATION**, FOURTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"In addition, the Contractor shall be aware that nonpressurized sewer lines, nonpressurized storm drains, and other nonpressurized drain lines are not required to be marked by the respective owners."

IN 5-1 **LOCATION**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"It shall be the Contractor's responsibility to determine the location and depth of all utilities, including service connections, which are shown on the Plans or have been marked by the respective owners and which it believes may affect or be affected by its operations. If no pay item is provided in the Contract for this work, full compensation for such work shall be considered as included in prices bid for other items of work. Under no circumstances will the Districts pay additional compensation based on a claim that the owner mismarked or failed to mark utilities, including service connections.

Substructures identified on the Plans as "possible pipes" may exist at those locations. The Contractor shall include in the appropriate bid items costs for crossing, supporting, protecting, and costs for constructing temporary and permanent supports under all possible substructures."

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IN 5-2 **PROTECTION**, FIRST PARAGRAPH, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"The Contractor shall assume that thrust blocks exist on water lines at all locations where there are changes in direction, branches, or valves."

IN **5-2 PROTECTION**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Requirements and payment for protection of house connection sewers shall be in accordance with 306-1.1.7."

IN **5-2 PROTECTION**, SECOND PARAGRAPH, ADD THE WORD "substantially" BETWEEN THE WORDS "located" AND "as."

IN **5-2 PROTECTION**, AFTER THE SIXTH PARAGRAPH, ADD THE FOLLOWING:

"The Contractor shall provide temporary and permanent supports under all existing concrete, asbestos cement, clay, telephone, and power conduits. The Contractor shall also provide temporary and permanent supports under all other conduits where required on the Plans. The supports shall conform with supports detailed on Districts' Standard Drawings or to other standards as directed by the Engineer. Costs for supports shall be absorbed in the Contractor's bid items for the pipeline construction. The Contractor shall not tunnel under conduits unless approved by the Engineer. All voids within the tunnel limits shall be filled with a 1-sack cement/sand slurry."

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IN **5-4 RELOCATION**, FIRST PARAGRAPH, AFTER THE SECOND SENTENCE, ADD THE FOLLOWING:

"In the event that the Districts are unable to have the utility relocated prior to when the Contractor is scheduled and ready to start work in an area, the Districts shall have the authority to direct the Contractor to proceed with the remaining Contract work and reschedule and complete the work at a later date. If rescheduling of the work delays the overall project completion, the Districts may extend the working days allowed. However, no additional monetary compensation will be granted due to such directive."

IN **5-4 RELOCATION**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"In addition, the Contractor shall include in its bid the cost for removing the interfering portions of the existing utility that has been left in place after the relocation."

IN **5-4 RELOCATION**, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The Contractor shall pothole and verify the location and elevation of all existing sewer pipes and utilities shown at the locations of the proposed structures including all jacking, tunneling and receiving pits to verify the locations of the existing sewer pipes and utilities shown and explore and identify if any additional utilities are located within the area. The Contractor shall incorporate the actual locations of the existing sewer pipes and utilities in the design of the shoring system and submit to the Districts for review. If any interfering utilities are found and if the utilities are not shown on the Plans, the Districts may either arrange to have the utilities relocated by others or direct the Contractor to relocate the utilities. If the Contractor is directed to relocate the utilities, the Contractor shall keep track of the costs and submit daily reports per 3-3.3 and will be reimbursed by purchase order. If the utilities are substantially as shown but the Contractor elects to remove and relocate the utilities instead of protecting and supporting them in place, then the cost for the removal and relocation of the utilities shall be at the sole expense of the Contractor. The potholing and verification work shall be the first order of work and shall be completed within 30 working days after the date of the Notice to Proceed prior to the design of the shoring system. The potholing work shall be scheduled with the Resident Engineer and the Districts will provide inspection and/or survey services during the work."

IN **5-4 RELOCATION**, DELETE ALL OF THE LAST PARAGRAPH EXCEPT THE LAST TWO SENTENCES.

AFTER **5-6 COOPERATION**, ADD THE FOLLOWING:

**"5-7 LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS - FLOOD CONTROL DISTRICT STORM DRAIN CONDUITS.** Construction in the vicinity of all Los Angeles County Department of Public Works (LACDPW) - Flood Control District storm drain conduits shall conform to the requirements of the LACDPW - Flood Control District. Construction under storm drain conduits shall be accomplished by jacking, tunneling, open cut methods, or as specified on the Plans. The Contractor shall submit to and obtain approval from the LACDPW - Flood Control District, through the Districts, for the proposed methods. The submittal shall be submitted not less than 45 calendar days in advance of the proposed construction to allow sufficient time for LACDPW - Flood Control District review and approval. If open cut method is used, the Contractor shall provide an approved temporary support and a permanent concrete support per Standard Drawing S-a-217. The Contractor shall submit to and obtain approval from the Districts of his proposed method of temporary support prior to any construction."

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IN **6-1 CONSTRUCTION SCHEDULE AND COMMENCEMENT OF WORK**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The Contractor shall have obtained approval of its construction schedule prior to mobilization and the start of excavation."

IN **6-1 CONSTRUCTION SCHEDULE AND COMMENCEMENT OF WORK**, SECOND PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"The contract time shall start on date of the Notice to Proceed, which will be established by the Engineer and may be any date after award of Contract by the Districts' Board of Directors. The contract time shall commence upon the date of the Notice to Proceed."

IN **6-1 CONSTRUCTION SCHEDULE AND COMMENCEMENT OF WORK**, AFTER THE SECOND PARAGRAPH, ADD THE FOLLOWING:

"The contract time specified is the Districts' best estimate of how long it will take to complete the Work. If the Contractor elects to submit an early completion schedule for the Project, it does so at its own risk and such a submission does not change the working day schedule contained in the Contract Documents. Moreover, the Districts will not accept any responsibility for nor be held liable for any damages allegedly caused by the Contractor's failure to complete the Project within its proposed early completion schedule."

IN **6-1 CONSTRUCTION SCHEDULE AND COMMENCEMENT OF WORK**, NEXT TO LAST PARAGRAPH, ADD THE WORDS "for acceptance" AFTER THE WORDS "submit to the Engineer".

IN **6-1 CONSTRUCTION SCHEDULE AND COMMENCEMENT OF WORK**, AFTER THE LAST PARAGRAPH, ADD THE FOLLOWING:

**"6-1.1 General.** The construction schedule shall conform to requirements in this section. Bar charts shall be clear and legible. All schedule information shall be submitted in hard copy format. The submission of computer discs or CDs is not permitted.

The contract time, contract milestones, and special construction requirements specified shall be accurately represented in the schedule.

**6-1.2 Baseline Schedule.** The baseline schedule shall represent the Contractor's plan to build the work in accordance with all requirements of the bid documents without exception. The baseline schedule shall be accepted by the Districts prior to the start of physical work. The Districts review period for the baseline schedule submittal and each resubmittal shall be fifteen (15) working days. The Contractor shall continue to resubmit the baseline schedule until obtaining Districts acceptance.

The baseline schedule will be reviewed by the Districts for general conformity with the plans and specifications. Districts acceptance of any schedule submittal shall not relieve the Contractor of its obligation to fulfill all requirements of the contract. Errors in the schedule may be discovered at any time and shall be corrected by the Contractor in the next update for consistency with the contract requirements.

**6-1.3 Schedule Structure.** The schedule shall include activities of sufficient detail to accurately represent a feasible plan for the timely completion of the full scope of the work. Schedule activities shall include, but not necessarily be limited to the following: site mobilization; all construction activities; required notifications to Engineer for shop and field testing; punchlist and demobilization; and one activity for each contract milestone, the preparation of each submittal, the review of each submittal, and the procurement of each major material and type of equipment.

The schedule shall contain activities with a maximum duration of fifteen (15) working days.

Float shall be a jointly owned resource available to the Districts and Contractor on an equal basis. Float shall be consumed by both the Districts and the Contractor on a first come, first served basis. Generated float shall be applied to mitigate delays in the reverse order of their occurrence.

**6-1.4 Schedule Update.** The Contractor shall update the project schedule monthly. In each update, the Contractor shall accurately document the progress of the work to date and correct the schedule to accurately reflect the Contractor's current plan for the timely completion of the work. Updates shall include a pay request and a brief, clear narrative explanation of the changes made to the project schedule. Updates shall be submitted on the 2<sup>nd</sup> working day after the data date of the update. The data date will be determined by the Engineer at the preconstruction meeting. The Districts' review period for project schedule updates and resubmittals shall be five (5) working days.

The Contractor shall not be eligible to receive pending progress payments until the corresponding monthly update is accepted by the Districts. No final payment shall be made nor any bonds released by the Districts until the as-built schedule submittal is accepted by the Districts.

**6-1.5 Contract Time Accounting.** The Contractor shall mitigate all delays as efficiently and economically as possible, with the objective of minimizing both the time and cost impact of the delay, regardless of responsibility for the delay. The Districts will not be liable for damages which the Contractor could have avoided by reasonable means, such as prudent scheduling of the work and judicious handling of forces, equipment, or plant.

The Contractor shall provide written notice to the Districts of each change in work within forty-eight (48) hours after each change becomes apparent. The Contractor shall submit a schedule analysis of the impact of each change in work or contemplated change in work, and the cost breakdown per 3-2 within five (5) working days after providing the required written notice of a change in work, receiving notice to proceed with a change, or receiving a request to evaluate a contemplated change. When appropriate, the schedule analysis shall include a request for time extension. If it fails to provide the specified timely notice or to submit a schedule analysis and request for a time extension by the specified deadline, the Contractor shall not be eligible for compensation of any kind.

A time extension to a contract milestone will only be granted to the extent that a change in work impacts the timely completion of a contract milestone. The resulting delay must be beyond the fault and negligence of the Contractor. "

IN **6-2 PROSECUTION OF WORK**, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"If the Contractor fails to complete any work with a specified time limit, the Engineer may suspend all other work until the past due work is complete. No additional compensation and/or time extension will be granted due to such work suspension."

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IN **6-4 DEFAULT BY CONTRACTOR**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"If the Contractor fails to begin delivery of material and equipment, to commence work within the time specified, to maintain the rate of delivery of material, to execute the work in the manner and at such locations as specified, fails to maintain a work program which will ensure the Districts' interest, becomes insolvent, or, if the Contractor is not carrying out the intent of the Contract, the Engineer's written notice may be served upon the Contractor and the Surety on its faithful performance bond demanding satisfactory compliance with the Contract. If the Contractor or its Surety does not comply with such written notice within five days after receiving it, or after starting to comply, fails to continue, the Districts may exclude them from the premises, take possession of all material and equipment and find the Contractor and its Surety in default and cancel the Contract. The Contractor, in having tendered a Bid, shall be deemed to have waived any and all claims for damages because of cancellation of the Contract for any such reason.

Upon taking such action, the Districts may complete the work by Districts forces, by letting the unfinished work to another Contractor, or by a combination of such methods. In any event, the cost of completing the Work shall be charged against the Contractor and its Surety and may be deducted from any money due from the Districts. If the sums under the Contract are insufficient for completion of the Work, the Contractor or Surety shall pay to the Districts, within five days after completion of the Work, all costs in excess of the Contract Price.

If the Surety assumes any part of the Work, it shall take the Contractor's place in all respects for that part and shall be paid by the Districts for all work performed by it in accordance with the Contract. If the Surety assumes the entire Contract, all money due the Contractor at the time of its default shall be payable to the Surety as the work progresses, subject to the terms of the Contract.

The provisions of this section shall be in addition to all other rights and remedies available to the Districts under law."

IN **6-6.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE BEGINNING:

"The Contractor shall immediately provide written notification to the Engineer of any delay to the work and submit, when required or requested by the Engineer, a schedule analysis demonstrating the impact on the project schedule and a written plan of delay mitigation."

IN **6-6.1 General**, ADD THE FOLLOWING TO THE END:

"The Contractor's inability to obtain specified material or equipment shall not constitute an unforeseen event under this Section if it results from matters within the control of the Contractor's subcontractor, equipment vendor or manufacturer, or material vendor or manufacturer."

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**IN 6-6.3 Payment for Delays to Contractor, ADD THE FOLLOWING TO THE END:**

"Compensation for losses sustained by the Contractor shall be limited to actual labor, equipment and work site facilities affected by such delays together with applicable mark-up under 3-3.2.3. Under no circumstances will the Districts compensate the Contractor for general or administrative costs for such delay including without limitation, interest on money or costs attributable to home office or branch office overhead in excess of the applicable markups."

**AFTER 6-6.4 Written Notice and Report, ADD THE FOLLOWING:**

**"6-6.5 Unfavorable Construction Conditions.** During unfavorable weather, wet ground, or other unsuitable construction conditions, the Contractor shall confine his operations to work which will not be affected adversely thereby. No portion of the work shall be constructed under conditions which would affect adversely the quality or efficiency thereof, unless special means or precautions are taken by the Contractor, with approval of the Engineer, to perform the work in a proper and satisfactory manner."

The Engineer shall have the authority to direct the Contractor to cease operations in areas of work which might be affected adversely by predicted unfavorable weather, wet ground, or other unsuitable construction conditions. The Contractor, being directed to cease operations, shall not be entitled to claim additional compensation for delays."

**IN 6-7.1 General, ADD THE FOLLOWING TO THE END:**

"The Contractor shall not, in the absence of the express consent of the Engineer, cause any work to be done on the following days:

- 1) Any Saturday.
- 2) Any Sunday.
- 3) Any day designated or observed as a holiday by the Districts for the following holidays: New Years Day, Memorial Day, Independence Day, Labor Day, Veterans Day, Thanksgiving Day, the Friday immediately after Thanksgiving Day, and Christmas Day.

If the Contractor is allowed to work on any of the above days, it shall be considered a working day.

Unless otherwise specified, normal working hours for any working day shall be starting at 7:00 a.m. and ending at 3:30 p.m. The Contractor shall not perform any work outside of normal working hours without prior written approval of the Districts. The Contractor shall provide a written request to the Districts a minimum of 48 hours prior to performing any work outside of normal working hours and shall provide a written request a minimum of five (5) working days prior to a shift change. Nothing herein shall be construed as granting a right to the Contractor to demand approval of changes to working hours or a shift."

**IN 6-7.2 Working Day, ADD THE FOLLOWING TO THE END:**

"If the Contractor is allowed to work on any Saturday, Sunday, or holiday designated or observed by the Districts as defined in 6-7.1, it shall be considered a working day."

IN **6-8 COMPLETION, ACCEPTANCE, AND WARRANTY**, SECOND PARAGRAPH, LAST SENTENCE, ADD THE FOLLOWING TO THE END:

"and the date to which liquidated damages for late completion of the Work, if any, will be computed."

IN **6-8 COMPLETION, ACCEPTANCE, AND WARRANTY**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The Contractor shall guarantee that the equipment, materials, and workmanship furnished will be as specified and will be free of defects due to faulty materials or workmanship for a period of one year from the date of final acceptance of the Work by the Districts' Board. In addition, the equipment furnished by the Contractor shall be guaranteed to be free from defects in design. The performance bond shall remain in full force and effect through the guarantee period. The guarantee period shall apply to all work, regardless of when it is placed into service by the Districts.

In the event that equipment is placed into service prior to acceptance of the Work by the Districts' Board, the Engineer may, at his option, accept the equipment after all punch list items regarding that equipment are completed, and allow the one year guarantee period to start from the date of such acceptance, except for defects in design, which shall remain as described above.

Within the guarantee period and upon notification of the Contractor by the Districts, the Contractor shall within ten calendar days make needed adjustments, repairs or replacement arising out of defects which, in the judgment of the Engineer, become necessary during such period. The cost of materials, parts, labor transportation, supervision, special tools and supplies required for correction of abnormalities shall be paid by the Contractor.

Parts of equipment that have been repaired or replaced shall be guaranteed against failure or defect for a period of one year from the date of installation of the repaired or replaced part.

If the Contractor neglects to make or undertake with due diligence the necessary repair or adjustments within ten days after the Districts gives the Contractor notice of a defect, failure, or abnormality of the work, the Districts will make the repair or adjustment or order the work to be done by a third party. The cost of the work shall be paid by the Contractor.

In the event of an emergency where, in the Districts' judgment, delay would cause serious loss or damage, repairs or adjustments will be made by the Districts, or a third party chosen by the Districts without a requirement for notice to the Contractor. The cost of the work shall be paid by the Contractor."

IN **6-9 LIQUIDATED DAMAGES**, FIRST PARAGRAPH, LAST SENTENCE, ADD THE WORDS: "commencing from the date specified in the Notice to Proceed" AFTER THE WORDS "completion of Work" AND DELETE THE AMOUNT "\$250" AND REPLACE WITH THE AMOUNT "\$500".

IN **6-9 LIQUIDATED DAMAGES**, SECOND PARAGRAPH, FIRST SENTENCE, DELETE THE AMOUNT "\$250" AND REPLACE WITH THE AMOUNT "\$500".

IN **7-1 CONTRACTOR'S EQUIPMENT AND FACILITIES**, ADD THE FOLLOWING TO THE END:

"The Contractor shall render his machinery and equipment inoperable at all times except during actual construction. The Contractor shall be responsible for construction means, controls, techniques, sequences, procedures and construction safety."

IN 7-3 LIABILITY INSURANCE, DELETE THE SECOND AND THIRD PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"The Contractor may file insurance acceptable to the Districts covering more than one project. The coverage shall provide the following minimum limits for liability insurance:

Contracts less than \$2,000,000

Each Occurrence Limit ..... \$3,000,000  
Products/Completed Operations Aggregate Limit ..... \$3,000,000  
General Aggregate Limit..... \$3,000,000  
(other than Products/Completed Operations)

Contracts \$2,000,000 and over

Each Occurrence Limit ..... \$5,000,000  
Products/Completed Operations Aggregate Limit ..... \$5,000,000  
General Aggregate Limit..... \$5,000,000  
(other than Products/Completed Operations)

The Contractor shall provide automobile liability insurance with the following minimum limits:

Each Occurrence Limit ..... \$1,000,000

All-Risk/Builders Insurance will be required when the contract entails taking possession of any Districts' property, including building and equipment. The coverage shall provide a sufficient amount to include the value of the property and the value of the contract for the duration of the contract as specified in the Special Provisions."

IN 7-5 PERMITS, AFTER THE FIRST PARAGRAPH, ADD THE FOLLOWING:

"All expenses for complying with the requirements of the permits obtained by the Districts and by the Contractor including, but not limited to, traffic control, repairs, lights, signs, and backfill shall be borne by the Contractor. Inspection fees for resurfacing required by local authority will be borne by the Districts. The Districts will reimburse the Contractor for all State inspection costs incurred for work performed within State of California Department of Transportation (Caltrans) right of way. The Contractor shall invoice the Districts for the costs without any Contractor's markup and the Contractor will be reimbursed by purchase order. Prior to commencing any work, the Contractor shall obtain a separate Caltrans permit (Double Permit) and shall submit to Caltrans a signed construction application including a Performance Bond in the specified amount and an excavation permit from the Division of Occupational Safety and Health."

IN 7-6 THE CONTRACTOR'S REPRESENTATIVE, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The Contractor shall designate in writing a superintendent for contracts in excess of \$500,000. This superintendent shall be the Contractor's representative."

IN 7-8.1 **Cleanup and Dust Control**, FIRST PARAGRAPH, LAST SENTENCE, DELETE THE WORD "streets" AND REPLACE WITH THE WORDS "or private streets or roadways".

IN 7-8.1 **Cleanup and Dust Control**, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The Contractor shall have a self-loading motor sweeper with spray nozzles on the jobsite at all times to keep paved areas acceptably clean wherever construction, including restoration, is incomplete. Care shall be taken to prevent spillages and tracking on haul routes. Trucks shall not be overloaded. Any spillage or tracking shall be removed immediately and the areas cleaned to the satisfaction of the Engineer. The routes used by trucks to carry material, including pipe, to the jobsite and debris and excavation therefrom shall be approved by the Engineer at the preconstruction conference."

IN 7-8.1 **Cleanup and Dust Control**, FIFTH PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Excess excavated material from trenches, structures, general excavation and manholes or similar structures shall be removed from the site immediately."

IN 7-8.1 **Cleanup and Dust Control**, FIFTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Excess or waste concrete, including concrete truck wash out wastes, shall be placed in a lined container for proper disposal after the concrete has set up."

IN 7-8.1 **Cleanup and Dust Control**, LAST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Failure of the Contractor to comply with the Engineer's cleanup orders may also result in the Districts having the cleanup work done by others. The Contractor shall bear all costs incurred by the Districts in having the work done and such costs shall be deducted from amounts due or become due to the Contractor."

IN 7-9 **PROTECTION AND RESTORATION OF EXISTING IMPROVEMENTS**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The Contractor shall verify in the field the existing improvements which may be damaged or removed by his construction operations before submitting his bid."

IN 7-9 **PROTECTION AND RESTORATION OF EXISTING IMPROVEMENTS**, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"If traffic signal vehicle detection loops are damaged during construction, the entire loop shall be replaced. The replacement of vehicle detection loops shall be performed by a Subcontractor specialized in this type of work. If the damaged or removed curb or sidewalk is in a pedestrian crosswalk area, the Contractor shall construct a sidewalk access ramp for the handicapped as part of the restoration required by this subsection, unless otherwise approved by the jurisdictional agency through the Engineer. At an intersection, the crosswalk area shall be considered to include, but not necessarily be limited to, the entire curb return area. If the damaged or removed curb is in an area where no sidewalk exists, the ramp will not be required. The ramp shall be constructed in accordance with the notes and details shown on the

Plans, or, on the absence thereof, the requirements of the jurisdictional agency as furnished by the Engineer. In the event field conditions necessitate a change of plan which requires the removal of curb or sidewalk not previously requiring removal within pedestrian crosswalk areas as described above, the Contractor shall construct a sidewalk access ramp, and payment therefore will be made under the provisions of 3-3. The ramp shall be constructed in accordance with details furnished by the jurisdictional agency through the Engineer."

IN **7-9 PROTECTION AND RESTORATION OF EXISTING IMPROVEMENTS**, FOURTH PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Lawns shall be replaced with sod, unless otherwise approved by the Engineer."

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IN **7-10.1 Traffic and Access**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Unless otherwise specified or allowed by the jurisdictional agency and approved by the Engineer, the Contractor shall not implement traffic control measures (i.e. lane closure, traffic diversion and detour) within a public street for more than 2,500 feet in length at any one time."

IN **7-10.2 Storage of Equipment and Materials in Public Streets**, SECOND PARAGRAPH, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"Construction equipment not used in productive construction for 5 consecutive days shall be removed from the work site unless otherwise approved by the Engineer."

IN **7-10.2 Storage of Equipment and Materials in Public Streets**, LAST PARAGRAPH, FIRST SENTENCE, ADD THE WORDS "or excavation" AFTER THE WORD "trench".

IN **7-10.2 Storage of Equipment and Materials in Public Streets**, LAST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Excavated material which is to be used as backfill shall not be stored in public streets for more than 5 consecutive days."

IN **7-10.2 Storage of Equipment and Materials in Public Streets**, AFTER THE LAST PARAGRAPH, ADD THE FOLLOWING:

"The Engineer shall approve all storage locations."

IN **7-10.3 Street Closures, Detours, Barricades**, FIRST PARAGRAPH, SECOND SENTENCE, ADD THE WORD "K-rails," AFTER THE WORD "barriers,".

IN **7-10.3 Street Closures, Detours, Barricades**, AFTER THE THIRD PARAGRAPH, ADD THE FOLLOWING:

"Traffic shall be maintained on the proper sides of any raised median at all times. Unless otherwise permitted by the Engineer, all traffic lanes shall have a minimum width of 10 feet. A minimum distance of 5 feet to any excavation and 2 feet from obstructions such as curbs or poles shall be maintained in addition to the lane width specified. Traffic lanes shall have a minimum radius of 250 feet. When parking restriction is to be imposed, 'Temporary No Parking' signs shall be posted at least 24 hours prior to commencing construction, unless otherwise required by the jurisdictional agency. All signs to be used on the project during periods of darkness shall be reflectorized. Unless otherwise noted, all signs,

barricades, and methods shall conform to requirements of the current "Work Area Traffic Control Handbook" (WATCH), except in State of California Department of Transportation (Caltrans) right of way and within unincorporated Los Angeles County right of way or as required by a city, where all signs, barricades and methods shall conform to the requirements of the current "California Manual on Uniform Traffic Control Devices" adopted by the State of California Department of Transportation. Flashing arrow boards, if used, shall be solar powered. When a traffic control plan is required by the Plans, the traffic control plan shall be drawn to a 1" = 40' scale on size D sheets (24" x 36"). The total length of the project shall be shown including the advance signing and striping transitions in advance of and beyond the end of the work area. The sheets shall display the project name, phase identification, name of firm preparing the plan, name and stamp of the design engineer, approval block, north arrow, sheet number, and number of sheets comprising the traffic control plans. Include general notes and symbol definition when required. Adequate dimensioning shall be provided to allow for checking and proper field installation.

All costs for temporary and permanent traffic striping shall be borne by the Contractor and shall be included in the appropriate pipe and/or structure bid items. The Contractor shall hire a firm specialized in traffic striping, removal and replacement of pavement markers and street lettering to perform the work. The firm shall be approved by the Engineer. All traffic striping shall be restored to its original condition, or better, within 60 calendar days after relocation.

Plate bridging of trench excavation shall be in accordance with the requirements of the 1996 Edition of WATCH. The Contractor shall furnish and erect a temporary 6 foot high chain link fence to completely enclose all excavation left unattended or left overnight. Chain link material shall be fastened to posts driven into the pavement or anchored in concrete. The posts shall be spaced adequately to support the fencing. Substituting supports for posts in lieu of driving or anchoring shall be used only if approved by the Engineer. All fence panels shall be undamaged and securely fastened to adjacent fencing at the top, middle and bottom locations.

When the Contractor's operation requires that traffic is transitioned to the opposite side of a street to maintain the number of traffic lanes specified in the Plans, the Contractor shall adjust positioning of existing traffic signals and/or provide temporary traffic signal as required by the jurisdictional agency."

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IN 7-10.4.1 Safety Orders, SECOND PARAGRAPH, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Before commencing any excavation 5 feet or more in depth, the Contractor shall submit to the Districts a detailed plan showing the design of shoring, bracing, sloping or other provisions to be made for the workers' protection from the hazard of caving ground during the excavation. If the plan varies from the shoring, or bracing system standards (Construction Safety Orders of the California Code of Regulations), the plan along with calculations shall be prepared and stamped by a Structural or Civil Engineer currently registered by the State of California. The shoring design shall accommodate the existing underground utilities. If the sloping plan varies from standards, or the sloping or benching for excavations is greater than 20 feet deep, the plan shall be prepared and stamped by a Geotechnical Engineer registered by the State of California. Any additional soils investigation or testing required to provide substantiation or justification for the adequacy of the registered Geotechnical Engineer's plan shall be performed by the Contractor at his expense. Any damage to the utilities which occurs through the negligence or fault of the Contractor shall be repaired by the Contractor at his expense.

The shoring design shall list all assumptions and cite references for the design methodology. Photocopies of the pertinent sections of the cited references shall be included as a part of the submittal. **SUBMITTALS RECEIVED WITHOUT THE REQUIRED REFERENCES WILL BE RETURNED WITHOUT REVIEW.** Design conforming to the assumptions and methods detailed in the Caltrans Trenching and Shoring manual will be accepted as conforming to the above requirements if cited as the reference source.

Results from computer programs used in the analysis shall be accompanied with copies of the manual which details the required input and defines the output and design assumptions. All calculations shall be typed with a minimum character size of 12 point. No excavation shall start until the Engineer has accepted the plan and the Contractor has obtained a permit from the Division of Occupational Safety and Health. A copy of the permit shall be submitted to the Engineer. In addition, prior to any excavation, the Contractor shall submit the name of the "competent person" as defined in Title 8, Section 1504 of the California Code of Regulations. The "competent person" shall be present at the job site as required by Cal-OSHA.

If the Contractor fails to submit a shoring system plan or fails to comply with an accepted plan, the Contractor shall suspend work at the affected location(s) when directed to do so by the Engineer. Such a directive shall not be the basis of a claim for extra work and the Contractor shall not receive additional compensation due to the suspension.

While working in existing sewerage facilities or making connections to existing sewerage facilities, the Contractor shall provide positive ventilation as accepted by the Engineer. The Contractor's employees working in said facilities shall be provided with safety lines, harnesses, gas detectors, and other protective equipment as accepted by the Engineer.

All shoring shall be removed when no longer needed."

**IN 7-10.4.3 Special Hazardous Substances and Processes**, FIRST PARAGRAPH, SECOND SENTENCE, ADD THE WORDS "Title 8," BEFORE THE WORDS "Section 5194."

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**IN 7-11 PATENT FEES OR ROYALTIES**, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The Contractor shall absorb in its Bid, the patent fees or royalties on any patented article or process which may be furnished or used in the Work.

The Contractor agrees to hold the Districts harmless from and to indemnify the Districts against any and all costs, attorneys' fees, and damages arising out of or connected with any claim, demand, action, lawsuit, judicial determination or judgment concerning infringement upon the rights of others, including patent rights, by the use of any article or process which may be furnished or used in the Work. In the event of any such claim of infringement, the Contractor shall notify the Districts within ten days of such claim, and keep the Districts advised of all developments; shall comply with all reasonable requests by the Districts for information and data in defense of any such suit; and agrees to defend any and all such claims, demands, actions and suits.

In the event that any equipment or process furnished or used in the Work is determined by the Districts or by a Court to infringe upon the rights of a third party, the Districts shall in addition have the option of:

1. Replacing the equipment with non-infringing equipment;
2. Modifying the equipment or process to the extent required to avoid such infringement;
3. Continuing to use the equipment or process;
4. Receiving as partial compensation the refund of all monies paid to the Contractor.

In the event of replacement or modification, the amounts spent on such replacement or modification shall be charged against and be recoverable from the Contractor. Final payment to the Contractor by the Districts will not be made while any suit or claim remains unsettled.

The Districts may itself defend any such claim, demand, action or suit, and settle or take any other action it deems necessary or advisable in connection with any such claim, demand, action or suit."

AFTER 7-14 ANTITRUST CLAIMS, ADD THE FOLLOWING:

**"7-15 PROJECT SIGN.** On all sewer projects, the Contractor shall furnish and install two project signs in accordance with the Districts' Standard Drawing S-a-221.

#### **7-16 STORM WATER POLLUTION PREVENTION.**

**7-16.1 General.** The Contractor shall comply with the applicable provisions of the State Water Resources Control Board's Water Quality Order 99-08-DWQ, "National Pollutant Discharge Elimination System General Permit for Storm Water Discharges Associated with Construction Activity (General Permit)" and any modifications thereof (including, but not limited to, Resolution No. 2001-046); and Federal, State, and local regulations that govern the Contractor's operations and storm water discharges from the project site.

In accordance with State Water Resources Control Board (SWRCB) requirements, the Contractor may be required to prepare, submit and implement a Storm Water Pollution Prevention Plan (SWPPP) for this project. Based on the requirements of the General Permit and the Contractor's proposed construction activities, the Contractor shall determine whether or not a SWPPP will be required for this project. If the Contractor determines that a SWPPP will not be required for this project, the Contractor shall submit a letter to the Districts certifying compliance with SWRCB Water Quality Order 99-08-DWQ.

If a SWPPP will be required, the Contractor shall notify the Districts in writing within 20 working days from the date of the award of the contract by the Districts' Board of Directors. The Districts will submit a Notice of Intent to the SWRCB. The Contractor shall submit a minimum of three (3) copies of the SWPPP to the Districts for review and approval. The Contractor shall select appropriate Best Management Practices (BMPs) from the 2003 CASWQA Construction Handbook ([www.cabmphandbooks.com](http://www.cabmphandbooks.com)). If the project includes groundwater dewatering activities, the extract and groundwater shall not be discharged to the street surfaces, storm drains or surface waters without an NPDES Permit as required under Section 306-1.1.8 of the Standard Specifications.

If revisions to the SWPPP are required, as determined by the Districts, the Contractor shall revise and resubmit the SWPPP. Review by the Districts will not relieve the Contractor of the adequacy of the SWPPP or serve to eliminate full compliance with all applicable Federal, State, and local laws and regulations that govern water quality. The Contractor will not be allowed to start any construction activities without an approved SWPPP.

**7-16.2 Storm Water Pollution Prevention Plan (SWPPP).** The SWPPP shall conform to the requirements of the General Permit and shall include, but not be limited to, the following items:

**7-16.2.1** A site plan with sufficient detail to show proposed grading; soil stockpile location; equipment staging, storage, fueling and maintenance areas; and storage areas for construction materials (i.e., chemicals, fuel, lubricants). The site plan shall also show the location of all affected storm drain catch basins and include anticipated surface drainage patterns. Digital file(s) of the topography of the project area, in a Portable Data File (PDF) format, will be made available to the Contractor upon request.

**7-16.2.2** Information regarding the construction site surface area: the size (in acres or square feet), the runoff coefficient for the site, and the percentage of surface area that is paved or otherwise impervious.

**7-16.2.3** A construction schedule which describes the anticipated start date and duration for grading/excavation or other work activities that could affect water quality. This construction schedule shall be updated to reflect any changes in the Contractor's operations that would affect the necessary implementation of BMPs.

**7-16.2.4** A listing of construction activities which could cause pollutants, sediment, fuel, chemicals, or construction materials to contaminate storm water discharges from the site.

**7-16.2.5** A listing of all anticipated non-storm water discharges.

**7-16.2.6** A listing of all hazardous materials which will be used and stored on site. Proper material handling, storage, and disposal protocols shall be established and enforced. Training must be provided for personnel who have a role in the management of hazardous materials including delivery, maintenance, storage, disposal, and spill response. Materials Safety Data Sheets (MSDS) must be submitted for review prior to moving any hazardous materials onto the site.

**7-16.2.7** The rationale used for selecting or rejecting BMPs, a narrative description of the BMPs selected and a description identifying the proposed location for each BMP. In addition, a listing of specific individuals, contractors, and subcontractors responsible for BMP installation, monitoring, inspection, maintenance, repair and record keeping shall be included. Such individuals shall possess training in the use of BMPs. Documented evidence of the training and/or experience shall also be included in the SWPPP.

**7-16.2.8** When applicable, a description of the erosion and sediment control practices that will be implemented during rain events.

**7-16.2.9** An inspection program at the construction site that includes inspection of the BMPs prior to a forecast storm, after a precipitation event which causes site runoff, at 24 hour intervals during extended precipitation events and routinely, a minimum of once every week.

**7-16.3 Sampling and Analysis.** The Contractor shall develop and implement a sampling and analysis program for pollutants which are not visually detectable in storm water discharges, which are or should be known to occur on the project site, and which could cause or contribute to pollution of the receiving water. All sampling, sample preservation, and analyses must be conducted in accordance with the test procedures under 40 CFR Part 136. Laboratory analyses shall be conducted by a laboratory accredited by the California Department of Health Services, Environmental Laboratory Accreditation Program (ELAP) and approved by the Districts. A list of accredited laboratories is available from ELAP-Headquarters, 1625 Shattuck Avenue, Berkeley, CA 94709-1611 or contact by telephone at (510) 540-2800. The Contractor shall submit all water quality analytical results to the Districts within ten (10) working days from the date of the sampling. If downgradient samples show elevated levels of the tested parameter relative to levels in the control sample, the Contractor shall correct or modify BMPs and/or the SWPPP to prevent downgradient impacts.

All proposed modifications or amendments to the SWPPP shall be submitted and approved by the Districts prior to implementation. In the event a deficiency is identified in any aspect of the implementation of the SWPPP or amendments, the deficiency shall be corrected immediately. If the Contractor fails to correct the identified deficiency and submit the appropriate documentation to the Districts, the Districts may order the suspension of any construction operation until such time that the deficiency is corrected.

The Contractor shall keep a copy of the SWPPP on site at all times, along with updates, revisions, and amendments until a Notice of Termination (NOT) has been submitted to the Regional Water Quality Control Board and the Regional Board has approved the NOT. The SWPPP shall be made available upon request of a representative of the Regional Water Quality Control Board, State Water Resources Control Board, United States Environmental Protection Agency or the local storm water management agency. Requests for review by the public shall be directed to the Engineer.

When the project is completed, the Contractor shall submit a complete copy of the SWPPP, all reports generated, and all documents related to updates and modifications of the SWPPP.

**7-16.4 Certification of the SWPPP.** The SWPPP shall be prepared and stamped by a Civil Engineer currently registered in the State of California and has experience preparing a SWPPP. The SWPPP shall include a statement from the Civil Engineer certifying to the effect:

*"As the engineer of record, I have selected appropriate BMPs to effectively minimize the negative impacts of this project's construction activities on storm water quality. The project owner and contractor are aware that the selected BMPs must be installed, monitored, and maintained to ensure their effectiveness. The BMPs not selected for implementation are redundant or deemed not applicable to the proposed construction activity."*

The SWPPP shall also include a statement from the Contractor certifying to the effect:

*"I certify that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, to the best of my knowledge and belief, the information submitted is true, accurate, and complete. I am aware that submitting false and/or inaccurate information, failing to update the SWPPP to reflect current conditions, or failing to properly and/or adequately implement the SWPPP may result in revocation of grading and/or other permits or other sanctions provided by law."*

**7-16.5 Annual Certification.** By June 15 of each year or at the completion of the project, the Contractor shall submit to the Districts an annual certification of compliance. If the Contractor is unable to certify compliance, a detailed report shall be submitted to the District within five working (5) days, identifying all noncompliance events. For each noncompliance event, the report shall include an assessment of any impact caused by the event, describe the actions necessary to achieve compliance, and include a time schedule indicating when compliance will be achieved."

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IN 8-1 GENERAL, FIFTH PARAGRAPH, FIRST SENTENCE, ADD THE WORD "weekly" BEFORE THE WORD "janitorial".

IN 8-2.1 Class "A" Field Office, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Furniture shall be provided as follows: One 6 foot drafting table, one standard 5 foot double pedestal desk with a drawer suitable for holding files, two chairs, one 5 caster desk chair, one drafting stool, four-drawer legal size filing cabinet, three-shelf bookcase at least 4 foot high and one plan rack of the vertical plan-hold type, including twelve hanging clamps. The furniture provided shall be new and shall be subject to the Engineer's approval."

IN 8-2.1 Class "A" Field Office, FOURTH PARAGRAPH, SECOND SENTENCE, DELETE THE WORDS "drinking water" AND REPLACE WITH THE WORDS "a drinking water unit (hot and cold type)."

IN 8-2.1 Class "A" Field Office, DELETE THE FIFTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"A copier, fax machine and telephone, with extended area telephone service, shall be provided within the office area. The telephone shall have a voice messaging system and sufficient extension cord to serve the plan table and desk."

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IN 9-3.1 General, DELETE THE SIXTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Whenever, in the opinion of the Engineer, the Contractor has not taken sufficient precaution for the safety of the public or the protection of the Work to be constructed under this Contract or of adjacent structures or property, and whenever, in the opinion of the Engineer, an emergency has arisen and immediate action is considered necessary, then the Districts, with or without notice to the Contractor, may provide suitable protection by causing work to be accomplished and material to be furnished and placed. The cost of such work and material shall be borne by the Contractor, and such costs will be deducted from amounts due or to become due to the Contractor. The performance of such emergency work shall not relieve the Contractor of responsibility for damage which may occur."

AFTER 9-3.1 General, ADD THE FOLLOWING:

"9-3.1.1 Stipulated Unit Prices. The stipulated unit prices listed below shall be used as payment for work performed, and not cover by contract unit prices as directed by the Engineer. Unless otherwise specified, the following prices are for work and materials, complete and in place, including all labor and incidental costs:

Pavement and Resurfacing

Premix or AC pavement, per inch of thickness per 302-5 and 306-1.5.2 .....	\$0.75/sq. ft.
Concrete pavement, per inch of thickness per 302-6 and 306-1.5.2 .....	\$1.25/sq. ft.
Base material per inch thickness per 301-2 and 306-1.5.2.....	\$0.25/sq. ft.
Emulsion Aggregate Slurry (Type I) per 302-4 and 306-1.5.2 .....	\$0.15/sq. ft.

Backfill Materials

Crushed aggregate per 200-2.2 and 306-1.3 .....	\$35.00/cu. yd.
Sand per 200-1.5 and 306-1.3 .....	\$24.00/cu. yd.

Miscellaneous

Concrete curb, 8" thick base, CF to match existing per 303-5 .....	\$10.00/lin. ft.
Concrete gutter, 8" thick per 303-5 .....	\$5.50/lin. ft.
Integral concrete curb and gutter, 8" thick and 2' wide per 303-5 .....	\$22.00/lin. ft.
Unclassified excavation, e.g. from utility conflicts.....	\$150.00/cu. yd.
Adjustment of pullbox to grade.....	\$120.00 each
Removal of integral concrete curb and 2' wide gutter, including any curb armor, curb bar, or reinforcing steel.....	\$5.50/lin. ft.

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IN **9-3.2 Partial and Final Payment**, SECOND PARAGRAPH, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"When payment has been made for work, material or equipment, including material or equipment delivered to the site, which is subsequently damaged, discovered to be defective or otherwise not in conformance with the Contract Documents, such payment shall be deducted from future monthly progress payments until the damage and/or nonconformance are corrected to the satisfaction of the Engineer."

IN **9-3.3 Delivered Materials**, ADD THE WORDS "**and Equipment**" TO THE TITLE.

IN **9-3.3 Delivered Materials and Equipment**, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"The progress estimate so prepared will be subject to the following constraints where applicable:

- 1) No values will be included for specific equipment and materials until the equipment and materials have been approved by the Districts and have been delivered and stored in accordance with the Special Provisions and the manufacturer's recommendations, as approved by the Engineer.
- 2) Five (5) percent of the value of a specific equipment item will not be included until the associated Operation and Maintenance manuals are submitted and approved by the Districts.
- 3) Additional withholding of the value of a specific equipment item may apply per the Special Provisions.
- 4) For sewer pipe, the value of delivered material not yet used in the work shall be limited to that corresponding to 1,500 linear feet of pipe or the pipe footage which the Contractor has proved capable of laying in five (5) working days, whichever is greater."

IN **9-3.4 Mobilization**, ADD THE FOLLOWING TO THE END:

"When a mobilization bid item is included in the Proposal Form on sewer projects, a lump sum progress payment will be made to the Contractor once the Contractor has started physical work on permanent facilities and once all the following submittals, when required, are approved: construction schedule, shoring, pipe, flow bypass plan, and traffic control. The lump sum payment will be made under the mobilization bid item. Potholing will not be considered as the start of physical work."

AFTER **9-3.4 Mobilization**, ADD THE FOLLOWING:

**"9-4 PROMPT PAYMENT**

Pursuant to Subsection (f) of Section 20104.50 of Public Contract Code, Article 1.7 of Part 3 of Division 2 of said Code is included below:

ARTICLE 1.7

Modifications; Performance; Payment

**§ 20104.50. Timely progress payments; legislative intent; interest; payment requests**

(a) (1) It is the intent of the Legislature in enacting this section to require all local governments to pay their contractors on time so that these contractors can meet their own obligations. In requiring prompt payment by all local governments, the Legislature hereby finds and declares that the prompt payment of outstanding receipts is not merely a municipal affair, but is, instead a matter of statewide concern.

(2) It is the intent of the Legislature in enacting this article to fully occupy the field of public policy relating to the prompt payment of local governments' outstanding receipts. The Legislature finds and declares that all government officials, including those in local government, must set a standard of prompt payment that any business in the private sector which may contract for services should look towards for guidance.

(b) Any local agency which fails to make any progress payment within 30 days after receipt of an undisputed and properly submitted payment request from a contractor on a construction contract shall pay interest to the contractor equivalent to the legal rate set forth in subdivision (a) of Section 685.010 of the Code of Civil Procedure.

(c) Upon receipt of a payment request, each local agency shall act in accordance with both of the following:

(1) Each payment request shall be reviewed by the local agency as soon as practicable after receipt for the purpose of determining that the payment request is a proper payment request.

(2) Any payment request determined not to be a proper payment request suitable for payment shall be returned to the contractor as soon as practicable, but not later than seven days, after receipt. A request returned pursuant to this paragraph shall be accompanied by a document setting forth in writing the reasons why the payment request is not proper.

(d) The number of days available to a local agency to make a payment without incurring interest pursuant to this section shall be reduced by the number of days by which a local agency exceeds the seven-day return requirement set forth in paragraph (2) of subdivision (c).

(e) For purposes of this article:

(1) A "local agency" includes, but is not limited to, a city, including a charter city, a county, and a city and county, and is any public entity subject to this part.

(2) A "progress payment" includes all payments due contractors, except that portion of the final payment designated by the contract as retention earnings.

(3) A payment request shall be considered properly executed if funds are available for payment for the payment request, and payment is not delayed due to an audit inquiry by the financial officer of the local agency.

(f) Each local agency shall require that this article, or a summary thereof, be set forth in the terms of any contract subject to this article."

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IN **201-1.1.1 General**, FIRST PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Concrete shall consist of portland cement, concrete aggregates, water, and when required or approved for use, admixture and/or fly ash in accordance with these provisions."

IN **201-1.1.1 General**, FIRST PARAGRAPH, DELETE THE FOURTH SENTENCE AND REPLACE WITH THE FOLLOWING:

"The mix design shall show the mix identification number and the applicable proportions, weights, and quantities, of portland cement, aggregate, water, and where applicable, fly ash, and admixtures."

IN **201-1.1.1 General**, FIRST PARAGRAPH, FIFTH SENTENCE, AFTER THE WORDS "shall also include the size and source of aggregate", ADD THE WORDS "(with the results of sieve analysis and gradation), results of reactive aggregate testing,".

IN **201-1.1.1 General**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Reclaimed concrete material may only be incorporated into concrete mixtures being used in non-structural applications when approved by the Engineer. The reclaimed concrete material, if used, shall be in accordance with 201-1.2.6.

Ready-mixed concrete shall comply with the requirements of ASTM C94, Standard Specification for Ready-Mixed Concrete, Sections 1, 2, 6, 15, 16, 17.4, and Annex A1. In case of conflict between the listed ASTM C94 sections and the Standard Specifications, the most stringent requirements as determined by the Districts shall apply. In cases where the term "purchaser" is found in ASTM C94, it shall indicate the Districts or Engineer as applicable.

Water shall not be added to the batch on arrival at the job site without the approval of the Engineer. Water shall not be added once discharge of the batch from the ready mix truck begins. Water in excess of the amount shown on the mix design or which will change the mix proportions shall not be added."

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IN **201-1.1.2 Concrete Specified by Class and Alternate Class, TABLE 201-1.1.2(A), Sewer<sup>2</sup> & Storm Drainage Facilities**, DELETE "Pre-Cast Manhole Components,".

IN **201-1.1.2 Concrete Specified by Class and Alternate Class, TABLE 201-1.1.2(A), Sewer<sup>2</sup> & Storm Drainage Facilities, Sidehill Surface Drainage Facilities**, DELETE "560-E-2000P" AND REPLACE WITH "560-E-2500P".

IN **201-1.1.2 Concrete Specified by Class and Alternate Class, TABLE 201-1.1.2(A), Sewer<sup>2</sup> & Storm Drainage Facilities, Sidehill Surface Drainage Facilities**, DELETE "532-EFW-2000P" AND REPLACE WITH "532-EFW-2500P".

IN **201-1.1.2 Concrete Specified by Class and Alternate Class**, AFTER **TABLE 201-1.1.2(A)**, ADD THE FOLLOWING:

"Lean Concrete. Where lean concrete is specified for backfilling, the Contractor shall use a two-sack cement/sand grout with a maximum slump of 5 inches."

IN **201-1.1.2 Concrete Specified by Class and Alternate Class**, AFTER **TABLE 201-1.1.2(A)**, Note 4, DELETE THE SECOND AND THIRD SENTENCES AND REPLACE WITH THE FOLLOWING:

"For backfill after 24 hours, add a non-chloride accelerating admixture approved by the Engineer at dosages as required by the manufacturer of the admixture. For backfill after 16 hours and removal of sheeting after 18 hours, use 660-C-3750 with a non-chloride accelerating admixture approved by the Engineer at dosages as required by the manufacturer of the admixture."

IN 201-1.1.2 Concrete Specified by Class and Alternate Class, AFTER TABLE 201-1.1.2 (A), DELETE NOTE 5.

IN 201-1.1.2 Concrete Specified by Class and Alternate Class, AFTER TABLE 201-1.1.2 (A), NOTE 7, DELETE THE NOTE AND REPLACE WITH THE FOLLOWING NOTE:

"7. 28 MPA (4000 psi) concrete mixes require the use of a water reducing admixture conforming to the requirements of 201-1.2.4, 'Admixtures'."

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IN 201-1.1.4 Concrete Specified by Compressive Strength, THIRD PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Alternatively, if test data are not submitted, the Contractor shall submit a mix design with a water-cement ratio that complies with the following:

Maximum Permissible Water-Cement Ratios for  
Concrete When Strength Data From Field Experience  
or Trial Mixtures Are Not Available

Specified 28-day compressive strength, f <sub>c</sub> psi	Water-cement ratio by weight	
	Non-air entrained concrete	Air-entrained concrete
2500	0.67	0.54
3000	0.58	0.46
3500	0.51	0.40
4000	0.44	0.35
4500	0.38	*
5000	*	*

\*For strength above 4500 psi (non-air entrained concrete) and 4000 psi (air-entrained concrete), concrete proportions shall be established from field data and trial mixtures."

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IN 201-1.1.5 Test for Portland Cement Concrete, DELETE THE THIRD PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Strength tests shall be performed on the concrete by an independent accredited testing laboratory. All costs for testing of cylinders by the testing laboratory shall be borne by the Contractor. The Engineer shall procure test samples using the containers provided by the laboratory. The Contractor shall afford the Engineer all reasonable access, without charge for the procurement of samples of fresh concrete at time of placement. The frequency of sampling for each class of concrete placed each day shall be taken: not less than once a day, or not less than once for each 50 cubic yards of concrete, or not less than once for each 1,350 square feet of surface area for slabs or walls, or a minimum of one for every five columns. On a given project, if the total volume of concrete is such that the frequency of testing required would provide less than five strength tests for a given class of concrete, tests shall be made from at least five randomly selected batches or from each batch if fewer than five batches are used. A strength

test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or a test age designated. Each sampling shall consist of four test cylinders. One cylinder shall be tested at 7 days, two test cylinders tested at 28 days or at age specified, and one test cylinder held. The laboratory shall pick up the test samples and perform the required tests and send certified tests results directly to the Engineer."

IN **201-1.1.5 Test for Portland Cement Concrete**, AFTER THE FOURTH PARAGRAPH, ADD THE FOLLOWING:

"Strength tests of specimens cured under field conditions may be required by the Engineer to check the adequacy of curing and protection of the concrete in the structure. Such specimens shall be molded at the same time and from the same samples as the laboratory-cured acceptance test specimens. Procedures for protecting and curing the concrete shall be improved when the strength of field-cured cylinder at the test age designated for measuring  $f_c$  is less than 85 percent of that of the companion laboratory-cured cylinders. When the laboratory-cured cylinder strengths are appreciably higher than  $f_c$  the field-cured cylinder strengths need not exceed  $f_c$  by more than 500 psi even though the 85 percent criterion is not met."

IN **201-1.1.5 Test for Portland Cement Concrete**, LAST PARAGRAPH, DELETE THE SEVENTH SENTENCE AND REPLACE WITH THE FOLLOWING:

"If the concrete in the structure will be dry under service conditions, the core shall be air dried (temperature 60 to 80°F, relative humidity less than 60 percent) for 7 days before test and shall be tested dry. If the concrete in the structure will be more than superficially wet under service conditions, the cores shall be immersed in water for at least 40 hours and tested wet."

IN **201-1.1.5 Test for Portland Cement Concrete**, LAST PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"To check testing accuracy, locations represented by erratic core strengths may be retested. If these strength acceptance criteria are not met by the core tests, and if structural adequacy remains in doubt, the Engineer may order load tests for the questionable portion of the structure, or take other action appropriate to the circumstances."

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IN **201-1.2.2 Aggregates**, ADD THE FOLLOWING TO THE END:

"Aggregates from all of the Upper San Gabriel River area will be accepted as having a silica-released to alkali-reduced ratio less than one without the testing requirements."

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IN **201-1.2.4 Chemical Admixtures, (e) Air-Entraining Admixtures**, ADD THE FOLLOWING TO THE END:

"Unless otherwise specified or directed by the Engineer, the Contractor shall furnish and add an air-entraining agent, containing no calcium chloride, conforming with ASTM C-260 to all concrete. The agent shall be added in such amounts that not less than 4 percent or more than 6 percent of air by volume is entrained in the concrete as it enters the forms. The air entraining agent shall be added to the concrete in solution in the mixing water in such a manner as to insure uniform distribution throughout the concrete."

IN **201-1.2.5 Fly Ash, (b) Class C Fly Ash**, SECOND TO THE LAST SENTENCE, DELETE THE PERCENT BY WEIGHT "30" AND REPLACE WITH "20".

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IN **201-1.2.6 Reclaimed Concrete Material**FIRST PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Reclaimed concrete material may be used only in concrete mixtures for non-structural applications in accordance with this section when approved by the Engineer and subject to the satisfactory results of tests of the proposed mix design which include but is not limited to slump, strength, modulus of rupture, modulus of elasticity, and permeability which meets or exceeds the properties of the specified concrete mix without the addition of reclaimed concrete material. An independent testing laboratory approved by the Engineer shall perform the tests using the latest ASTM or ACI standards. All test results shall be submitted to the Engineer prior to approval of the proposed concrete mix. The cost of sampling and testing shall be the responsibility of the Contractor."

IN **201-1.2.6 Reclaimed Concrete Material** DELETE THE FOURTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Reclaimed concrete material may not be used in special exposure mixtures or where architectural aesthetics are a concern."

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IN **201-1.4.3 Transit Mixers**, FOURTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The revolving of the drum shall be continuous until the concrete is completely emptied from the drum."

IN **201-1.4.3 Transit Mixers**, SIXTH PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"The Engineer may waive this limitation if the concrete is of such condition, based on tests and other factors, after the 90-minute time limit has been reached that it can be placed without the addition of water to the batch. These tests may include, but are not limited to, slump and temperature readings of the batch, formwork and reinforcing steel. Other factors may include, but are not limited to, time required to place the concrete and extent of placing and finishing effort, the time of day, and weather conditions."

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IN **201-2.2.1 Reinforcing Steel**, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Unless otherwise specified, reinforcing steel shall be Grade 400 (60) billet steel conforming to ASTM A706/706M."

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IN **201-2.4.1 General**, LAST SENTENCE, ADD THE WORDS "or requested" AFTER THE WORD "required".

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IN **201-3.6 Type "C" Sealant (Asphalt-Latex Emulsion Joint Sealant)**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"The sealing compound shall be an emulsion consisting of paving asphalt conforming to 203-1 emulsified with rubber latex in a suitable emulsifying agent."

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IN **201-6.1.1 General**, FIRST PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Controlled Low Strength Material (CLSM) shall be placed as required on the Plans or specified in the Special Provisions. At the written request of the Contractor and with the approval of the Engineer, CLSM may be used a trench backfill, non-structural backfill or pipe backfill."

IN **201-6.1.1 General**, DELETE THE THIRD AND FOURTH PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"The CLSM mix shall contain: at least 100 pounds of cement and 250 pounds of flyash; no more than 500 pounds of water; with about 2700 pounds of sand and no more than 1.25 percent entrapped air per cubic yard. The density shall be a minimum of 132 pounds per cubic feet and the compressive strength shall be no less than 100 psi and no more than 300 psi."

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IN **201-7 NON-MASONRY GROUT**, DELETE ALL THE PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**201-7.1 Portland Cement Grout and Dry Pack.** Unless otherwise shown or specified, grout and dry pack shall conform to the following: Grout shall be composed of 1 part Portland cement and not more than 3½ parts of sand by volume with sufficient water for placing. Dry pack shall be composed of 1 part Portland cement and not more than 2½ parts of sand with sufficient water for hydration of the cement. Dry pack shall provide an effective load bearing surface and shall be used where a stiff or plastic grout is needed. Dry pack may also be used to repair the holes.

**201-7.2 Nonshrink Grout.** Nonshrink grout shall be a high strength nonstaining grout meeting the requirements of ASTM C 1107. The nonshrink grout shall be submitted to the Engineer for review and approval. The grout shall be mixed, handled, placed, and cured in accordance with the manufacturer's written instructions. The non-shrink grout shall be suitable and certified by the manufacturer for the purpose intended.

**201-7.3 Epoxy Grout.** Epoxy grout shall be used where specified on the plans and shall be a Sika grout manufactured by Sika Chemical Corporation, Lyndhurst, New Jersey, Five Star grout manufactured by Five Star Products, Inc., Fairfield, Connecticut, or equal. The surface to receive the grout shall be dry and shall be prepared in accordance with the manufacturer's written instructions. The epoxy grout shall be mixed and placed strictly in accordance with the manufacturer's written recommendations."

IN 203-1.2 Testing Requirements, AFTER THE SENTENCE, ADD THE FOLLOWING:

"Performance grade paving asphalt shall conform to the requirements in Table 203-1.2(B). As used in Table 203-1.2(B), the term "binder" shall mean paving asphalt."

IN 203-1.2 Testing Requirements, AFTER Table 203-1.2(A), ADD THE FOLLOWING:

**"TABLE 203-1.2(B)**

Grade	AASHTO Test	PG 64-10	PG 64-16	PG 64-28	PG 70-10
<b>Original Binder</b>					
Flash Point, °C, minimum	T48	230	230	230	230
Solubility, %, minimum	T44	99.0	99.0	99.0	99.0
Viscosity, 135°C, Pa-s, maximum <sup>a</sup>	T316	3.0	3.0	3.0	3.0
Dynamic Shear Test Temperature, °C	T315	64	64	64	70
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, minimum	T315	1.00	1.00	1.00	1.00
<b>RTFO Aged Binder (T240)</b>					
Mass Loss, %, maximum	T240	1.00	1.00	1.00	1.00
Dynamic Shear Test Temperature, °C	T315	64	64	64	70
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, minimum	T315	2.20	2.20	2.20	2.20
Ductility, 25°C, 5 cm/min, cm, minimum	T51	75	75	75	75
<b>RTFO and PAV Aged Binder (R28)</b>					
PAV Aging Temperature, °C	R28	100	100	100	110
Dynamic Shear Test Temperature, °C	T315	31 <sup>b</sup>	28 <sup>b</sup>	22 <sup>b</sup>	34 <sup>b</sup>
Dynamic Shear, 10 rad/s, G*/Sinδ, kPa, minimum	T315	5000	5000	5000	5000
Bending Beam Test Temperature, °C	T313	0	-6	-18	0
Creep Stiffness, Mpa, maximum	T313	300	300	300	300
m-value, minimum	T313	0.300	0.300	0.300	0.300

<sup>a</sup>This requirement may be waived by the Engineer if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

<sup>b</sup>If the PAV aged binder exceeds 5000 kPa at the designated test temperature, it will be deemed acceptable if it is less than 5000 kPa when tested at a 3°C higher test temperature."

IN 203-1.4 Temperatures, DELETE THE SECOND PARAGRAPH AND Table 203-1.4(a) AND REPLACE WITH THE FOLLOWING: "Each grade of paving asphalt shall be applied within the temperature range specified in Table 203-1.4(A).

**TABLE 203-1.4(A)**

Grade	Plant Mixing Temperature °C (°F)		Distribution Application Temperature °C (°F)	
	Minimum	Maximum	Minimum	Maximum
AR 16000	150 (300)	175 (350)	140 (285)	175 (350)
AR 8000	135 (275)	160 (325)	140 (285)	175 (350)
AR 4000	135 (275)	160 (325)	140 (285)	175 (350)
AR 2000	135 (275)	160 (325)	140 (285)	175 (350)
AR 1000	95 (200)	150 (300)	125 (260)	160 (325)
PG 70-10	150 (300)	175 (350)	140 (285)	175 (350)
PG 64-28	135 (275)	160 (325)	140 (285)	175 (350)
PG 64-16	135 (275)	160 (325)	140 (285)	175 (350)
PG 64-10	135 (275)	160 (325)	140 (285)	175 (350)

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IN 203-1.6 Measurement and Payment, DELETE Table 203-1.6(A) AND REPLACE WITH THE FOLLOWING:

**"TABLE 203-1.6(A)**

Grade	Liters Per Tonne at 15°C (Gallons per Ton at 60°F)	Grams Per Liter at 15°C (Pounds per Gallon at 60°F)
AR 16000	981 (235)	1020 (8.51)
AR 8000	981 (235)	1020 (8.51)
AR 4000	981 (235)	1020 (8.51)
AR 2000	989 (237)	1011 (8.44)
AR 1000	997 (239)	1002 (8.36)
PG 70-10	981 (235)	1020 (8.51)
PG 64-28	981 (235)	1020 (8.51)
PG 64-16	981 (235)	1020 (8.51)
PG 64-10	981 (235)	1020 (8.51)

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IN 203-6.1 General, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Asphalt concrete will be designated by class and grade i.e., "C2-AR-4000" or C2-PG 64-10". Asphalt concrete containing up to 15 percent RAP shall be identified by adding the suffix "RAP" to the class and grade i.e., "C2-AR4000-RAP" or "C2-PG 64-10-RAP"."

**In 203-6.2 Mix Designs**, THIRD PARAGRAPH, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"Unless otherwise waived by the Engineer at delivery time, the Contractor shall furnish the Districts an updated mix certificate."

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**IN 203-7.1 General**, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"RAC will be designated by class and grade, i.e., "C2-AR-4000-RAC" or "C2-PG 64-10-RAC". The end product shall meet both the gradation and paving asphalt grade specified."

**IN 203-7.2.2 Reclaimed Asphalt Pavement**, SECOND PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"The RAC producer shall perform sand equivalent tests on the unextracted RAP, and tests of RAP paving asphalt content, RAP paving asphalt viscosity or performance grade, and gradation of RAP aggregates on solvent extracted samples of RAP taken from stockpiles."

**IN 203-7.2.3 RAC Bituminous Materials**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The results of tests performed on the RAC binder shall meet the RTFO residue requirements in Table 203-1.2(A) for the AR grade specified in the RTFO and PAV test requirements in Table 203-1.2(B) for the PG grade specified, except the "Percent of Original Penetration" is not required."

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**IN 203-11.2.1 Paving Asphalt**, DELETE THE SENTENCE AND REPLACE WITH THE FOLLOWING:

"Paving asphalt used for asphalt-rubber shall be viscosity grade AR 4000 or performance grade PG 64-16 and shall be modified with an asphalt modifier. Performance grade paving asphalt other than PG 64-16 may be used if so specified in the Special Provisions or approved by the Engineer."

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**IN 203-12.2.2 Screenings**, LAST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"Screenings shall be preheated to between 127°C (260°F) to 163°C (325°F) and adequately coated with 0.70 percent to 1 percent paving asphalt viscosity grade AR 4000 or performance grade PG 64-10 conforming to 203-1 at a central mixing plant to prevent free dust."

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**AFTER 204-2.5 Handling and Protection of Treated Materials**, ADD THE FOLLOWING:

**"204-2.6 Rough Hardware for Permanent Construction.**

**204-2.6.1 Common Nails.** Commercial Standard, 16d unless otherwise specified; galvanized or aluminum where exposed to weather.

**204-2.6.2 Threaded Nails.** "Screw -Tite" or "Stronghold", or equal, either spiral thread or annular-grooved. Type 316 stainless steel where exposed to weather, water or wastewater, galvanized otherwise.

**204-2.6.3 Screws.** Commercial Standard, galvanized where exposed.

**204-2.6.4 Bolts and Nuts.** American Standard, unfinished, except galvanized where exposed. Provide with matching cut or pressed steel washers for both bolts and nuts, where bearing on wood, unless otherwise shown."

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IN **206-1.1.1 General**, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Unless noted otherwise, all steel, the class of which is not definitely designated herein, in the Special Provisions, or on the Plans, shall be structural steel and shall conform to the requirements of ASTM A36. Structural steel wide flange shapes shall conform to the requirements of ASTM A992 or ASTM A572 with S5, Charpy V-notch Impact Test and S14 Bend Test."

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IN **206-1.4.1 Unfinished Bolts**, DELETE THE THIRD SENTENCE AND REPLACE WITH THE FOLLOWING:

"Washers shall be furnished unless otherwise specified. In addition, structural plate washers shall be supplied for oversized and slotted holes and shall completely cover the oversized or slotted holes with minimum ¼-inch overlap. The minimum thickness of the structural plate washers shall be the same thickness as the outermost ply of the bolted materials."

IN **206-1.4.1 Unfinished Bolts**, ADD THE FOLLOWING TO THE END:

"Stainless steel bolts shall be Type 316 with stainless steel nuts and washers, unless shown otherwise."

IN **206-1.4.2 High-Strength Bolts**, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"The bolts shall conform to ASTM A325 and shall be furnished with hardened washers. In addition, structural plate washers shall be supplied for oversized and slotted holes and shall completely cover the oversized and slotted holes with minimum ¼-inch overlap. The minimum thickness of the structural plate washers shall be the same thickness as the outermost ply of the bolted materials."

IN **206-1.4.3 Anchor Bolts**, DELETE THE SENTENCE AND REPLACE WITH THE FOLLOWING:

"Steel anchor bolts shall conform to ASTM F1554 Grade 36 and shall be galvanized where shown on the Plans. Stainless steel anchor bolts shall be TYPE 316 with stainless steel nuts and washers."

AFTER **206-1.4.3 Anchor Bolts**, ADD THE FOLLOWING:

"**206-1.4.4 Concrete Fasteners.** Concrete fasteners including concrete anchors, stud or wedge anchors, and adhesive anchors shall have an ICBO Evaluation Report. Concrete nails and power-driven fasteners are not acceptable. Adhesive anchors shall be epoxy adhesive anchors with Type 316 stainless

steel, unless noted otherwise. Installation shall comply with the ICBO Evaluation Report. Special inspection shall be provided for adhesive anchors."

IN **206-3.1 General** FOURTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Foundry identification mark, heat and date shall be cast on the bottom of the cover and on the inside of the frame. Imported covers and frames shall have the country of origin marking in compliance with the Federal Regulations."

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IN **206-3.2 Test Requirements**, THIRD PARAGRAPH, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"The proof-load shall be 55,300 pounds."

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AFTER **206-6.8 Repair of Damaged Coatings**, ADD THE FOLLOWING:

"**206-7 Stainless Steel.** Stainless steel shall conform to TYPE 316. Where welding is used to join, the stainless steel shall conform to TYPE 316L.

**206-8 Aluminum.** All aluminum plate, rods, and structural shapes shall conform to alloy and temper designation 6061-T6. All aluminum bearing on or embedded in concrete shall have one coat of an epoxy primer by Porter International, TPA 830N, or Tnemec Co. Series 69 Hi-Build Epoxoline II, or equal."

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IN **207-2.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING THE END:

"Reinforced concrete pipe shall be manufactured in accordance with ASTM C76 except as modified herein."

IN **207-2.1 General**, THIRD PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "three sets of".

IN **207-2.1 General**, DELETE THE FOURTH PARAGRAPH AND ADD THE FOLLOWING TO THE END OF THE THIRD PARAGRAPH:

"Vertical and horizontal curves shall be constructed with a uniform deflection at each joint within the curve using factory fabricated beveled pipe and/or by pulling joints. Siphons shall be constructed along a vertical curve having a vertical point of intersection as shown on the Plans using factory fabricated mitered or beveled pipe and/or by pulling joints. The deflection at any point along the siphon shall not exceed 10° and points of deflection shall be separated by a pipe joint. On mitered pipe, the maximum space between the adjacent ends of the pipe at the point of deflection shall not exceed 4 inches. If the mitered pipe is to be plastic lined, the space shall be plastic lined with a Type P-1 joint, except that the joint strip shall be 6 inches wide. Detailed drawing of the mitered pipe shall be submitted to the Engineer for approval. All drawings for siphons and vertical curves shall include a scaled drawing indicating the station and elevation of each pipe joint or mitered bend.

Where 6 inch or larger stubs are required on the Plans, the pipe manufacturer shall provide holes blocking out prior to spinning or casting the pipe. Unless otherwise stated, stubs are to be placed at 45 degrees above the horizontal axis. Any circumferential steel, cut for placement of holes, shall be secured by a circle of reinforcing steel of the same size placed around the blockout. Minimum steel clearance shall be maintained. Blockouts shall be 2 inches in diameter larger than the outside diameter of the stubs at the outside diameter of the concrete pipe and tapering to the outside diameter of the stub at the inside diameter of the concrete pipe.

Grout holes shall be provided on all jacked pipe. Grout holes shall be cast into the pipe on 4 foot longitudinal centers at 45 degrees above the horizontal axis alternating left and right. No grout holes shall be closer than 2 feet to any joint. These grout holes shall consist of steel couplings 1½ inch minimum diameter for pipe sizes through 57 inches and 2 inch minimum diameter for 60 inches and larger pipe. After the grouting operation has been completed, the steel couplings shall be sealed with steel grout plugs. The grout plugs shall be recessed a minimum of ¾ inch from the inside of the pipe. Prior to manufacture of the jacked pipe, detailed drawings of the grout couplings and grout plug design, and grout hole spacing and location within the pipe shall be submitted to the Engineer for approval.

Unless otherwise specified, RCP shall be either wet cast or spun. Machine-made RCP is acceptable if 360 degree PVC lined and supplied by a plant certified for machine-made RCP by the Districts prior to bid. Machine-made RCP shall not be used for jacking."

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IN **207-2.4.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Welded wire fabric shall not be used as reinforcement unless otherwise approved by the Engineer."

IN **207-2.4.1 General**, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"unless otherwise approved by the Engineer."

IN **207-2.4.1 General**, FOURTH PARAGRAPH, ADD TO THE FOLLOWING TO THE END:

"Fastenings placed against the forms shall be stainless steel or plastic, approved by the Engineer."

IN **207-2.4.1 General**, LAST PARAGRAPH, DELETE THE WORDS "Upon request," AND ADD THE WORDS "area of steel," AFTER THE WORD "spacing,"

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IN **207-2.4.2 Location of Reinforcement**, LAST PARAGRAPH, DELETE THE SECOND SENTENCE.

IN **207-2.5 Joints**, ADD THE FOLLOWING TO THE END:

**207-2.5.1 Rubber-Gasketed Joints.** Depending on the method of construction, joints for the rubber gasket reinforced concrete pipe shall be of the types specified in 207-2.5.1.1 or 207-2.5.1.2. All surfaces of the reinforced concrete pipe which come into contact with the rubber gasket shall be coated with epoxy. The epoxy shall be Select Bond GP-2000, as manufactured by Select Products Company, Upland, California or equal.

**207-2.5.1.1 Open Cut and Tunneling Construction.** Pipe joints of the rubber gasket reinforced concrete pipe for open cut and tunneling construction shall be double-gasketed joints designed such that the joint can be pulled ¾-inch open along the outside of the pipe from normal closure without impairment

of the water tightness or contact of the concrete surfaces between the bell and the spigot. Thickness of the bell or the spigot shall not be less than 35 percent of the pipe barrel wall thickness and shall in no case be less than 3 inches thick measured at the body. The spigot end of the pipe shall have a length to thickness ratio not to exceed 2 to 1. All steel used shall be well embedded in concrete and shall serve the purpose of reinforcement only. Circumferential reinforcement shall be placed in both the bell and the spigot and shall have an area of steel not less than that of the barrel of the pipe for single cage pipe, and not less than the area of the inner cage for double cage pipe. In addition, both the bell and the spigot shall be manufactured with a minimum total longitudinal reinforcing steel area of 0.22 in<sup>2</sup>/ft. of pipe circumference. The inner face of the bell shall include an additional reinforcing steel cage embedded into the pipe barrel. The longitudinal reinforcing steel in the bell or the spigot shall terminate one inch from the end face.

Additional longitudinal reinforcing steel, if provided, shall be extended through the joint not less than 12 inches into the barrel and shall be equally spaced around the circumference of the pipe matching the spacing of the longitudinal steel bars of the reinforcement cage. Additional longitudinal steel bars if used, shall not be larger than ½-inch in diameter and shall be placed to provide maximum clearance between the steel and the forms as determined by the Engineer. The size, spacing and location of all additional reinforcing steel used shall be included as a part of the pipe submittal.

The Contractor shall test each pipe joint immediately after it has been installed and prior to installing the adjoining pipe or backfilling the pipe. The joints shall be pressurized to 15 psig and held for a minimum of 5 seconds and shall drop not more than 1 psig. In the event the pressure drop is greater than 1 psig, the Contractor shall remove and re-install the pipe and retest the pipe until the leakage test passes. This testing shall be in addition to the field joint leakage test outlined in 207-2.5.2.2.

**207-2.5.1.2 Jacking Construction.** Pipe joints of the rubber gasket reinforced concrete pipe to be jacked shall be full wall, double gasket joint with stainless steel compression band design. The joint shall have an outside diameter same as the pipe, so when assembled, the joint is essentially flush with the outside diameter of the pipe. In no case shall the outside diameter of the stainless steel band be greater than the outside diameter of the pipe. The stainless steel compression band shall be of one piece design and fit over the recessed end(s) of the pipe. The band shall be made of Type 316 stainless steel and shall be a minimum 3/8-inch thick. Pipe wall thickness at the recess shall be designed to withstand the maximum allowable jacking forces to be used and the recess shall be manufactured ¼-inch greater in depth than the band thickness and with a continuous groove for the placing of the gasket. The longitudinal length of the recess shall be designed such that after the joint is assembled and jacked in place, the clearance remaining on each side of the stainless steel band will be 1 inch or less. Leading edge of the band shall be tapered upwards to ensure that the stainless steel band will properly mate with the preceding joint of pipe during jacking. The minimum concrete cover over the reinforcing steel at the recess shall be in accordance with 207-2.4.2 of the Standard Specifications. The longitudinal reinforcing steel shall extend to 1 inch from the pipe end. The variation in laying lengths of two opposite sides of the pipe to be jacked shall not be more than ¼-inch in any length of pipe. The ends of the pipe shall be square within 3/16 inch.

**207-2.5.2 Rubber-Gasketed Joint Leakage Tests.** In addition to all the testing requirements specified for reinforced concrete pipe, rubber gasket reinforced concrete pipe shall be subjected to both a yard joint leakage test and a field joint leakage test. The Contractor shall, at his own expense, furnish all water, materials and labor for performing the tests required. All tests shall be conducted under the direction and in the presence of the Engineer. Any damages resulting or becoming evident from the leakage tests and any subsequent repair that is necessary shall be the responsibility of the Contractor. The Contractor shall submit to and obtain approval from the Engineer of his proposed testing procedures and setup prior to conducting the leakage tests. All leakage tests shall be conducted prior to welding the plastic liner at the pipe joints.

**207-2.5.2.1 Yard Joint Leakage Tests.** Two yard joint leakage tests shall be conducted by the pipe manufacturer for each pipe size and each joint design. The Engineer will select two pieces of pipe of each pipe size and each joint design for each yard test. The pipe manufacturer may elect to bulkhead the ends of the pipes and pressurize the pipes. The joint shall be subjected to the test pressure of 15 psig for a period of 24 hours prior to testing. The test pressure shall be maintained for a minimum of 30 minutes with no apparent leakage. The pipe manufacturer shall not ship any pipe until both yard joint leakage tests are passed.

**207-2.5.2.2 Field Joint Leakage Tests.** One field joint leakage test shall be performed on each reach of the installed rubber gasket reinforced concrete pipe. The pipe shall be saturated with water before the test. The test pressure of 15 psig shall be held on the pipe reach for a minimum of 30 minutes with no apparent leakage. If the test is failed, the Contractor shall repair the leaking joint(s) in accordance with 207-2.5.3.

In lieu of testing the entire pipe reach, the Contractor may elect to test each of the pipe joints installed. The joint shall be pressurized to 15 psig. The test pressure shall be held for a minimum of 5 seconds and shall drop not more than 1 psig. If the test is failed, the Contractor shall repair the joint in accordance with 207-2.5.3.

The testing including any re-testing of each pipe joint shall be witnessed by an independent laboratory. The laboratory shall be retained by the Contractor, at its expense, and approved by the Engineer prior to the start of testing. Upon completion of all joint testing within each reach of sewer, the Contractor shall submit certification by the independent laboratory that all joints have been tested in accordance with the approved testing procedures and are in compliance with these specifications. This certification shall not relieve the Contractor of the responsibility to correct defective work. The Contractor shall perform repairs in accordance with 207-2.5.3 and retest the pipe reach until the leakage test passes. In addition, this certification shall be received by the Districts prior to welding the plastic liner at the pipe joints.

**207-2.5.3. Joint Repair.** The Contractor shall repair any pipe joint not passing the leakage test in accordance with any additional joint repair methods as deemed necessary. The Contractor shall comply with and develop the joint repair procedures in accordance with these requirements as a minimum and submit to the Districts for approval any additional joint repair methods as deemed necessary. The submittal shall include a detailed description of the procedures, all the materials to be used and installation procedures as recommended by the pipe and material manufacturers, the joint testing procedure, and the independent laboratory with the name and qualifications of the inspector(s). The Contractor shall not begin any joint repair work without an approved submittal. The Contractor shall use a subcontractor specializing in this type of work to repair the joints and shall hire an independent laboratory approved by the Districts to witness the preparation, the joint repair work, and the testing. All joint repair costs shall be borne by the Contractor.

The Contractor shall remove the plastic liner, clean and prepare the surfaces, and repair the joint using hydrophobic polyurethane chemical grout and epoxy grout. The polyurethane chemical grout shall be SikaFix HH as manufactured by Sika Corporation, Concrevice 1230 as manufactured by ChemRex Corporation, or equal. The epoxy grout shall be Sikadur 45 as manufactured by Sika Corporation, Masterflow MP as manufactured by Master Builders, or equal. The Contractor shall prepare the joint as required by the epoxy grout manufacturer. The joint shall be cleaned by mechanical abrasion and shall be free of contaminants and laitance with a surface profile as required to provide a bond with the epoxy grout.

For joint gaps greater than 3/16-inch, the Contractor shall insert oakum material saturated with polyurethane chemical grout 1½ inches into the joint and allow the polyurethane chemical grout to

activate. The Contractor may have to spray with water to allow the polyurethane chemical grout to activate, if necessary. Oakum shall be sized to fill the full width of the joint. After the polyurethane chemical grout has set, the Contractor shall fill the remaining joint gap with epoxy grout. For joint gaps less than 3/16-inch, the Contractor shall omit the use of oakum material and shall inject the epoxy directly into the joint per the pipe manufacturer's written instructions.

The Contractor shall drill holes for injection ports along the joints and install the injection ports (packers) into the drilled holes. For polyurethane chemical grout injection, holes shall be drilled at an angle to intersect the joint behind the oakum and to avoid damaging reinforcing steel. The holes shall be placed on alternating sides of the joint and placed at interval to allow for maximum penetration of the polyurethane resin. The Contractor shall start the polyurethane chemical grout injection starting at the pipe invert and work towards the pipe soffit and shall follow the manufacturer's recommended injection procedures for mixing, injection pressure and injection process. The Contractor shall remove the injection ports flush with the surrounding concrete surface and remove any excess polyurethane chemical grout.

The joint shall then be tested in accordance with 207-2.5.2.2. The independent laboratory inspector shall monitor the testing. After the joint has been repaired and when directed by the Engineer, the Contractor shall repair the existing plastic liner in accordance with applicable provisions of 311.

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IN **207-2.8 Causes for Rejection**, FIRST PARAGRAPH, AFTER SUBPARAGRAPH 17) ADD THE FOLLOWING:

- "18) Use of unapproved fasteners.
- 19) Inside pipe diameter larger than specified.
- 20) Inside pipe diameter smaller than 99 percent of specified diameter."

IN **207-2.8 Causes for Rejection**, SECOND PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"All pipes found to be acceptable shall be marked with the Districts' stamp prior to delivery to the jobsite. Marking of the pipe at the place of manufacture shall not be considered a final acceptance of the pipe."

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IN **207-2.9.2 D-Load Bearing Strength Test**, DELETE THE LAST PARAGRAPH.

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IN **207-3.1 General**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"The plastic lining material shall be embedded in concrete and shall comply with 210-2 and shall be tested in accordance with 211-2."

IN **207-3.1 General**, FIRST PARAGRAPH, AFTER THE THIRD SENTENCE, ADD THE FOLLOWING:

"Unless otherwise shown on the Plans, lined reinforced concrete pipe shall be supplied with Type P-2 joints as specified in 311-1.5.2."

IN 207-3.1 General, ADD THE FOLLOWING TO THE END:

"When coverage for plastic lined reinforced concrete pipe is 360°, the manufacturer shall furnish test pipes identical in design to the lined pipe except without the plastic liner. The test pipe length shall be determined by the pipe manufacturer but in no case shall the test section be less than 4 feet. The number of test pipes and the tests to be performed shall be in accordance with the applicable provisions of 207-2.9.2, except that for pipe size 60 inches and larger, the number of test pipes shall be two for each pipe size and D-load required."

IN 207-3.2 Causes For Rejection, SUBPARAGRAPH 1), ADD THE WORDS "stainless steel" BEFORE THE WORDS "holding rods".

IN 207-3.2 Causes for Rejection, SUBPARAGRAPH 12) (a), DELETE THE WORDS "throughout a continuous" AND REPLACE WITH WORDS "measured at close intervals for a".

IN 207-3.2 Causes for Rejection, ADD THE FOLLOWING TO THE END:

- "13) Test pipe fails the D-Load bearing strength test.
- 14) Any reduction in thickness of the spigot due to compression of the liner extension except as allowed by the Engineer.
- 15) Any longitudinal wrinkling or locking extension pullout except as allowed by the Engineer."

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IN 207-5.1 General, ADD THE FOLLOWING TO THE END:

"The Contractor shall submit design calculations for approval prior to the manufacture of any pipe."

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IN 207-8.1 General, ADD THE FOLLOWING TO THE END:

"Vertical and horizontal curves shall be constructed with a uniform deflection at each joint within the curve using factory fabricated mitered or beveled pipe and/or by pulling joints. In no case shall joints be pulled more than recommended by the pipe manufacturer or approved by the Engineer.

Siphon shall be constructed along vertical curves having no more than 4° of deflection at any point along the curve. Points of deflection shall be separated by a pipe joint.

Prior to the manufacture of pipe required for horizontal and vertical curves and for siphons, pipe detail and layout drawings for said curve and siphons shall be submitted to the Engineer for review and approval. All drawings for siphons and vertical curves shall include a scaled drawing indicating station and elevation of each pipe joint or mitered bend."

IN 207-8.2.1 General, ADD THE FOLLOWING TO THE END:

"and shall be marked so as to clearly identify the long and short sides, and curve designation or plan station."



IN 207-10.4.2 **Cement-Mortar Lining and Coating**, ADD THE FOLLOWING TO THE END:

"After the lining has been properly cured, the ends of the pipe shall remain tightly sealed with transparent plastic covers until field installation. Care shall be taken to insure a moist environment within the pipe at all times. After installation, linings shall be kept continuously moist by sprinkling until placed into service. The surface of the pipe exposed to sunlight shall be sprinkled with water in the daytime to prevent cracking of the lining and/or coating."

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IN 207-21.6 **Joints**, ADD THE FOLLOWING TO THE END OF SUBPARAGRAPH (a):

"The seat shall be concentric with the inside diameter of the pipe. An eccentricity greater than  $\frac{3}{8}$ " will be cause for rejection of the pipe."

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AFTER 207-24.6 **Inspection and Acceptance**, ADD THE FOLLOWING:

"207-25 **Precast Manhole Shafting**. Prior to the shipment of precast concrete manhole components, the Contractor shall submit stacking sequence to the Engineer for approval. The submittal shall indicate the location and spacing of all manhole steps.

All manholes shall conform to the Districts' Standard Drawings and concrete for the components shall be 660-B-4000. All pinholes exceeding  $\frac{1}{8}$ -inch in dimension shall be treated as pockets for finishing. Pockets are defined as areas where aggregate is exposed and shall be filled using a class "C" mortar. Any precast components which have lost cement fines at form closures and/or cracked components will be subject to rejection.

All precast manhole shafting found to be acceptable shall be marked with the Districts' stamp prior to delivery to the jobsite. Marking of the shafting at the place of manufacture shall not be considered as final acceptance of the precast manhole shafting.

If plastic liner is specified, the plastic liner shall be installed in accordance with the applicable provisions of 210-2 and 311."

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IN 208-6.1 **General**, ADD THE FOLLOWING TO THE END:

"This type of flexible coupling shall not be used unless specified and/or approved by the Engineer"

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IN 209-2.3 **Conduit**, LAST PARAGRAPH, LAST SENTENCE, DELETE "conductors" AND REPLACE WITH "conduits".

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IN **209-2.4 Wire**, LAST PARAGRAPH, LAST SENTENCE, DELETE "THW OR THWN" AND REPLACE WITH "XHHW or THHN/THWN".

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IN **210-2.1 General**, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Testing of the plastic liner for conformance with 210-2 shall be witnessed and approved by the Engineer."

IN **210-2.1 General**, LAST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"or in structures."

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IN **210-2.2.1 Approval of Details**, ADD THE FOLLOWING TO THE END:

"Plans, sections, details, and location where details are used shall be submitted for the Engineer's review and approval"

IN **210-2.2.3 Material Sizes**, AFTER THE WORD "pipe", ADD THE WORDS "or structure".

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IN **210-2.4.2 Shop-Welded Joints**, ADD THE FOLLOWING TO THE END:

"All PVC liner sheets to be formed in the shop shall be fabricated by lapping basic size sheets a minimum of 0.50 inch and fusing the sheets together by high frequency dielectric fusion to produce continuous welded seams."

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IN **210-3.3 Workmanship**, FIRST PARAGRAPH, DELETE THE THIRD SENTENCE AND REPLACE WITH THE FOLLOWING:

"Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening and other fabricating shall be completed before the galvanizing, or as approved by the Engineer."

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IN **210-3.5 Repair of Damaged Zinc Coatings**, AFTER THE WORD "methods", ADD THE WORD "as".

IN **210-3.5.3 Zinc Dust Paint**, FOURTH SENTENCE, DELETE "A3" AND REPLACE WITH "A2".

IN **210-3.5.4 Zinc Based Solders**, DELETE "A3" AND REPLACE WITH "A1".

IN 211-1, DELETE THE HEADING "**COMPACTION TESTS**" AND REPLACE WITH "**SOILS AND AGGREGATE TESTS**," AND DELETE SUBSECTIONS 211-1.1, 211-1.2 AND 211-1.3 AND REPLACE WITH THE FOLLOWING:

" **211-1.1 LABORATORY TESTING.** All soils and aggregate testing shall be performed by an independent accredited testing laboratory approved by the Engineer at the Contractor's expense. The frequency of sampling shall be as needed to determine the acceptability of fill materials or shall be as required in other sections or items of the Standard Specifications (i.e., 306), and for structure backfill or compaction shall be as required in the County of Los Angeles Building Code, Section 3313.8. For trenches, a minimum of one compaction test for the pavement base material and one compaction test for each specified relative compaction of backfill material is required for every 300 feet of trenching and at least once for every 300 cubic yards of backfill material. For other excavations besides trenches, compaction tests shall be taken at least once every 2 vertical feet and at least once every 500 cubic yards. The independent testing laboratory representative shall notify the Engineer's representative upon arrival at the site and advise the Engineer's representative of preliminary results prior to leaving the site.

The accredited soils testing laboratory shall confirm and verify that the fills installed were placed upon competent and properly prepared material and compacted in compliance with the Standard Provisions and the Building Code and shall prepare a final soils engineers report attesting the above, which shall be stamped and signed by a Geotechnical or Civil Engineer currently registered by the State of California. The report shall include the following:

- A. Description of the materials encountered at the bottom of the excavation.
- B. Preparation of the subgrade prior to placement of fill.
- C. Inspection and approval of the subgrade by the Soils Engineer.
- D. Inspection and approval of the subdrain installation by the Soils Engineer.
- E. Identification of the types of fill material placed with the Unified Soil Classification System, maximum dry densities and optimum moisture contents.
- F. Thickness of layers (typically 6 - 8 inches).
- G. Method of compaction.
- H. Moisture content control if mechanical compaction is used.
- I. ASTM testing designations for density and laboratory maximum density.
- J. Purpose/use of fill: i.e., to support footings (structural), for walkways/paving (secondary), for landscaping (non-structural), etc.
- K. Certification that a qualified representative of the independent testing laboratory continuously monitored fill placement, when required.

**211-1.2 COMPACTION TESTS.**

**211-1.2.1 Laboratory Maximum Density.** The following method shall be used for compaction tests:

Laboratory maximum density test shall be performed in accordance with ASTM D 1557, Method "C".

The Engineer may modify ASTM D 1557 at his option to calculate relative compaction based on adjusted laboratory maximum wet density calculated as follows:

$$Da = (100 Dm) (100 \pm Wa)$$

Da = Adjusted laboratory maximum wet density.

Dm = Maximum wet density per ASTM D 1557, Method "C".

$\pm W_a$  = Percent change in moisture content from field moisture to laboratory optimum moisture. Use minus when field moisture content is higher than laboratory optimum moisture content. Use plus when field moisture content is lower than laboratory optimum moisture content.

**211-1.2.2 Field Density and Relative Compaction.** Field density of soil shall be determined by any method which will accurately and consistently determine the density and moisture content of the soil.

A minimum of 20 percent of the field density tests shall be by the sand cone method in accordance with ASTM D 1556. Locations of the field density test shall be mutually acceptable to the laboratory and Engineer, and the results of the testing shall be presented to the Engineer monthly. Test results shall be reported as Relative Compaction, which shall be defined as the ratio of the field dry or wet density to the laboratory maximum dry density or adjusted wet density, respectively, expressed as a percentage. Test results showing less than the specified compaction will not be acceptable. Removal, recompaction, and re-testing of the areas that failed to meet specified degree of compaction shall be included.

**211-1.3 SAND EQUIVALENT TEST.** This test is intended to serve as a field test to indicate the presence or absence of plastic fine material. The test shall be run in accordance with Calif. Test 217 or ASTM D 2419. When testing material containing asphalt, this test method shall be modified by drying the sample at a temperature not exceeding 38°C (100°F).

**211-1.4 PERMEABILITY TEST.** Permeability tests for granular soils will be performed in accordance with ASTM D 2434, using samples compacted to the specified field density.

**211-1.5 SIEVE ANALYSES.** Sieve analyses shall be performed in accordance with ASTM C 136."

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IN **212-1.4.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Plant labels shall identify each species and variety of plant."

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IN **212-2.2.7 Valve Boxes**, ADD THE FOLLOWING TO THE END:

"or if approved, plastic valve boxes may be substituted."

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IN **212-3.2.1 Conduit**, ADD THE FOLLOWING TO THE END:

"or if approved, UL approved schedule 40 PVC conduit."

IN **212-3.2.2 Conductors**, FIRST PARAGRAPH, DELETE "THW OR THWN" AND REPLACE WITH "XHHW or THHN/THWN".

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IN **213-1.5.5 Apparatus and Asphalt Cement**, DELETE THE FIFTH SENTENCE AND REPLACE WITH THE FOLLOWING:

"Asphalt cement shall be viscosity grade AR 4000 or performance grade PG 64-10 paving asphalt conforming to 203-1."

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**IN 300-1.3.2 Requirements, (a) Bituminous Pavement, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:**

"Bituminous pavement shall be removed to clean, straight lines. Where only the surface of existing bituminous pavement is to be removed, the method of removal shall be approved by the Engineer, and a minimum laying depth of 1 inch of new pavement material shall be provided at the joint line. Unless otherwise stated on the Plans, where bituminous pavement adjoins a trench, the edges adjacent to the trench shall be saw cut to neat straight lines before resurfacing to ensure that all areas to be resurfaced are accessible to the rollers used to compact the subgrade or paving materials. The saw cut lines shall parallel the trench centerline. Angled cuts (1:10 maximum) may be allowed by the Engineer. The saw cut edge shall be made to a minimum depth of 1½ inches after trench backfill and compaction have been completed and shall be a minimum of 6 inches beyond the trench edges. Removal of the full thickness of the existing bituminous pavement is required between the trench edge and saw cut edge."

If the edge of the remaining section of pavement which adjoins an excavation is within 2½ feet of an existing edge of pavement, curb and gutter, spandrel, cross gutter, concrete pavement or other existing improvement, the Contractor shall remove and replace the remaining section of pavement. If an improvement is to be constructed adjacent to existing bituminous pavement, a 1 foot section of pavement shall be removed and then replaced after the improvement is completed."

**IN 300-1.3.2 Requirements (b) Concrete Pavement, SECOND SENTENCE, DELETE THE WORDS "a minimum depth of 38 mm (1½ inches)" AND REPLACE WITH THE WORDS "the full thickness of the pavement".**

**IN 300-1.3.2 Requirements, (b) Concrete Pavement, AFTER THE THIRD SENTENCE, ADD THE FOLLOWING:**

"The saw cut edge adjacent to a trench shall extend a minimum of 6 inches beyond the actual edge of trench, such that the concrete replaced will be a minimum of 1 foot wider than the trench width at the surface."

**IN 300-1.3.2 Requirements (c) Concrete Curb, Walk, Gutters, Cross Gutters, Driveways, and Alley Intersections, FIRST SENTENCE, DELETE THE WORDS "a minimum depth of 38 mm (1½ inches)" AND REPLACE WITH THE WORDS "the full thickness of the concrete".**

**IN 300-1.3.2 Requirements, (c) Concrete Curb, Walk, Gutters, Cross Gutters, Driveways, and Alley Intersections, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:**

"Curb and gutter shall be sawed to the full thickness of the concrete on a neat line at right angles to the curb face. If any concrete cross gutter is removed, the concrete cross gutter shall be removed by sawcutting between the centerline of the street and the spandrel, and the sawcut section shall be replaced. After backfilling and compacting the trench, an approved epoxy binder shall be used on all construction joints. If a portion of a spandrel is cut, the entire spandrel shall be replaced. If a concrete cross gutter is tunneled under, the tunnel shall be backfilled with sand-cement grout having 141 pounds of cement per cubic yard of grout."

**IN 300-2.1 General, ADD THE FOLLOWING TO THE END:**

"such as trench excavation".

IN **300-2.2.1 General**, DELETE THE FIRST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Material that is unsuitable for the planned use shall be excavated and removed from the job site immediately."

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IN **300-2.4 Slides and Slipouts**, DELETE THE FIRST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Material outside the planned excavation limits which is unstable and constitutes a potential slide as determined by the soils laboratory or Engineer, material which has come into the planned excavation limits, and material which has slipped out of new or old fills shall be excavated to designated lines or slopes either by benching or in such manner as directed by the Engineer. Such material may be used in the construction of an unclassified fill or disposed of as approved by the Engineer."

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IN **300-3.3 Foundation Material Treatment**, AFTER THE LAST PARAGRAPH ADD THE FOLLOWING:

"In the presence of the Engineer and after approval of the excavation, the Contractor shall scarify the exposed surface to a depth of 8 inches, moisture condition to about 2 percent above optimum moisture content, and compact the subgrade to at least 90 percent of maximum dry density."

IN **300-3.4 Inspection**, FIRST AND SECOND SENTENCES, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

IN **300-3.5.1 Requirements**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The backfill shall be brought up uniformly on all sides of the structure."

IN **300-3.5.1 Requirements**, SECOND PARAGRAPH, AFTER THE TABLE, ADD THE FOLLOWING:

"Material used shall also have an expansion index less than 20 as determined by UBC Standard No. 18-2."

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IN **300-4.1 General**, DELETE THE THIRD AND FOURTH PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Clods or hard lumps of earth shall be broken up before compacting the material in the fill. Clods, rocks or boulders incorporated into the fill shall have no dimension greater than 6 inches. No cemented brick rubble, broken asphalt pavement, or broken concrete will be allowed in the fill unless allowed by the Contract Documents."

IN **300-4.3 Other Fill Materials**, DELETE THE ENTIRE SUBSECTION 300-4.3.

IN **300-4.4 Benching**, SECOND PARAGRAPH, FIRST SENTENCE, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

IN **300-4.5 Placing Materials for Fills**, FIRST PARAGRAPH, THIRD SENTENCE AND SECOND PARAGRAPH, FIRST SENTENCE, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

IN **300-4.5 Placing Materials for Fills**, DELETE THE FOURTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Broken portland cement concrete and bituminous type pavement and cemented brick rubble shall not be placed in the fill."

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IN **300-4.6 Application of Water**, SECOND PARAGRAPH, FIRST AND SECOND SENTENCES, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

IN **300-4.7 Compaction**, FIRST PARAGRAPH, FIRST SENTENCE, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

IN **300-5.1 Local Borrow**, FIRST PARAGRAPH, FOURTH SENTENCE, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

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IN **300-5.2 Imported Borrow**, SECOND PARAGRAPH, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

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IN **300-6.5 Compacted Fills**, THIRD AND FIFTH PARAGRAPHS, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

IN **300-6.5 Compacted Fills**, SIXTH PARAGRAPH, ADD THE WORDS "soils laboratory and" BEFORE THE WORD "Engineer".

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IN **301-1.6 Adjustment of Manhole Frame and Cover Sets to Grade**, FIRST PARAGRAPH, DELETE THE FIRST TWO SENTENCES AND REPLACE WITH THE FOLLOWING:

"Sewer and storm drain manhole frames and covers within the area to be paved shall be set to finish grade by the Contractor. Utility manhole and vault frames and covers owned by the Districts shall also be set to finish grade by the Contractor. Utility manhole and vault frames and covers owned by others shall be set to finished grade by the owners thereof."

IN **301-1.6 Adjustment of Manhole Frame and Cover Sets to Grade**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The Contractor shall exercise necessary caution to prevent debris from falling into manholes. In the event that debris should fall into a manhole, the Contractor shall immediately notify the Districts and then remove the debris following all required safety measures. Unless otherwise authorized by the

Engineer, the adjustment to grade shall be completed prior to final inspection of the pipe interior and manholes."

IN **301-1.6 Adjustment of Manhole Frame and Cover Sets to Grade**, ADD THE FOLLOWING TO THE END: "FOR LOS ANGELES COUNTY DEPARTMENT OF PUBLIC WORKS CASH CONTRACTS ONLY:

"The Contractor shall notify the County Sanitation Districts, telephone (323) 774-7272, two working days prior to starting any work involving the Districts' manhole and shall furnish the cost, to be confirmed in writing, for adjusting or reconstructing each manhole according to 301-1.6, 301-1.7 and 302-5.8. The Districts will notify the Contractor within one work day whether to proceed with the work, at the price quoted, or that the Districts will perform the necessary adjusting or reconstruction as the utility owner.

If the Contractor is authorized to proceed to adjust or reconstruct each manhole, then the Districts will issue a purchase order in the amount of the written price. The Contractor shall proceed to adjust or reconstruct each manhole as the owner, as stipulated in 301-1.6, 301-1.7 and 302-5.8. The Districts will provide inspection of the work at no cost to the Contractor. Full payment for the work performed will be made within 30 days of the receipt of an invoice and acceptance of the work by the Districts.

If the Districts elect to adjust or reconstruct Districts' manholes as the owner, then the following procedures will be followed:

For each manhole involved, the Districts will place a temporary cover over the channel and will lower the manhole to a point 6 inches below subgrade. The Contractor shall provide and place a suitable temporary cover plate for the manhole. Following completion of paving operations, the Contractor shall remove the pavement and base material from the surrounding area, remove the temporary cover plate and remove any construction debris that may have accumulated in the manhole. The Districts will adjust the manhole to final grade. The Contractor shall then backfill and pave the surrounding area.

Where the Districts' manholes are existing within a paved area to be resurfaced with asphalt concrete pavement, the Contractor shall mark the location of the Districts' manholes which have been paved over. The Districts will perform all removal and adjustment work within 48 hours. The Contractor shall then repave around the adjusted manholes."

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IN **302-5.4 Tack Coat**, FIRST PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"If the asphalt concrete pavement is being constructed directly upon an existing hard-surfaced pavement, a tack coat of viscosity grade AR 4000 or AR 8000, or performance grade PG 64-10 paving asphalt conforming to 203-1 applied at an approximate rate of 0.25 L/m<sup>2</sup> (0.05 gallon per square yard), or SS-1h emulsified asphalt applied at an approximate rate of 0.25 L/m<sup>2</sup> to 0.45 L/m<sup>2</sup> (0.05 to 0.10 gallon per square yard), shall be uniformly applied upon the existing pavement preceding the placement of the asphalt concrete."

IN **302-5.4 Tack Coat**, REPLACE THE LAST PARAGRAPH WITH THE FOLLOWING:

"The contact surfaces of all cold pavement joints, curbs, gutters, manholes, and the like shall be painted with either SS-1h emulsified asphalt or grade AR 4000/AR 8000 or PG 64-10 paving asphalt immediately before the adjoining asphalt concrete is placed."

IN **302-5.5 Distribution and Spreading**, FOURTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Unless otherwise approved by the Engineer, asphalt concrete shall not be placed over cement/sand slurry backfill within 48 hours after placement of the slurry."

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IN **302-5.6.2 Density and Smoothness**, FIRST PARAGRAPH, LAST SENTENCE, ADD THE FOLLOWING TO THE END:

"unless otherwise approved by the Engineer."

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IN **302-5.8 Manholes (and other structures)**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"After the pavement has been completed, the pavement, base and subgrade shall be removed to a depth of 12 inches below finish grade and a distance of 12 inches around the outside of the manhole frame and the manhole frame set to the grade of the adjacent pavement. The removal area shall be backfilled to within 1½ inches of the surface with Portland cement concrete conforming to 302-6.1. The remaining 1½ inches shall be filled by the Contractor with asphalt concrete placed and compacted in a workmanlike manner to match the pavement surface. For Los Angeles County Department of Public Works Cash Contracts, see 301-1.6 for procedures.

Proposed manholes on new sewer construction shall be constructed to approximate finish grade prior to placing temporary or permanent resurfacing. Paving over structures temporarily covered with steel plate will not be allowed."

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IN **302-6.5.1 General**, LAST PARAGRAPH, ADD THE FOLLOWING:

"Unless noted otherwise on the plans or specifications, weakened-plane joints shall be installed in concrete pavements at 10 feet on center in each direction. Greater spacing may be directed by the Engineer."

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IN **302-7.2.2 Tack Coat**, FIRST PARAGRAPH, REPLACE THE FIRST SENTENCE WITH THE FOLLOWING:

"The tack coat shall be viscosity grade AR 4000 or performance grade PG 64-10 paving asphalt conforming to 203-1."

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IN **303-1.1 General**, FIRST PARAGRAPH, FIRST SENTENCE, ADD THE WORDS "sewer manholes," BEFORE THE WORDS "catch basins"

IN **303-1.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The Contractor shall coordinate the work of all trades so that all piping, conduits, anchor bolts and other shapes to be cast in the concrete are properly placed in the forms, and that provision is made for all adjacent and abutting construction and equipment. All such work shall be in place at least 24 hours prior to the scheduled concrete placement to allow adequate time for inspection. Concrete placement will not be permitted until all noted deficiencies are corrected. Adequate equipment and sufficient workmen shall be on the job site to handle the amount of concrete being placed and finished."

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IN **303-1.2 Subgrade for Concrete Structures**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"When excavation has occurred below the subgrade of the structures, it shall be filled with select material, approved by the Engineer and compacted to a relative density of 95 percent."

IN **303-1.3 Forms**, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Forms for all surfaces shall be constructed using plywood and shall be approved by the Engineer. Plywood forms shall be made with 4 foot by 8 foot sheets for all concrete surfaces unless otherwise approved by the Engineer. Prior to setting reinforcing steel for walls, one side of the forms shall be set and braced to line and grade."

IN **303-1.3 Forms**, THIRD PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Forms for all surfaces of concrete structures shall be constructed of plywood or an approved equal."

IN **303-1.3 Forms**, THIRD PARAGRAPH, DELETE THE FIFTH SENTENCE AND REPLACE WITH THE FOLLOWING:

"Plywood panels shall be a minimum of 15 mm (5/8-inch) thick and shall be attached directly to the studs or joists, which shall be spaced not more than 305 mm (12 inches), center to center."

IN **303-1.3 Forms**, LAST PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"With the approval of the Engineer, concrete may be placed directly against the sides of excavations, provided the following conditions are met:"

IN **303-1.3 Forms**, LAST PARAGRAPH, SUBPARAGRAPH 1), ADD THE FOLLOWING TO THE END:

"The Contractor may place building paper in lieu of gunite if, in the opinion of the Engineer, ground conditions do not require gunite to prevent raveling."

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IN **303-1.4.1 General**, ADD THE FOLLOWING TO THE END:

"Forms of vertical members such as walls, including those on box sections, may be removed after the concrete has obtained a compressive strength of 1,500 psi as determined by cylinder tests, but not before 24 hours after completion of the concrete placement. Forms supporting horizontal members such as beams and slabs, including those on box sections, may be removed after the concrete has attained a compressive strength of 2,000 psi as determined by cylinder tests. The age-strength relations shall be determined from tests of representative samples taken from batches of concrete used in the members under consideration and cured under job conditions. Additional test cylinders as required shall be obtained and cylinder testing shall comply with the requirements of 201-1."

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IN **303-1.5 Removal of Forms for Box Sections**, DELETE THE SECTION IN ITS ENTIRETY.

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IN **303-1.6.1 General**, DELETE THE FIRST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Falsework shall comply with Article 29, Section 1717 of the Construction Safety Orders issued by the Division of Occupational Safety and Health."

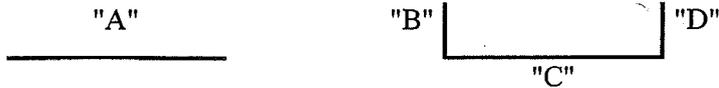
IN **303-1.6.1 General**, THIRD PARAGRAPH, FIRST SENTENCE DELETE "HE" AND REPLACE WITH "THE".

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IN **303-1.7.1 General**, DELETE THE FIRST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Before placing reinforcing steel, the Contractor shall submit a reinforcing steel placing drawing and bar list in accordance with 2-5.3 and as specified below.

- 1) Reinforcing steel placing drawing shall show plans and sections detailing the size, spacing, and location of the bars in the structure.
- 2) Bar list prepared from the placing drawing used in cutting, bending, tagging and shipping shall show the number of pieces, size, length, grade of steel, mark of bars, and bending details of all bent bars. The bar list shall be a complete summary of materials required. The bar list shall be submitted with the reinforcing steel placement drawings and shall be presented in the following format."



MARK NUMBER	"A"	"B"	"C"	"D"	REBAR SIZE	QUANTITY	GRADE (KSI)
450	3'-2"				4	10	60
451	4'-6"				4	6	60
500		2'-6"	2'-6"		5	2	60
501		2'-6"	3'-6"		5	12	60
502		4'-0"	6'-4"		5	12	60
650		8'-0"	20'-6"	8'-0"	6	8	60
651		6'-4"	15'-0"	3'-6"	6	8	60
652		7'-6"	14'-6"	6'-0"	6	24	60

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IN **303-1.7.2 Splicing**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"Where bars are spliced, they shall be at least a Class B Splice in accordance with ACI 318, latest edition or lapped at least 30 diameters, whichever is greatest or most stringent, unless otherwise shown on the Plans."

IN **303-1.8.2 Grouting**, ADD THE FOLLOWING TO THE END:

"The grout mixture shall be submitted to the Engineer for review and approval prior to use. The depth of the grout mixture shall be 3 inches minimum to 6 inches maximum."

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IN **303-1.8.3 Depositing**, THIRD PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Concrete shall not be permitted to fall more than 1.8m (6 feet) without the use of tremies."

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IN **303-1.8.8 Placing Concrete Under Adverse Weather Conditions**, LAST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"During inclement weather, concrete shall not be placed without prior approval of the Engineer. See 6-6.5."

IN 303-1.9.1 **General**, DELETE THE LAST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The entire channel and shelves of cast-in-place and precast channels for sewer manholes and structures shall be given a steel trowel finish."

IN 303-1.9.2 **Ordinary Surface Finish**, FIRST PARAGRAPH, FIRST SENTENCE, DELETE THE WORD "Immediately"

IN 303-1.9.2 **Ordinary Surface Finish**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"All pinholes exceeding 1/8 inch in dimension shall be treated as pockets for finishing. Pockets are defined as areas where aggregate is exposed."

IN 303-1.9.2 **Ordinary Surface Finish**, SECOND PARAGRAPH, DELETE SUBPARAGRAPHS 1) THRU 4) AND REPLACE WITH THE FOLLOWING:

- 1) All interior surfaces of tanks, hoppers, channels, and pumping plant wet wells and other similar surfaces.
- 2) All exterior surfaces of tanks, hoppers, channels, galleries and similar structures which are to be temporarily buried underground but later exposed as a result of future expansion.
- 3) Exposed interior vertical and soffit surfaces of galleries, pipe shafts, stairwells and similar interior structures."

IN 303-1.9.3 **Class 1 Surface Finish**, DELETE THE FIRST PARAGRAPH AND SUBPARAGRAPHS 1) THRU 6) AND REPLACE WITH THE FOLLOWING:

"Class 1 surface finish shall be applied to all surfaces as a preparation for Class 2 surface finish."

IN 303-1.9.3 **Class 1 Surface Finish**, LAST PARAGRAPH, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING:

"After completion of the ordinary surface finish, bulges which exceed the tolerance for a true flat surface of 1/4 inch in any 10 foot length in any direction shall be removed by chipping or bushhammering and the surface repaired with mortar as described for ordinary surface finish."

IN 303-1.9.4 **Class 2 Surface Finish**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Upon completion of the Class 1 surface finish (the preparation finish for Class 2 surface finish), and after the concrete has been pre-dampened, a slurry consisting of 1-part cement (including appropriate quantity of white cement) and 1 1/2 parts sand passing the No. 16 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats. Any surplus shall be removed by scraping and then rubbing with clean burlap.

Class 2 surface finish shall be the final finish for the following surfaces, which includes all concrete exposed to view:

- 1) All exposed vertical surfaces of walkways and walls above finished ground and to at least one foot below finished ground.
- 2) All exposed vertical surfaces of walkways and walls above normal water level and to at least one foot below normal water level in all tanks not covered.
- 3) All exposed interior surfaces of walls and stairs in the open galleries, stairwells, pumping plant dry wells and access openings."

AFTER **303-1.9.4 Class 2 Surface Finish**, ADD THE FOLLOWING:

"**303-1.9.5 Flatwork Finish.** All slabs and exposed horizontal surfaces shall be finished with a steel trowel. The steel trowel finish shall be an integral finish obtained by troweling with a steel trowel after the surface has been floated and allowed to stand until all water sheen has disappeared. Final troweling shall be done after the concrete has hardened sufficiently to prevent drawing moisture and fine materials to the surface and when the concrete is sufficiently hard that no mortar accumulates on the trowel. Cement or mixtures of cement and sand shall not be spread on surfaces to absorb excess water or to stiffen the concrete. Troweling shall produce a dense, smooth, impervious surface, free from defects and blemishes. Final troweling shall be applied in a rotary pattern to achieve a sweat finish."

IN **303-1.10 Curing**, DELETE THE FOURTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The use of plastic sheeting to cover the surface shall be submitted to the Districts for approval. When the surface is covered with plastic sheeting, it shall remain covered for at least 14 consecutive days. The plastic sheeting shall be minimum 6 mil thickness, reinforced, transparent plastic sheet vapor barrier. The plastic sheeting shall be laid with edges lapped not less than 6 inches and taped. The perimeter of the plastic sheet vapor barrier shall be completely sealed in a manner acceptable to the Engineer. The vapor barrier shall be maintained in a sealed condition and any damage to the vapor barrier shall be immediately repaired as directed by the Engineer. The Contractor's submittal shall include the method of maintaining the plastic sheeting in place."

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IN **303-4.1.2 Construction**, FOURTH PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"All concrete block units and any partially laid walls which become wet during the construction shall be permitted to dry until such time that sufficient bond between the mortar and masonry units is accomplished, before recommencing work."

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IN **303-4.1.3 Placing Reinforcing Steel**. FIRST PARAGRAPH, DELETE THE SECOND AND THIRD SENTENCES AND REPLACE WITH THE FOLLOWING:

"Unless shown otherwise on the plans, splices shall be lapped a minimum of 40 diameters, except column dowels. Column dowels shall lap 60 diameters."

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IN **304-1.1.2 Falsework Plans**, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Falsework shall comply with Article 29, Section 1717 of the Construction Safety Orders issued by the Division of Occupational Safety and Health."

IN **304-1.3 Inspection**, DELETE THE FIRST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"An authorized representative of the Engineer may examine the metals and metal items to be fabricated before they are worked in the shop and may exercise constant surveillance over the Work during its progress with full power to reject all materials or workmanship not conforming to the Plans and Specifications.

An independent inspector acceptable to the Engineer shall be retained by the Contractor to inspect all materials and workmanship. The inspector shall be certified by the American Welding Society (AWS) and the County of Los Angeles Building Department as a Special Inspector. All inspection reports shall be furnished by the inspector to the Engineer in a timely manner for acceptance by the Engineer prior to shipping from the shop or access to the work is removed, restricted or eliminated for both shop and field work. The Contractor is responsible for the cost of all inspection.

In lieu of a special inspector, a certificate of compliance from an "Approved Shop" performing shop fabrication shall be furnished to the Engineer for acceptance prior to shipment of the assemblies. The "Approved Shop" shall be certified by the City of Los Angeles Building Department in the appropriate category for the work."

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IN **304-1.5.7 Bolted Connections**, IN THE FIFTH PARAGRAPH ADD THE FOLLOWING:

"All high strength steel bolted assemblies shall be 100 percent inspected by a Special Inspector approved by the Engineer. The inspector shall be certified by the County of Los Angeles Building Department as a Special Inspector. All cost for inspection shall be the responsibility of the Contractor."

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IN **304-1.7 Bearings and Anchorage**, AT THE END OF THE FIRST PARAGRAPH ADD THE FOLLOWING:

"All concrete and masonry anchors shall have a minimum embedment depth of eight (8) bolt diameters."

IN **304-1.9 Welding**, DELETE THE FIRST AND SECOND PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"All welding shall conform to the requirements of American Welding Society (AWS) Structural Welding Codes or national standards which include, but is not limited to, the ASME Codes, as appropriate for the application, unless noted otherwise, and these specifications. The latest edition shall be used. In cases of conflict the most stringent requirement shall apply. Compliance shall be in accordance with, but is not limited to, the partial list of AWS Codes below.

Structural Welding Code	ANSI/AWS Standard
Steel	D1.1
Aluminium	D1.2
Sheet Steel	D1.3
Reinforcing Steel	D1.4
Stainless Steel	D1.6

The welder shall be certified by AWS and the City of Los Angeles Building Department . For welding under ASME or other national standards, the welder shall be certified in accordance with the appropriate standards.

Inspection of welding made to control the quality of welds and workmanship shall be performed in accordance with the requirements of the AWS and national standards. An independent inspection agency or laboratory acceptable to the Engineer shall perform the inspection. The inspector shall be certified by AWS and the County of Los Angeles Building Department. All welds shall be 100 percent visually inspected. Welds in material 1 inch thick and thicker shall be inspected using radiographic, ultrasonic, and magnetic particle techniques. All non-destructive testing of welds (which include but is not limited to visual, radiographic, ultrasonic, magnetic particle and liquid penetrant techniques) that are designated in the Contract Documents and these specifications shall be the Contractors responsibility. The cost of re-inspection of defective welds that are repaired shall also be borne by the Contractor."

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IN **304-3.2 Fence Construction**, DELETE THE FIFTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Unless otherwise specified, all fence shall be installed with top and bottom tension wires or rails."

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IN **306-1.1.1 General**, FIRST PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "For the purpose of shoring or bracing, a".

IN **306-1.1.1 General**, SECOND PARAGRAPH, ADD THE WORDS "insertion pits" AFTER THE WORDS "thrust blocks,".

IN **306-1.1.1 General**, ADD THE FOLLOWING TO THE END:

"Unless otherwise allowed by the Engineer, the Contractor shall commence construction at the lower end of the Project defined on the Plans as 'BEGINNING OF CONSTRUCTION' and shall proceed up grade in a continuous operation. The Contractor shall not have open excavation at more than one location unless required on the Plans or authorized by the Engineer."

IN 306-1.1.2 **Maximum Length of Open Trench**, DELETE THE FIRST PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Except as authorized by the Engineer, the trench at the end of each day shall not be excavated more than 25 feet in advance of the pipe laid that day, nor left unbackfilled for more than 25 feet where pipe has been laid.

Unless otherwise allowed by the Engineer, the Contractor shall complete construction at each location including the base course of the final resurfacing within 30 calendar days after commencement of construction at the location. The final course of resurfacing shall be completed within 60 calendar days after commencement of construction at each location. Completion of construction shall include all work required on the Plans and in the Specifications, including manholes, house connections, planting, and replacement or repair of damaged surface improvements. Failure on the part of the Contractor to complete construction at each location, including final resurfacing, within the time limit specified may result in a directive from the Engineer to cease progress on any or all parts of the Work under Contract until the past due work is completed and progress payments may be withheld. No additional compensation will be allowed as a result of such directive.

Irrespective of the requirements as stated above, unless otherwise authorized by the Engineer, the maximum length of trench without the base course of the final resurfacing shall not exceed 2,000 linear feet at any one time and the maximum length of trench without the final course of final resurfacing shall not exceed 5,000 linear feet at any one time."

IN 306-1.1.3 **Maximum and Minimum Width of Trench**, DELETE THE FIRST, FOURTH AND FIFTH PARAGRAPHS AND REPLACE THE FIRST PARAGRAPH WITH THE FOLLOWING:

"Unless otherwise stated on the Plans or Special Provisions, the maximum allowable width of trench for vitrified clay pipe, including the width required for sheeting measured at the top of the pipe, shall be as shown in the following tables. Values for the maximum allowable trench width may not be interpolated. Unless otherwise permitted by the Engineer, if the actual depth of cover over pipe is in between the depths of cover shown, the trench width value of the greater depth of cover shall be used. The maximum trench width for reinforced concrete pipe shall be as shown on the Plans or as specified in the Special Provisions.

**TABLE 306-1.1.3(A)**

**EXTRA STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITHOUT SPECIAL BEDDING**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
7	*	*	*	*	*	*	*	*	*	*	*	*	*
8	*	*	*	*	*	*	*	*	*	*	*	78	82
9	*	*	*	*	*	*	*	61	63	66	71	73	77
10	*	*	*	39	43	49	54	57	60	62	67	69	73
11	*	*	33	38	42	47	52	55	57	60	64	66	69
12	*	31	32	36	40	45	50	53	55	57	61	63	66
13	29	30	32	36	39	44	48	51	53	**	59	**	**
14	28	30	31	35	38	43	47	50	52	**	**	**	**
15	28	29	31	34	38	42	46	**	**	**	**	**	**
16	27	29	30	34	**	41	45	**	**	**	**	**	**
17	27	29	30	**	**	**	**	**	**	**	**	**	**
18	27	28	30	**	**	**	**	**	**	**	**	**	**
19	27	28	**	**	**	**	**	**	**	**	**	**	**
20	27	28	**	**	**	**	**	**	**	**	**	**	**
21	26	28	**	**	**	**	**	**	**	**	**	**	**
22	26	28	**	**	**	**	**	**	**	**	**	**	**
23	26	28	**	**	**	**	**	**	**	**	**	**	**
24 to 40	26	**	**	**	**	**	**	**	**	**	**	**	**

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(B)**

**EXTRA STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITH CRUSHED ROCK BEDDING**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
9	*	*	*	*	*	*	*	*	*	*	*	*	*
10	*	*	*	*	*	*	*	*	*	73	*	81	85
11	*	*	*	*	*	*	*	64	66	69	74	77	80
12	*	*	*	42	46	52	57	61	63	66	71	73	77
13	*	*	36	40	45	50	55	59	61	63	68	70	73
14	*	33	35	39	44	49	53	57	59	61	65	68	71
15	*	33	34	39	43	47	52	55	57	60	63	65	68
16	31	32	34	38	42	46	51	54	56	58	62	64	66
17	30	32	34	37	41	46	50	53	55	57	60	**	**
18	30	32	33	37	41	45	49	52	54	**	59	**	**
19	30	31	33	36	40	44	48	51	53	**	**	**	**
20	30	31	33	36	40	44	47	50	52	**	**	**	**
21	29	31	32	36	39	43	47	49	**	**	**	**	**
22	29	31	32	36	39	43	46	49	**	**	**	**	**
23	29	31	32	35	39	42	46	**	**	**	**	**	**
24	29	30	32	35	38	42	45	**	**	**	**	**	**
25	29	30	32	35	38	42	45	**	**	**	**	**	**
26	29	30	32	35	38	41	45	**	**	**	**	**	**
27	29	30	31	35	38	41	45	**	**	**	**	**	**
28	29	30	31	35	38	41	**	**	**	**	**	**	**
29	29	30	31	34	**	41	**	**	**	**	**	**	**
30	29	30	31	34	**	41	**	**	**	**	**	**	**
31	29	30	31	34	**	41	**	**	**	**	**	**	**
32 to 40	28	30	31	34	**	**	**	**	**	**	**	**	**

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(C)**

**EXTRA STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITH CONCRETE CRADLE TYPE 1 OR 1A PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
13	*	*	*	*	*	*	*	*	*	*	*	*	*
14	*	*	*	*	*	*	*	*	*	*	*	88	93
15	*	*	*	*	*	*	*	*	74	77	82	85	89
16	*	*	*	*	53	*	*	69	72	74	79	82	86
17	*	*	*	47	52	57	63	67	70	72	77	80	83
18	*	*	41	46	51	56	62	65	68	71	75	78	81
19	*	*	40	45	50	55	60	64	66	69	73	76	79
20	*	38	40	45	49	54	59	63	65	68	72	74	77
21	*	38	40	44	48	53	58	62	64	66	70	73	76
22	35	37	39	44	48	53	58	61	63	65	69	71	74
23	35	37	39	43	47	52	57	60	62	64	68	70	73
24	35	37	39	43	47	52	56	59	61	63	67	69	72
25	35	37	38	43	47	51	56	58	61	63	66	68	71
26	35	36	38	42	46	51	55	58	60	62	65	67	70
27	35	36	38	42	46	50	55	57	59	61	65	67	69
28	34	36	38	42	46	50	54	57	59	61	64	66	69
29	34	36	38	42	45	50	54	56	58	60	64	65	68
30	34	36	38	41	45	49	53	56	58	60	63	65	67
31	34	36	37	41	45	49	53	56	58	60	63	64	67
32	34	36	37	41	45	49	53	55	57	59	62	64	66
33	34	36	37	41	45	49	53	55	57	59	62	64	66
34	34	36	37	41	44	49	52	55	57	58	61	63	**
35	34	36	37	41	44	48	52	55	56	58	61	63	**
36	34	35	37	41	44	48	52	54	56	58	61	63	**
37	34	35	37	41	44	48	52	54	56	58	61	**	**
38	34	35	37	41	44	48	52	54	56	57	60	**	**
39	34	35	37	41	44	48	51	54	56	57	60	**	**
40	34	35	37	40	44	48	51	54	55	57	60	**	**

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(D)**  
**EXTRA STRENGTH VITRIFIED CLAY PIPE**  
**MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES**  
**WITH CONCRETE CRADLE TYPE 2 OR 2A PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
19	*	*	*	*	*	*	*	*	*	*	*	*	*
20	*	*	*	*	*	*	*	*	*	*	*	97	101
21	*	*	*	*	*	*	*	*	*	86	91	94	98
22	*	*	*	*	*	*	*	*	81	84	89	92	96
23	*	*	*	*	60	*	*	76	79	82	87	90	94
24	*	*	*	53	59	65	71	75	78	81	86	89	93
25	*	*	*	53	58	64	70	74	77	80	84	87	91
26	*	*	47	52	58	63	69	73	76	79	83	86	90
27	*	*	47	52	57	63	68	72	75	78	82	85	88
28	*	44	46	52	57	62	68	71	74	77	81	84	87
29	*	44	46	51	56	62	67	71	73	76	80	83	86
30	*	44	46	51	56	61	67	70	73	75	79	82	85
31	42	44	46	51	55	61	66	69	72	74	79	81	84
32	42	44	46	50	55	60	66	69	71	74	78	80	83
33	41	43	45	50	55	60	65	68	71	73	77	79	83
34	41	43	45	50	55	60	65	68	70	73	77	79	82
35	41	43	45	50	54	59	64	68	70	72	76	78	81
36	41	43	45	50	54	59	64	67	69	72	75	78	81
37	41	43	45	50	54	59	64	67	69	71	75	77	80
38	41	43	45	49	54	59	63	66	69	71	75	77	80
39	41	43	45	49	54	58	63	66	68	71	74	76	79
40	41	43	45	49	53	58	63	66	68	70	74	76	79

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(E)**

**EXTRA STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITH CONCRETE ENCASEMENT TYPE 1 PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
26	*	*	*	*	*	*	*	*	*	*	*	*	*
27	*	*	*	*	*	*	*	*	*	*	*	104	108
28	*	*	*	*	*	*	*	*	*	93	99	102	107
29	*	*	*	*	*	*	*	*	89	92	98	101	105
30	*	*	*	*	*	*	*	85	88	91	96	99	104
31	*	*	*	*	66	73	79	84	87	90	95	98	102
32	*	*	*	60	66	72	79	83	86	89	94	97	101
33	*	*	*	59	65	72	78	82	85	88	93	96	100
34	*	*	53	59	65	71	77	81	84	87	92	95	99
35	*	*	53	59	64	71	77	81	84	87	91	94	98
36	*	*	53	59	64	70	76	80	83	86	91	93	97
37	*	50	53	58	64	70	76	80	82	85	90	93	96
38	*	50	53	58	63	69	75	79	82	85	89	92	96
39	*	50	52	58	63	69	75	79	81	84	89	91	95
40	*	50	52	58	63	69	75	78	81	84	88	91	94

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(F)**

**EXTRA STRENGTH VITRIFIED CLAY PIPE  
 MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
 WITH CONCRETE ENCASEMENT TYPE 1A PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
29	*	*	*	*	*	*	*	*	*	*	*	*	*
30	*	*	*	*	*	*	*	*	*	*	*	108	113
31	*	*	*	*	*	*	*	*	*	97	*	107	111
32	*	*	*	*	*	*	*	*	93	96	102	105	110
33	*	*	*	*	*	*	*	*	92	95	101	104	108
34	*	*	*	*	*	*	*	88	91	94	100	103	107
35	*	*	*	*	69	76	83	87	90	94	99	102	106
36	*	*	*	63	69	76	82	86	90	93	98	101	105
37	*	*	*	63	68	75	82	86	89	92	97	100	104
38	*	*	*	62	68	75	81	85	88	91	96	99	103
39	*	*	56	62	68	74	81	85	88	91	96	99	102
40	*	*	56	62	67	74	80	84	87	90	95	98	102

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(G)**

**HIGH STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITHOUT SPECIAL BEDDING**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
8	*	*	*	*	*	*	*	*	*	*	*	*	*
9	*	*	*	*	*	*	*	*	*	*	*	80	84
10	*	*	*	*	*	*	*	62	65	68	72	76	79
11	*	*	*	40	45	50	56	59	62	65	68	72	75
12	*	*	35	39	44	48	54	57	60	62	65	68	71
13	*	32	34	38	42	47	52	55	57	59	63	66	68
14	30	31	33	37	41	46	50	53	56	58	61	63	66
15	29	31	33	36	40	44	49	52	54	56	59	**	**
16	29	30	32	36	40	44	48	50	53	**	**	**	**
17	29	30	32	35	39	43	47	49	52	**	**	**	**
18	28	30	32	35	39	42	46	**	**	**	**	**	**
19	28	29	31	35	38	42	46	**	**	**	**	**	**
20	28	29	31	34	38	41	45	**	**	**	**	**	**
21	28	29	31	34	**	41	**	**	**	**	**	**	**
22	28	29	31	34	**	**	**	**	**	**	**	**	**
23	28	29	31	34	**	**	**	**	**	**	**	**	**
24	27	29	31	**	**	**	**	**	**	**	**	**	**
25	27	29	30	**	**	**	**	**	**	**	**	**	**
26	27	29	30	**	**	**	**	**	**	**	**	**	**
27 to 40	27	28	30	**	**	**	**	**	**	**	**	**	**

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(H)**

**HIGH STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITH CRUSHED ROCK BEDDING**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
10	*	*	*	*	*	*	*	*	*	*	*	*	*
11	*	*	*	*	*	*	*	*	*	*	*	84	87
12	*	*	*	*	*	*	*	65	69	72	76	79	83
13	*	*	*	43	48	54	60	63	66	69	73	76	79
14	*	*	38	42	47	52	58	61	64	66	70	73	76
15	*	35	37	41	46	51	56	59	62	64	68	71	74
16	*	34	36	40	45	49	55	57	60	62	66	69	71
17	32	34	36	40	44	48	53	56	59	61	64	67	69
18	32	33	35	39	43	48	52	55	58	59	63	65	68
19	31	33	35	39	43	47	51	54	56	58	61	64	66
20	31	33	35	38	42	46	51	53	56	57	60	63	**
21	31	32	34	38	42	46	50	52	55	56	59	**	**
22	31	32	34	38	41	45	49	52	54	56	**	**	**
23	31	32	34	37	41	45	49	51	53	**	**	**	**
24	30	32	34	37	41	44	48	51	53	**	**	**	**
25	30	32	34	37	41	44	48	50	52	**	**	**	**
26	30	32	34	37	40	44	48	50	52	**	**	**	**
27	30	31	33	37	40	43	47	49	**	**	**	**	**
28	30	31	33	36	40	43	47	49	**	**	**	**	**
29	30	31	33	36	40	43	47	49	**	**	**	**	**
30	30	31	33	36	40	43	46	**	**	**	**	**	**
31	30	31	33	36	39	43	46	**	**	**	**	**	**
32	30	31	33	36	39	42	46	**	**	**	**	**	**
33	30	31	33	36	39	42	46	**	**	**	**	**	**
34	30	31	33	36	39	42	46	**	**	**	**	**	**
35	30	31	33	36	39	42	46	**	**	**	**	**	**
36 to 40	30	31	33	36	39	42	45	**	**	**	**	**	**

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(I)**

**HIGH STRENGTH VITRIFIED CLAY PIPE  
 MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
 WITH CONCRETE CRADLE TYPE 1 OR 1A PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
15	*	*	*	*	*	*	*	*	*	*	*	*	*
16	*	*	*	*	*	*	*	*	*	80	85	89	93
17	*	*	*	*	*	*	*	72	75	78	83	86	90
18	*	*	*	*	54	60	66	70	73	76	80	84	87
19	*	*	*	48	53	59	65	68	72	74	78	82	85
20	*	*	43	47	53	58	64	67	70	73	77	80	83
21	*	40	42	47	52	57	62	66	69	71	75	78	81
22	*	39	42	46	51	56	62	65	68	70	74	77	80
23	*	39	42	46	51	55	61	64	67	69	72	75	78
24	37	39	41	45	50	55	60	63	66	68	71	74	77
25	37	38	41	45	50	54	59	62	65	67	70	73	76
26	36	38	41	45	49	54	59	61	64	66	70	72	75
27	36	38	40	44	49	53	58	61	63	65	69	71	74
28	36	38	40	44	49	53	58	60	63	65	68	71	73
29	36	38	40	44	48	52	57	60	62	64	67	70	72
30	36	38	40	44	48	52	57	59	62	64	67	69	72
31	36	37	40	44	48	52	56	59	61	63	66	69	71
32	36	37	40	43	48	52	56	59	61	63	66	68	70
33	36	37	40	43	47	51	56	58	61	62	65	68	70
34	36	37	39	43	47	51	55	58	60	62	65	67	69
35	36	37	39	43	47	51	55	58	60	62	65	67	69
36	35	37	39	43	47	51	55	57	60	61	64	66	69
37	35	37	39	43	47	51	55	57	59	61	64	66	68
38	35	37	39	43	47	50	55	57	59	61	64	66	68
39	35	37	39	43	47	50	54	57	59	61	63	65	68
40	35	37	39	43	46	50	54	57	59	60	63	65	67

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(J)**

**HIGH STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITH CONCRETE CRADLE TYPE 2 OR 2A PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
21	*	*	*	*	*	*	*	*	*	*	*	*	*
22	*	*	*	*	*	*	*	*	*	*	*	99	103
23	*	*	*	*	*	*	*	*	*	88	93	97	101
24	*	*	*	*	*	*	*	*	84	87	92	95	99
25	*	*	*	*	*	*	*	79	83	85	90	94	97
26	*	*	*	*	62	67	74	78	81	84	89	92	96
27	*	*	*	55	61	67	73	77	80	83	87	91	94
28	*	*	*	55	60	66	72	76	79	82	86	90	93
29	*	*	49	54	60	65	72	75	78	81	85	89	92
30	*	46	49	54	59	65	71	74	78	80	84	87	91
31	*	46	49	54	59	64	70	74	77	79	83	87	90
32	*	46	49	53	59	64	70	73	76	79	83	86	89
33	*	45	48	53	58	63	69	72	76	78	82	85	88
34	43	45	48	53	58	63	69	72	75	77	81	84	87
35	43	45	48	53	58	63	68	71	74	77	80	83	86
36	43	45	48	52	57	62	68	71	74	76	80	83	86
37	43	45	48	52	57	62	68	71	74	76	79	82	85
38	43	45	48	52	57	62	67	70	73	75	79	82	84
39	43	45	47	52	57	62	67	70	73	75	78	81	84
40	43	45	47	52	57	61	67	70	72	75	78	81	83

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(K)**

**HIGH STRENGTH VITRIFIED CLAY PIPE  
 MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
 WITH CONCRETE ENCASEMENT TYPE 1 PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
28	*	*	*	*	*	*	*	*	*	*	*	*	*
29	*	*	*	*	*	*	*	*	*	*	*	*	112
30	*	*	*	*	*	*	*	*	*	*	*	107	111
31	*	*	*	*	*	*	*	*	*	96	101	105	109
32	*	*	*	*	*	*	*	*	92	95	100	104	108
33	*	*	*	*	*	*	*	87	91	94	99	103	107
34	*	*	*	*	69	75	82	86	90	93	98	102	106
35	*	*	*	*	69	75	82	86	90	92	97	101	104
36	*	*	*	62	68	74	81	85	89	92	96	100	103
37	*	*	*	62	68	74	81	84	88	91	95	99	103
38	*	*	56	61	67	73	80	84	87	90	95	98	102
39	*	*	56	61	67	73	80	83	87	90	94	97	101
40	*	52	56	61	67	73	79	83	86	89	93	97	100

Note: \* No limit on width of trench. \*\* Not permitted.

**TABLE 306-1.1.3(L)**

**HIGH STRENGTH VITRIFIED CLAY PIPE  
MAXIMUM ALLOWABLE TRENCH WIDTH IN INCHES  
WITH CONCRETE ENCASEMENT TYPE 1A PER S-a-212**

Depth of Cover Over Pipe, ft.	Pipe Size, in.												
	8	10	12	15	18	21	24	27	30	33	36	39	42
32	*	*	*	*	*	*	*	*	*	*	*	*	*
33	*	*	*	*	*	*	*	*	*	*	*	112	116
34	*	*	*	*	*	*	*	*	*	101	106	110	115
35	*	*	*	*	*	*	*	*	*	100	105	109	113
36	*	*	*	*	*	*	*	*	96	99	104	108	112
37	*	*	*	*	*	*	*	91	95	98	103	107	111
38	*	*	*	*	72	79	*	90	94	97	102	106	110
39	*	*	*	*	72	78	86	90	94	97	101	105	109
40	*	*	*	65	72	78	85	89	93	96	101	104	108

Note: \* No limit on width of trench. \*\* Not permitted.

Crushed rock bedding shall be ½ inch crushed rock as defined in 200-1.2. The crushed rock shall extend from the bottom of the pipe to 12 inches above the top of the pipe and shall be densified by mechanical compaction or vibration, unless otherwise approved by the Engineer. Crushed rock bedding shall be at the option of the Contractor and at his expense.

Unless otherwise stated on the Plans, the maximum allowable width of trench in undisturbed soil for all pipe other than vitrified clay pipe, including the width required for sheeting, measured at the top of the pipe or conduit, shall be the outside diameter of the pipe exclusive of bells or collars, plus 16 inches.

The width of trench for all pipes or conduits shall be such that there will be a minimum of 4 inches clear between the outer surface of the pipe or conduit and the excavation or the trench sheeting."

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IN **306-1.1.6 Bracing Excavations**, DELETE THE THIRD PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Soldier piles shall be installed in drilled holes. Driving soldier piles is not permitted without written approval from the Engineer. Sheet piling shall only be used with prior written approval by the Engineer. The Contractor shall be responsible for the removal of all shoring and bracing materials used during trenching and excavations once the work is completed. During excavating, installation and removal of the excavation shoring or bracing, the Contractor shall exercise extreme care to avoid damage to utilities. The Contractor shall be responsible for repair of all damaged utilities."

AFTER 306-1.1.6 Bracing Excavations, ADD THE FOLLOWING:

**"306-1.1.7 House Connection Sewers.** Where an existing house connection sewer crosses the trench excavation and is not in actual conflict with the proposed sewer, it shall be temporarily maintained in place by the Contractor. Prior to placing final backfill and compaction, the house connection sewer shall be protected from damage due to settlement of the backfill in accordance with subparagraphs (a), (b), or (c) below.

Where an existing house connection sewer crosses the trench excavation and is in actual conflict with the proposed sewer, it shall be temporarily reconstructed to new line and grade to clear the proposed sewer, or connected to the proposed sewer as directed by the Engineer or shown on the Plans. Prior to placing final backfill and compaction, the temporary house connection sewer shall be permanently reconstructed and protected from damage due to settlement of the backfill in accordance with subparagraphs (a), (b), or (c) below.

- (a) After construction of the proposed sewer, the Contractor shall consolidate the material beneath the existing or temporary house connection sewer by mechanically compacting to a relative density of 90 percent, remove the existing or temporary house connection sewer and 8 inches of subbedding material 18 inches in width, then place sufficient compacted crushed aggregate base material on the subgrade to allow the new house connection sewer to be relayed on the proper grade. The permanent house connection sewer shall be Class 52 ductile iron pipe, and shall be equal in length to one and one half times the trench width at the elevation and line of the house connection sewer; however, in no case shall it extend less than 18 inches into the undisturbed trench wall at either end. Connection to the existing house connection sewer shall be by a coupling approved by the Engineer. All voids beyond the limits of the trench which are under the reconstructed house connection sewer shall be filled with 420-C-2000 concrete.
- (b) After construction of the proposed sewer, the Contractor shall consolidate the material beneath the existing or temporary house connection sewer by mechanically compacting to a relative density of 90 percent. The Contractor shall then reconstruct the house connection sewer on a reinforced concrete beam in accordance with the Districts' Standard Drawing S-a-227. Forms used for a beam cast in place shall be approved by the Engineer.
- (c) If the clear distance between the top of the proposed sewer and the house connection sewer is three feet or less, the Contractor shall support the house connection sewer in accordance with the Districts' Standard Drawing S-a-217. If the clear distance is more than three feet, the Contractor may support the house connection sewer in accordance with the Districts' Standard Drawing S-a-217 in lieu of (a) or (b) above.

Payment for reconstruction of house connection sewers in actual conflict with the proposed sewer and for the protection and support of house connection sewers not shown on the Plans shall be made under the bid item established for that purpose. No payment will be made for maintaining, repairing, or permanently supporting house connection sewers shown on the Plans which cross the excavation but which do not have to be reconstructed due to conflict with the proposed sewer. House connections which have been removed from service shall be bulkheaded.

**306-1.1.8 Dewatering.** The Contractor shall submit a dewatering plan for approval per 2-5.3. All water encountered during construction shall be disposed of lawfully by the Contractor in manner such that it will not damage public or private property or create a nuisance or health menace. Water shall not be discharged to street surfaces, storm drains, or surface waters without a NPDES permit. Copies of the NPDES permit application forms and the regulations upon which the permit will be based shall be

obtained from the California Regional Water Quality Control Board. The Districts will pay for the permit application fee, if any. The Contractor shall invoice the Districts for the cost without any Contractor's markup and the Contractor will be reimbursed by purchase order. The Contractor shall allow a minimum 60 days for the review and processing of the permit application. The Contractor shall comply with the requirements and conditions in the permit issued. A copy of the permit shall be submitted to the Districts for record. The Districts will provide water quality sampling and laboratory analysis of the water at the frequency required in the permit at no cost to the Contractor. The Contractor shall provide access for the Districts to obtain the water samples.

The Contractor shall furnish, install and operate pumps, pipes, and equipment of sufficient capacity to keep all excavations free from water while concrete or pipe is being placed, and until all concrete and mortar have set hard, unless otherwise authorized by the Engineer. The Contractor shall provide all means or facilities necessary to convey water to the pumps and to the point of discharge. The Contractor shall be aware that excessive dewatering may cause subsidence. The extent of the dewatering required for construction shall be determined solely by the Contractor. In addition, the Contractor shall be aware that the pipe may float due to water. The Contractor shall perform all work as deemed necessary to prevent the pipe from floating.

Except for the permit fee and the cost for sampling and laboratory analysis which will be paid for by the Districts, the Contractor shall be responsible for all costs for the dewatering operation, including pumping, storage, and desilting as required to meet the criteria for lawful disposal of the water."

IN **306-1.2.1 Bedding**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Bedding is defined as that material surrounding and extending to one foot above the top of the pipe. Subbedding is defined as that material below the bottom of the pipe and supporting the pipe. Where concrete or rock is specified or used to cover the pipe, the top of the concrete or rock shall be considered as the top of the bedding.

If soft, spongy, unstable, or similar other material or rock, shale or other hard unyielding material is encountered at the grade of the bottom of the pipe which, in the opinion of the Engineer, is not suitable subbedding material for the pipe, the unsuitable material shall be removed to a depth ordered by the Engineer and replaced with suitable densified subbedding material. If the necessity for such subbedding material has been caused by an act or failure to act on the part of the Contractor, or required for the control of the ground-water, the Contractor shall bear the expense of the additional excavation and subbedding. Otherwise, the additional subbedding will be paid for by the Districts under the appropriate bid item, if any, and if there is no appropriate bid item, under 3-2.2.3 or 3-3. Payment for densified subbedding shall be in full compensation for all expenses, including excavation and disposal of unsuitable subbedding material, furnishing, placing and compaction of the subbedding material, overhead and all other direct and indirect expenses. The quantity for payment shall be the computed weight or volume of densified subbedding based on the trench width of outside diameter of the pipe plus 16 inches and the thickness as ordered by the Engineer.

Unless otherwise indicated on the Plans or directed by the Engineer, the pipe shall be laid directly upon the undisturbed foundation material encountered in the trench bottom. Shaping of the trench bottom to fit the outside diameter of the pipe will not be required; however, the trench bottom shall be graded to provide firm and uniform bearing.

Unless otherwise specified, the bedding material for all pipe, except vitrified clay pipe, shall be the most granular native material from the excavation, free from stones and pieces of concrete and paving greater than 2 inches in diameter. Except where otherwise specified, bedding material for vitrified clay pipe shall be sand, crushed aggregate base (CAB), or, native free-draining granular material having a sand

equivalent of not less than 30, and shall be free from stones greater than ¾-inch in diameter, or other material approved by the Engineer. CAB, if used as bedding, shall meet the requirements as specified in 200-2.2 and conform to Table 200-2.2.2, except that the Percentage Passing the ¾-inch Sieve Size shall be 100 percent. The Districts will also allow the use of crushed miscellaneous base (CMB) as bedding material. CMB, if used as bedding, shall meet the requirements as specified in 200-2.4 and conform to Table 200-2.4.2 (A) for "Fine" gradation, except that the Percentage Passing for ¾-inch Sieve Size shall be 100 percent. The maximum allowable width of trench for vitrified clay pipe with CMB bedding shall comply with Table 306-1.1.3(A) or 306-1.1.3(G). The maximum trench width for rubber gasket reinforced concrete pipe with CMB bedding shall be the same as with normal bedding. All costs for the bedding material shall be absorbed in the pipe bid item.

Unless otherwise specified, whenever the Contractor is directed by the Engineer to place subbedding material, whether the Contractor is to bear the cost or the cost is to be paid by the Districts, the subbedding material shall be ½ inch crushed rock."

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IN **306-1.2.2 Pipe Laying**, SEVENTH PARAGRAPH, SECOND SENTENCE, DELETE THE WORD "bedding" AND REPLACE WITH THE WORD "subbedding".

IN **306-1.2.2 Pipe Laying**, EIGHTH PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"The maximum offset at any point of the joint shall be 1 percent of the inside diameter or 10mm (¾ inch), whichever is smaller."

IN **306-1.2.2 Pipe Laying**, AFTER THE TENTH PARAGRAPH, ADD THE FOLLOWING:

"Unless otherwise allowed by the Engineer, exterior surfaces of any concrete pipe that is to be encased in concrete or embedded in a concrete structure manhole, shall be cleaned by sandblasting prior to concrete placement."

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IN **306-1.2.3 Field Jointing of Clay Pipe**, ADD THE FOLLOWING TO THE END:

"d) **Flexible Joints at Manholes and Structures.** A flexible joint shall be installed in the pipeline within 18 inches of the outside manhole or structure wall and an additional flexible joint shall be installed 2 feet from the first joint."

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IN **306-1.2.4 Installation, Field Jointing, and Inspection of Reinforced Concrete Pipe**, (b) **Tongue and Groove (T&G) Self-centering Joints**, DELETE THE THIRD PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Pipes used on curves shall have one or both ends beveled, or shall be pulled to provide a smooth curve. If there is any space between the extremities (outmost elements) of adjacent pipe, a reinforced concrete collar as shown on the Districts' Standard Drawings, Plans or as required by the Engineer, shall be provided at the Contractor's expense. When the pipe is under 21 inches in diameter, the joints shall be made by filling the outer joint space with mortar."

IN **306-1.2.4 Field Jointing of Reinforced Concrete Pipe, (b) Tongue and Groove Self-centering Joints**, FOURTH AND FIFTH PARAGRAPHS, FIRST SENTENCE, DELETE THE NUMBERS "600 mm (24 inches)" AND REPLACE WITH THE NUMBERS "530 mm (21 inches)".

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IN **306-1.2.9 Field Jointing of Solvent-Welded ABS and PVC Pipe**, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"After cutting, the pipe ends shall be beveled in accordance with the manufacturer's printed instructions."

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IN **306-1.2.13 Installation of Plastic Pipe and Fittings**, DELETE THE THIRD PARAGRAPH AND TABLE 306-1.2.13(A) AND REPLACE WITH THE FOLLOWING:

"The subbedding zone shall extend down to not less than 6 inches below the pipe or bell, whichever is lower in elevation. The bedding zone shall extend to not less than 12 inches above the pipe or bell, whichever is higher in elevation. For bedding and subbedding zone width or minimum and maximum side clearance beyond the pipe or bell OD, see the Plans."

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IN **306-1.3.1 General**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"Backfill shall be considered as starting 12 inches above the pipe or conduit. All material below this point shall be considered as bedding and subbedding."

IN **306-1.3.1 General**, DELETE THE FOURTH PARAGRAPH.

IN **306-1.3.1 General**, ELEVENTH PARAGRAPH, FIRST SENTENCE, ADD THE WORDS "most granular native" BEFORE THE WORDS "material obtained from project excavations" AND DELETE THE WORD "may" AND REPLACE WITH THE WORD "shall".

IN **306-1.3.1 General**, FOURTEENTH PARAGRAPH, DELETE THE WORDS "or vibrated".

IN **306-1.3.1 General**, LAST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"All costs shall be borne by the Contractor."

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IN **306-1.3.3 Jetted Backfill**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"Jetting shall only be utilized where specified or otherwise allowed by the Engineer."

IN **306-1.3.3 Jetted Backfill**, SECOND PARAGRAPH, DELETE SUBPARAGRAPHS 3), 4) AND 5) AND REPLACE WITH THE FOLLOWING:

- "3) The lift of backfill shall not be limited, provided the jet pipe used for the flooding is of sufficient length to extend from the ground surface or from the surface of the backfill to within 2 feet of the bottom of the lift being densified.
- 4) Where, in the opinion of the Engineer, the nature of the material excavated from the trench is generally unsuitable for densification with water, the unsuitable material shall be removed as ordered by the Engineer and replaced with an imported material having a sand equivalent equal to or greater than 20. The removal of the unsuitable material and import of a material with a sand equivalent of 20 or greater shall be paid for by the Districts under the appropriate bid item. If there is no appropriate bid item, payment shall be made in accordance with 3-2.2.3 or 3-3. Payment for removal of the unsuitable material shall be in full compensation for all expenses, including excavation and disposal of unsuitable material, furnishing, placing and densification of the imported material and all other direct and indirect expense. The quantity for payment shall be the computed weight or volume of densified imported material based on a trench width of outside diameter of the pipe plus 16 inches and thickness (depth) as ordered by the Engineer.

The backfill shall be allowed to thoroughly drain until the surface of the backfill is in a firm and unyielding condition prior to commencement of any subsequent improvements. The Engineer may require the Contractor, at the Contractor's expense, to provide a sump and pump to remove any accumulated water."

IN **306-1.3.3 Jetted Backfill**, SECOND PARAGRAPH, SUBPARAGRAPH 7), AFTER THE FIRST SENTENCE, ADD THE FOLLOWING TO THE END:

"A water truck shall not be used for jetting unless approved by the Engineer."

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IN **306-1.3.5 Jetted Bedding and Backfill Compaction Requirements**. DELETE HEADING AND ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**"306-1.3.5 Backfilling Around Sewer Manholes and Structures.**

Unless otherwise specified or allowed by the Engineer, backfill around all sewer manholes and structures shall be a cement/sand slurry mix having 141 pounds of cement per cubic yard of slurry. The slurry backfill shall extend to undisturbed native soil or, if placed against compacted backfill material, shall extend a minimum of 2 feet beyond the manhole or structure outside wall; as directed by the Engineer."

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IN **306-1.3.6 Mechanical Compaction Requirements**, FIRST PARAGRAPH, DELETE SUBPARAGRAPHS 1, 2 AND 3 AND REPLACE WITH THE FOLLOWING:

- "1. 90 Percent Relative Compaction Required:

- a) In the upper 3 feet measured from the pavement subgrade (or finish grade where there is no pavement), within the existing or future traveled way, shoulders, sidewalks and other paved areas (or areas to receive pavement).
  - b) Within engineered embankments.
  - c) Where lateral support is required for existing or proposed structures.
2. A Specific Percent Relative Compaction not Required:
- a) Within the pipe bedding. Unless approved otherwise by the Engineer, the pipe bedding shall be densified by jetting.
  - b) Between the pipe bedding and the upper 3 feet measured from the pavement subgrade (or finish grade where there is no pavement), within the existing or future traveled way, shoulders, sidewalks, other paved areas (or areas to receive pavement) and within native material or unengineered embankments when densified by jetting.
  - c) Outside the traveled way, shoulders and other paved areas (or areas to receive pavement) when densified by jetting.
3. 85 Percent Relative Compaction Required:
- a) Between the pipe bedding and the upper 3 feet measured from the pavement subgrade (or finish grade where there is no pavement) if the backfill is mechanically compacted .
  - b) Outside the traveled way, shoulders, sidewalks and other paved areas (or areas to receive pavement) and within native material or unengineered embankments if the backfill is mechanically compacted.
4. 95 percent relative compaction where required by 301-1.3."

IN 306-1.4.1 GENERAL, SECOND PARAGRAPH, SUBPARAGRAPH 2), DELETE "600 MM (24 INCHES)" AND REPLACE WITH "680 MM (27 INCHES)"

IN 306-1.4.1 GENERAL, SECOND PARAGRAPH, SUBPARAGRAPH 3), DELETE "600 MM (24 INCHES)" AND REPLACE WITH "680 MM (27 INCHES)"

IN 306-1.4.1 General, SECOND PARAGRAPH, DELETE SUBPARAGRAPH 4) AND REPLACE WITH THE FOLLOWING:

"RGRCP gravity sewers - leakage test in accordance with 207-2.5.2."

IN 306-1.4.1 General, SECOND PARAGRAPH, DELETE SUBPARAGRAPH 5).

IN 306-1.4.1 General, SECOND PARAGRAPH, AFTER SUBPARAGRAPH 6), ADD THE FOLLOWING:

- "7) Gravity Sewer Siphons (any size in diameter) - Water exfiltration test or water infiltration test as directed. The pipe shall have zero leakage at siphons. The Engineer may allow substitution of an air pressure test for the water exfiltration test. On plastic lined reinforced concrete pipe, the leakage test shall be made prior to welding the plastic liner at the pipe joints."

IN **306-1.4.1 General**, SECOND PARAGRAPH, AFTER SUBPARAGRAPH 7), ADD THE FOLLOWING:

"In addition to the above requirements, sewers constructed by open trench, jacking, or tunneling operations shall be inspected by closed circuit television methods in accordance with 500-1.1.5."

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IN **306-1.4.2 Water Exfiltration Test**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The water exfiltration test shall be conducted for a minimum of 4 hours for each section of sewer."

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IN **306-1.5.1 Temporary Resurfacing**, FIRST PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Temporary resurfacing shall be placed as soon as the condition of the backfill, in the opinion of the Engineer, is suitable to receive it and it shall be maintained in place by the Contractor until the backfill is replaced by permanent resurfacing as determined and directed by the Engineer."

IN **306-1.5.1 Temporary Resurfacing**, THIRD PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"The temporary resurfacing shall be rolled with a self-propelled steel roller. It shall be maintained by the Contractor as directed by the Engineer, and removed and disposed of by the Contractor when directed by the Engineer."

If the Contractor is allowed to place the base course of the permanent resurfacing in lieu of temporary resurfacing, he shall maintain said base course to the satisfaction of the Engineer until the permanent resurfacing is completed and accepted."

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IN **306-1.5.2 Permanent Resurfacing**, FIRST PARAGRAPH, DELETE THE LAST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Trench resurfacing shall be one inch greater in thickness than existing pavement. Prior to placing the base course of asphalt concrete the Contractor shall thoroughly clean and wash the street to allow the Engineer to inspect and determine the limits of the pavement to be replaced. Pavement which is required to be replaced outside the excavation limits shall be replaced in conjunction with the excavation pavement. The final course of asphalt concrete placed shall overlap the saw cut edge a minimum 6 inches. The area to be resurfaced shall be prepared to receive a pavement as required in 300-1.3.2. Unless otherwise specified on the Plans, the maximum lift thickness for replacement of bituminous pavement shall not exceed 3 inches."

Unless otherwise approved by the Engineer, asphalt concrete shall not be placed over cement/sand slurry backfill within 48 hours after placement of the slurry."

If the Contractor is required to replace paving or base material of greater thickness than is indicated on the Plans, place paving or base material where none is indicated on the Plans, or slurry seal the pavement, the Districts will reimburse the Contractor at the rates specified in 9-3.1.1.

Payment for additional paving and base material at the rates in 9-3.1.1 or as specified in the Contract Documents shall be in full for all costs for sawcutting, removal and disposal of all materials required to place additional paving and base materials, and furnishing and installing expansion joint filler material.

Quantity for payment for additional paving or base material will be based on the actual width of material replaced. If the Contractor is required to replace paving or base material of less thickness than is indicated on the Plans, contract price will be reduced by an amount representing the reduction in paving or base material based on 80 percent of the rates and on the width indicated above.

Requirements on the Plans for thickness of resurfacing do not necessarily reflect the thickness of the existing pavement. Existing pavement may be greater or less thickness than required replacement."

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IN **306-1.5.5 Finish Course for Asphalt Concrete Placement**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"The final lift of asphalt concrete shall be placed with a paving machine which complies with the applicable provisions of 302-5.5 unless otherwise allowed by the Engineer."

IN **306-1.5.5 Finish Course for Asphalt Concrete Placement**, FIRST PARAGRAPH, DELETE THE LAST SENTENCE.

IN **306-1.5.5 Finish Course for Asphalt Concrete Placement**, DELETE THE SECOND AND THIRD PARAGRAPHS.

IN **306-1.5.6 Density and Smoothness**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING: "The Contractor shall comply with 302-5.6.2."

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IN **306-1.6 Basis of Payment for Open Trench Installations**, ADD THE FOLLOWING TO THE END:

"Payment for all stubs in the structure shall be made under the pipe bid items for the same size and strength. If no pipe item exists with the same size and strength, payment for such stubs shall be deemed to be included in the amount paid under the structure bid item."

IN **306-2.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Unless otherwise specified and approved by the Engineer, the actual pipe jacking operation to or from a pit shall commence within 10 working days from the date the excavation at that pit location was initially open. Once excavation at a location begins, all work required to complete construction at the location shall be diligently prosecuted to completion. Jacking pit shall be backfilled and final base course paved so existing traffic could be restored within 10 consecutive working days after the pipe jacking to or from the pit was completed. The Contractor shall complete construction at each jacking/receiving pit excavation, including base course of the final paving, within 45 calendar days after commencement of

construction at the pit location. Failure on the part of the Contractor to begin the jacking operation or complete construction within the time specified may result in a directive from the Engineer to cease work on any or all other parts of the Contract until construction is completed at locations where the time specified has been exceeded. No additional compensation will be allowed as a result of such directive."

IN **306-2.1 General**, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Dewatering shall be in accordance with 306-1.1.8."

IN **306-2.1 General**, DELETE THE THIRD PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"The leading section of conduit shall be equipped with a steel jacking head fit securely around the entire circumference of the leading section with sufficient overlap to prevent any wobble or variation in alignment during the jacking operation. The jacking head shall have sufficient structural elements welded to it to uniformly transmit the loads to the end of the leading section. Bolting of the jacking head to the leading section of conduit will not be permitted."

IN **306-2.1 General**, FIFTH PARAGRAPH, ADD THE FOLLOWING TO THE BEGINNING:

"Excavation shall be performed entirely within the jacking head and no excavation in advance thereof will be permitted."

IN **306-2.1 General**, DELETE THE SIXTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Jacking operations shall occur only during the working hours specified in the Contract Documents. The Contractor shall submit to the Engineer for prior approval methods and details that will prevent the "freezing" of the jacked conduit and ensure that the heading is stable at all times."

IN **306-2.1 General**, SEVENTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The Contractor shall verify the allowable grouting pressure with the pipe manufacturer and shall limit the grout pressure used to prevent any damage to the pipe and the pipe joints. The pressure used during grouting shall be monitored continuously to ensure that the maximum allowable grout pressure specified by the pipe manufacturer is not exceeded."

IN **306-2.1 General**, EIGHTH PARAGRAPH, DELETE THE WORDS "and drilling of grout holes".

IN **306-2.1 General**, ADD THE FOLLOWING TO THE END:

"Where the Engineer has reasonable doubt that the voids caused by the jacking operations have not been completely filled by pressure grouting from within the casing or conduit, the Contractor shall pressure grout such locations as ordered through grout pipes installed from the ground surface in accordance with 306-3.8."

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IN **306-2.2 Jacking Reinforced Concrete Pipe**, DELETE THE SEVENTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Grout plug fittings shall be cast in the reinforced concrete pipe in accordance with 207-2.1. All voids outside the pipe shall be filled by the Contractor with portland cement-sand grout placed under pressure. The grout shall contain 750 pounds of cement per cubic yard."

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IN **306-2.3 Jacking Steel Casing**, THIRD PARAGRAPH, ADD THE FOLLOWING TO THE END:

"After the pipe is installed in the casing but prior to backfilling, the pipe shall be air pressure tested in accordance with 306-1.4.4. In addition, the pipe shall be inspected by closed circuit television methods in accordance with 500-1.1.5."

IN **306-2.3 Jacking Steel Casing**, SIXTH PARAGRAPH, SECOND SENTENCE, DELETE THE WORD "bedding" AND REPLACE WITH THE WORD "subbedding."

IN **306-2.3 Jacking Steel Casing**, AFTER THE EIGHTH PARAGRAPH, ADD THE FOLLOWING:

"In lieu of laying the pipe on the concrete subbase or gravel subbedding specified above, the Contractor may, subject to the approval of details by the Engineer, lay the pipe on steel rails in the steel casing set to true line and grade.

All voids outside of the casing shall be filled by pressure grouting with portland cement-sand grout containing 750 pounds of cement per cubic yard. The Contractor shall place grout holes 1½ inch minimum diameter at 4 foot longitudinal centers at 45 degrees above the horizontal axis alternating right and left."

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IN **306-3.1 General**, FIRST PARAGRAPH, SECOND SENTENCE, DELETE THE WORDS "at the Contractor's option" AND REPLACE WITH THE WORDS ", if approved by the Engineer,".

IN **306-3.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Calculations supporting the above details shall be prepared and stamped by a Civil or Structural Engineer currently registered by the State of California and submitted to the Engineer."

IN **306-3.1 General**, DELETE THE SECOND AND THIRD PARAGRAPHS.

IN **306-3.2 Excavations**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Unless otherwise specified and approved by the Engineer, the actual tunneling operations to or from an access shaft or portal shall commence within 10 working days from the date the excavation at that location was initially open. Once excavation at a location begins, all work required to complete construction at the location shall be diligently prosecuted to completion. Access shaft and portals shall be backfilled and final base course paved so existing traffic could be restored within 10 consecutive working days after the tunneling to or from the location was completed. Failure on the part of the Contractor to begin tunneling operations or complete construction within the time specified may result in a directive from the Engineer to cease work on any or all other parts of the Contract until construction is complete at locations where the time specified has been exceeded. No additional compensation will be allowed as a result of such directive."

IN **306-3.2 Excavations**, FOURTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"No blasting shall be done until written permission has been obtained from the Engineer."

IN **306-3.2 Excavations**, LAST PARAGRAPH, FIRST SENTENCE, DELETE THE WORD "bedding" AND REPLACE WITH THE WORD "subbedding".

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IN **306-3.3 Dewatering**, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Dewatering shall be in accordance with 306-1.1.8."

IN **306-3.4 Tunnel Supports**, EIGHTH PARAGRAPH, SUBPARAGRAPH 3), DELETE THE WORD "bedding" AND REPLACE WITH THE WORD "subbedding".

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IN **306-3.5 Subgrade and Bedding**, DELETE THE WORD "**Bedding**" FROM THE TITLE AND REPLACE WITH THE WORD "**Subbedding**".

IN **306-3.5 Subgrade and Subbedding**, THIRD AND FIFTH PARAGRAPHS, DELETE THE WORD "bedding" AND REPLACE WITH THE WORD "subbedding".

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IN **306-3.7 Tunnel Backfill**, SECOND PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"The space between the tunnel supports and the pipe shall be completely backfilled with materials and by methods specified on the Plans or as approved by the Engineer. The Contractor shall completely fill the space and demonstrate complete filling by allowing material to flow from the next adjacent fill point, by drilling test holes in the crown of the pipe at locations selected by the Engineer or by an alternate method submitted to, and approved by the Engineer."

IN **306-3.7 Tunnel Backfill**, DELETE THE FIFTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Unless the Plans and Specifications (including the following provisions) for tunnels to be constructed in soil require the use of pressure concrete or gunite concrete for backfill, the Contractor may use dry silica sand for backfill. For rib and lag shored tunnels, the annular space shall be backfilled with a pressure grout containing a minimum of 750 pounds of cement per cubic yard."

IN **306-3.7 Tunnel Backfill**, ADD THE FOLLOWING TO THE END:

"The pipe shall be inspected by closed circuit television methods in accordance with 500-1.1.5, prior to placing the sewer in service."

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IN **306-5 ABANDONMENT OF CONDUITS AND STRUCTURES**, FIRST PARAGRAPH, IN THE FIRST SENTENCE AFTER THE WORDS "storm drain conduit", ADD THE WORDS " or other pipe or conduit".

IN **306-5 ABANDONMENT OF CONDUITS AND STRUCTURES**, FIRST PARAGRAPH, AFTER THE FIRST SENTENCE, ADD THE FOLLOWING: "The Contractor shall remove and dispose of any water, sewage, or debris in these conduits as necessary for the construction".

IN **306-5 ABANDONMENT OF CONDUITS AND STRUCTURES**, THIRD PARAGRAPH, ADD THE FOLLOWING TO THE END:

"and the structures shall be backfilled with sand or crushed miscellaneous base."

IN **306-5 ABANDONMENT OF CONDUITS AND STRUCTURES**, FIFTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"All frames and covers of manholes to be abandoned shall be salvaged and shall become the property of the Districts. The Contractor shall clean the manhole frames and covers and shall deliver them to the Districts' Compton Field Office, 920 South Alameda Street, Compton. The Contractor shall unload the manhole frames and covers at a location designated by the Engineer."

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IN **306-6 REMODELING EXISTING SEWER FACILITIES**, AFTER THE SECOND PARAGRAPH, ADD THE FOLLOWING:

"The existing concrete manhole bases are overpoured and the Contractor shall remove any overpoured concrete necessary to connect the proposed pipe to the manhole. Prior to joining an existing stub, the Contractor shall remove the bulkhead from the end of the stub and remove any sand, dirt or debris in the stub. If the stub is open to the manhole, the Contractor shall, prior to removing the bulkhead at the end of the stub, remove any debris in the stub and furnish and install a plug in the stub at the wall of the manhole. If the stub is bulkheaded at the manhole, the Contractor shall remove the bulkhead at the manhole when directed by the Engineer. If the joint of the existing stub is damaged or if the joint does not match that of the pipe being installed, the Contractor shall join the two pipe ends with a standard concrete collar in accordance with Standard Drawing S-a-225. Cost for all the above work shall be included in the appropriate pipe bid item."

IN **306-6 REMODELING EXISTING SEWER FACILITIES**, AFTER THE NEXT TO THE LAST PARAGRAPH, ADD THE FOLLOWING:

"Any connection between an existing facility and a proposed facility which has not been placed in service shall be sealed with a mechanical plug or a brick bulkhead. The mechanical plug or brick bulkhead shall be removed when directed by the Engineer."

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AFTER **306-8.5 Pipe Specifications**, ADD THE FOLLOWING:

**"306-9 HIGH PH SLURRY SPRAYING OF EXISTING SEWER.**

**306-9.1 General.** When designated in the Contract Documents, existing RCP and NRCP sewers to be removed from service shall be sprayed with a high pH slurry onto the entire interior surface of the pipe or conduit. The high pH slurry mixture to be used with the spray process shall be an approximate 50% magnesium hydroxide, Mg(OH)<sub>2</sub>, slurry by weight.

The Contractor or Subcontractor performing the high pH mixture spraying shall be trained and experienced in all aspects of safety related to work in sewers, handling of Mg(OH)<sub>2</sub> slurry, and be knowledgeable with regards to equipment operation and its performance when used in the spray application of Mg(OH)<sub>2</sub> slurry to sewers. In addition, the Contractor shall be a "qualified" Mg(OH)<sub>2</sub> slurry spray applicator. The Districts will consider the Contractor "qualified" if the Contractor has successfully sprayed Mg(OH)<sub>2</sub> slurry on at least 5 miles of concrete sewer 18-inches in diameter or greater. At the request of the Districts, the Contractor shall provide a listing of the names, addresses, telephone numbers, contacts, and scope of work (length, sizes, and production rate) for previous spray contracts using Mg(OH)<sub>2</sub> slurry.

The Contractor shall be responsible for providing all labor, materials, and equipment to spray the existing sewer pipe. All of the costs associated with spraying a high pH slurry mixture onto the entire interior surface of the existing sewer shall be included in the bid item for removing the sewer from service.

**306-9.2 Equipment.** The Contractor shall be responsible for selecting and furnishing all equipment necessary to meet the requirements of these specifications. The Districts will not be responsible for the contractor's equipment under any circumstances. Equipment shall not remain in a sewer unattended, nor shall manhole covers be left open unattended. Unless otherwise allowed by the Engineer, all equipment shall be removed from the sewer at the end of each workday.

**306-9.3 Material.** An approximate 50% Mg(OH)<sub>2</sub> slurry by weight shall be used with the spray process. The Contractor shall submit to the Districts a chemical analysis and physical property description representative of the Mg(OH)<sub>2</sub> product to be used and an applicable Material Safety Data Sheet. The Mg(OH)<sub>2</sub> slurry to be sprayed in the Districts' sewers shall meet the following criteria:

i.	Percent Solids	≥48%
ii.	Specific Gravity	1.4 - 1.6 (water = 1.0 at 60°F)
iii.	Solids Particle Size	10 microns (median)
iv.	Viscosity	400 cps (Brookfield model Hat 50 RPM, #3)
v.	Surface Area	10 m <sup>2</sup> /g
vi.	Magnesium Hydroxide, Mg(OH) <sub>2</sub>	≥ 93% dry basis
vii.	Calcium Oxide, CaO	≤ 2.5% dry basis
viii.	Iron Oxide, Fe <sub>2</sub> O <sub>3</sub>	≤ 0.6% dry basis
ix.	Aluminum Oxide, Al <sub>2</sub> O <sub>3</sub>	≤ 0.5% dry basis
x.	Sulfate, SO <sub>3</sub>	≤ 0.6% dry basis
xi.	Silica, SiO <sub>2</sub>	≤ 2.3% dry basis
xii.	Chloride, Cl	≤ 0.14% dry basis
xiii.	Asbestos	≤ 0.25% dry basis (using TEM method of analysis)
ivx.	Neutralization Capacity	≥ 87.0% dry basis as Mg(OH) <sub>2</sub>

**306-9.4 Application.** The minimum application thickness shall be 125 mils (1/8"). The spray rate and travel speed of the spray head to achieve the minimum application thickness shall be determined by the Contractor. The Contractor shall have an approved means of determining the quantity of chemical sprayed. Application records shall be kept and submitted to the Districts. If the application thickness in a treated reach does not meet the 125 mils minimum standard, as calculated by the Districts, the Contractor shall be responsible for re-spraying that reach at no additional cost to the Districts."

IN 310-5.1.3 Application of Paint, SECOND PARAGRAPH, DELETE THE WORDS "exposed to the atmosphere".

IN **310-5.1.3 Application of Paint**, DELETE THE FIFTH PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Open seams at contact surfaces shall be caulked with non-sag polysulphide material conforming to Federal Specification TT-S-230, Type 2; or other approved material that is compatible with paint before applying the second coat of primer."

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AFTER **310-5.6.10 Measurement and Payment**, ADD THE FOLLOWING:

**"310-5.7 Painting Miscellaneous Metals Except Steel Stop Logs.** 310-5.1 shall apply to painting miscellaneous metals except steel stop logs.

**310-5.8 Painting of Steel Stop Logs.** All surfaces of ferrous stop logs shall be cleaned and protective coated as follows:

All grease and oil shall be removed by steam or solvent cleaning. All surfaces shall be dry blast cleaned to a near-white blast cleaned surface finish conforming to 310-2.5. All dust shall be removed by brushing, vacuuming or air blasting. In no case shall bare metal surfaces be left overnight before applying the first coat.

The stop logs shall be painted with one of the following coating systems or equal:

1. International-Intergard 565HS
2. Mainstay Corporation - Mainstay DS-4
3. Courtaulds Aerospace/Specialty Products (PRC)-PR 475
4. Tenemec-104 H.S. Epoxy

Application shall be in strict conformance with the manufacturer's instructions using approved spray equipment. All surfaces to be coated shall first receive a prime coat recommended by the manufacturer. The finished system shall consist of a minimum of two coats with a total dry film thickness of 30 mils minimum. Each coat shall be a different color as approved by the Engineer. The finished system shall be checked with a low-voltage, non-destructive holiday detector furnished by the Contractor. Testing shall be performed by the Contractor in the presence of the Engineer. Repairs shall be made where directed by the Engineer in strict conformance with the manufacturer's instructions.

**310-5.9 Defective Workmanship or Material.** Any work or material not conforming to the Plans or Specifications is unacceptable and shall be redone, removed, replaced or made satisfactory to the Engineer at the sole expense of the Contractor."

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IN **311-1.1 General**. SECOND PARAGRAPH, SECOND SENTENCE, ADD THE FOLLOWING TO THE END:

"or contain other contaminates that will stain the plastic liner."

IN **311-1.1 General**. LAST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"For each specific project, all parts of the plastic liner installation including the liner sheets and corner, flat, angle, and contraction joint welding strips shall be extruded from the same batch of materials by the same manufacturer."

AFTER **311-1.1 General**, ADD THE FOLLOWING:

**311-1.1.1 Submittals.** Prior to plastic liner installation, the Contractor shall submit shop drawing of construction details per 2-5.3. The shop drawings shall include the following information:

- 1) Complete liner placement drawings for each location.
- 2) Complete description of plastic liner installation including material lists, certifications and required test results.
- 3) Welder certifications for each welder."

IN **311-1.2.2 Welders**, FIRST PARAGRAPH, DELETE THE SECOND SENTENCE AND REPLACE WITH THE FOLLOWING:

"Welders shall be requalified every five years or at any time deemed necessary by the Engineer."

IN **311-1.3.1 Coverage**, THIRD PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "where is a difference in" AND REPLACE WITH THE WORDS "where there is a difference in circumferential coverage".

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IN **311-1.4.1 Concrete Placement** DELETE THE WORDS "shall be", AND REPLACE WITH THE WORDS "the concrete shall be carefully, thoroughly, and".

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IN **311-1.5.1 General**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"When the pipe liner coverage is 360 degrees, 6 to 8 inches of the downstream side of the joint strip or flap at the pipe invert shall not be welded."

IN **311-1.5.1 General**, ADD THE FOLLOWING TO THE END:

"All field joints shall be double welded with 1-inch welding strips welded to both front and back of the joint wherever possible, as determined by the Engineer. All field joints that do not include a double welded strip shall be overlapped wherever possible, as determined by the Engineer. The overlap shall be welded to the adjacent plastic liner with locking extensions. The overlap shall not be less than 1½-inches and the entire seam between the overlap and plastic liner shall be covered by a 1-inch welding strip over the front of the joint. All welds shall be probed in accordance with 311-1.10. For joints requiring two welds, the first weld shall be probed and approved by the Engineer before applying the second weld."

IN **311-1.5.2 Field Joints in Pipe Installation**, FIRST PARAGRAPH, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Field joint in liner plate at pipe joints shall be double welded as specified in 311-1.5.1 and shall be one of the following types:"

IN **311-1.5.2 Field Joints in Pipe Installation**, FIRST PARAGRAPH, SUBPARAGRAPH 2), FIRST SENTENCE, DELETE THE WORDS "the spigot" AND REPLACE WITH THE WORDS "either the spigot or the bell".

IN **311-1.5.2 Field Joints in Pipe Installation**, FIRST PARAGRAPH, SUBPARAGRAPH 2), SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Heat shall be applied to straighten the PVC flap as needed to prevent cracking of the PVC."

IN **311-1.5.2 Field Joints in Pipe Installation**, FIRST PARAGRAPH, DELETE SUBPARAGRAPH 4) AND ALL REMAINING PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

- "4) Field joints in rigid liner at manhole joints shall use Type CJ-2 and shall consist of 38 mm (1½ inch) by 38 mm (1½ inch) factory-installed L-angle. When manholes are installed in the field, polyurethane compound, approved by the Engineer, shall be applied between L-angles for sealing purposes.

Field joints in liner at pipe joints shall not be made until the mortar in the pipe joint has been allowed to cure for at least 48 hours and the pipe has successfully passed the leakage test.

All joints between flexible-lined pipe and flexible-lined cast-in-place structures shall be either Type C-1 or Type C-2 specified herein."

IN **311-1.5.3 Field Joints in Cast-in-Place Structures**, DELETE THE FIRST SENTENCE AND REPLACE WITH THE FOLLOWING:

"Field joints in liner plate on cast-in-place structures shall be double welded as specified in 311-1.5.1 and shall be one of the following types:"

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IN **311-1.5.4 Installation of Welding Strips for Flexible Liner**, FIRST PARAGRAPH, ADD THE FOLLOWING TO THE END:

"Prior to welding, the surfaces which are to be fused to the welding strips shall be roughened with a wire wheel or with another approved method."

IN **311-1.5.4 Installation of Welding Strips for Flexible Liner**, FOURTH PARAGRAPH, ADD THE FOLLOWING TO THE END:

"The weld strip shall be completely fused across its entire width, except for the allowable gap. Incomplete fusion, charred, or blistered welds will be rejected."

IN **311-1.6 Application of Liner to Concrete Surfaces**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Attachment of PVC liner plate without locking extensions to concrete surfaces shall be by adhesive in accordance with the Special Provisions."

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IN **311-1.8 Application of Liner to Steel**. DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Attachment of PVC liner plate without locking extensions to steel surfaces shall be by adhesive in accordance with the Special Provisions."

IN **311-1.9 Protection and Repair of Liner**, SECOND PARAGRAPH, THIRD SENTENCE, ADD THE FOLLOWING TO THE END: "and holes not exceeding 1/4-inch diameter."

IN **311-1.9 Protection and Repair of Liner**, SECOND PARAGRAPH, ADD THE FOLLOWING TO THE END: "and holes not exceeding 1/4-inch diameter."

"Patching at liner plate holes shall be made with a patch which overlaps the edge of the hole by a minimum of 3/4-inch."

IN **311-1.10 Field Tests**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Upon completion of the installation, the Contractor shall clean the surface of the liner and shall perform visual inspection and spark testing in the presence of the Engineer. In addition, all weld joints shall be probed with a trowel, putty knife, or similar tool approved by the Engineer. Single weld joints shall be probed vigorously by striking with the corner of a stiff putty knife. Double weld joints may be probed in a less rigorous manner if the procedure is submitted to and approved by the Engineer. The Contractor shall provide adequate ventilation, ladders for access, barricades or other traffic control devices, and shall be responsible for opening and closing entrances and exits. All areas of liner failing to meet the field test shall be properly repaired and retested. The spark-type detector shall be supplied by the Contractor and shall be a Tinker & Rason Holiday Detector (Model AP-W). The voltage used for testing shall be approved by the Engineer. The Contractor, at his expense, shall have an independent laboratory perform the visual inspection and the probing of all weld joints. The independent laboratory and the inspection and probing procedures shall be approved by the Engineer. In addition, the independent laboratory shall witness the spark testing and any repairs performed by the Contractor. Inspectors employed by the independent laboratory to test the welds shall have passed the qualification welding test specified in 311-1.2. Upon completion of all liner testing and inspection, the Contractor shall submit certification by the independent laboratory that all installation and weld joints have been tested and inspected and are in compliance with the Specifications. However, this certification shall not relieve the Contractor of the responsibility to correct defective work.

Acceptance of the work is subject to inspection by the Engineer. If the overall quality of the welding is found to be unacceptable, in the opinion of the Engineer, re-testing and re-certification by the laboratory will be required. In addition, the Contractor shall comply with the following requirements:

- 1) The independent laboratory shall check the quality of work (i.e. probe the welds) of each welder after they have completed 100 linear feet of welding, but before 200 linear feet has been completed. The findings shall be immediately reported to the Engineer.
- 2) The specified field tests shall be performed within 30 working days after installation of the liner material at each location, or, in the case of pipeline construction, after the pipe is installed at each location.
- 3) Repair of defective weld joints shall extend a minimum of 3 inches beyond the defect.
- 4) If the number of defects in each weld strip exceeds an average of one per linear foot, the entire weld strip shall be considered defective and repaired accordingly.

Any spark testing of liner by the Contractor for its purposes shall be done with a detector complying with 210-2.3.6."

IN **400-4.1 General**, DELETE THE SECOND PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Asphalt concrete will be designated by the type of asphalt concrete, class of aggregate grading, and grade of paving asphalt, i.e., "III-B2-AR-4000" or "III-B2-PG 64-10" and shall conform to the requirements in this section. Unless otherwise specified, III-B3-AR-4000 or III-B3-PG 64-10 shall be used."

IN **500-1.1.1 General**, FIRST PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "that may be used as an alternative to pipeline replacement" AND ADD THE FOLLOWING TO THE END:

"Many of these processes are covered by patents. It is the sole responsibility of the Contractor to abide by the patents law and to ensure that the procedures being used will not infringe upon others' patented processes."

IN **500-1.1.1 General**, SECOND PARAGRAPH, DELETE THE SECOND SENTENCE.

IN **500-1.1.1 General**, ADD THE FOLLOWING TO THE END:

"The Contractor shall maintain the existing sewer in continuous service and shall be aware that periodic surcharging of the sewer may occur. Unless otherwise allowed or required by the Plans or Special Provisions, the Contractor shall not bypass or divert flow from the sewer and shall not cause flow to be backed up in the sewer at any time. If the Contractor's operation causes a flow back-up and if the Contractor is not responsive or unable to perform the work to correct the problem, the Districts are empowered to implement the emergency procedures as specified in 9-3.1. In addition, all equipment shall be removed from the sewer and manhole at the end of each day, no exception.

In the event any sewage overflow occurs, the Contractor shall be fully responsible for containing the spillage, preventing any sewage from reaching a watercourse, recovery of the spilled sewage back into the sewer, and any fines or penalties associated with the sewage spill.

Unless otherwise shown or specified, all requirements pertaining to underground construction of pipelines and/or conduits, including but not limited to the requirements specified in 5 and 306, shall apply to all work in this section. Where cost of the work is specified to be absorbed in the pipeline bid item, these costs shall be included under the sewer rehabilitation bid item."

IN **500-1.1.4 Cleaning and Preliminary Inspection**, DELETE THE FIRST PARAGRAPH, AND REPLACE WITH THE FOLLOWING:

"The Contractor shall verify the inside diameter of the sewer pipe, remove all protrusions and obstructions, and clean the sewer, prior to closed circuit television (CCTV) inspection and rehabilitation. All protruding rebars shall be cut from within the sewer and all intruding roots shall be removed by using a suitable mechanical cutting device.

The Contractor shall complete the cleaning of a sewer reach before the Contractor will be allowed to start the cleaning of the next reach. The Contractor shall be aware that re-deposition of the debris may occur. To effectively clean the sewer and to prevent flow backup, cleaning of a sewer reach may have to be repeated and performed in multiple passes. The Districts do not provide any special access for the Contractor to perform the sewer cleaning work. The Contractor shall be responsible for providing his own access as required to clean the sewer. The Contractor may gain access through existing manholes or construct access pits at his own cost for performing the sewer cleaning work.

Debris in the sewer may contain large pieces of broken concrete, aggregate, sludge, dirt, sand, rocks, grease, roots, solid or semisolid materials, and other foreign objects. The Contractor shall perform all work as necessary to trap and remove the debris from a sewer reach and shall not allow the debris to move to the sewer reach that has already been cleaned or to the sewer reach that is not a part of the project. All debris collected and removed from the sewer shall be disposed of off the site at the end of each day. The Contractor shall be aware that landfills may have daily tonnage limits and the business hours may vary. If the daily tonnage limit is reached, the landfill will be closed for business that day. The Contractor shall be responsible for scheduling and sequencing his cleaning operations. Temporary storage of the debris, if necessary, shall be arranged and provided by the Contractor at no additional cost to the Districts. If the Contractor elects to dispose the debris at the Districts' landfill facilities, the Contractor shall notify the Districts at least two days in advance. Disposal fee shall be the responsibility of the Contractor. Costs associated with the sewer cleaning work shall include construction of access pits, trapping, collecting, removing, hauling and transportation, temporary storage, dewatering, disposal of the debris and dumping fees, and closure of access pits. If there is no sewer cleaning bid item, all costs associated with the sewer cleaning shall be included in the appropriate sewer line rehabilitation or other appropriate bid item.

The Contractor shall be solely responsible for the cleaning method(s) being utilized. The Districts' acceptance of the cleaning method does not relieve the Contractor of such responsibility. The Districts reserve the right to reject the Contractor's proposed cleaning method if the Districts determine that the method selected may endanger or adversely affect the continuous operation of the existing facilities.

For segmented liner pipe installations, the Contractor may utilize the steel pipe test section as specified in 500-1.1.7(b) for cleaning the sewer at his own risk and may utilize the insertion pits as the cleaning access pits. If the Contractor elects to utilize an insertion pit as the access for sewer cleaning, the work shall start within five working days after the Engineer accepts the construction of the insertion pit for that reach of sewer. The Contractor may also construct separate access pits at his own cost for performing the sewer cleaning work. Cleaning access pit(s), if required, shall be located, constructed and waterproofed in the same manner as an insertion pit in accordance with 500-1.1.7(c) and are subject to the approval of the Districts and the Agencies. After the sewer cleaning work is completed, the Contractor shall reinstall the cut portion of the RCP and encase in reinforced concrete, backfill and restore all the disturbed areas in the same manner as an insertion pit."

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AFTER **500-1.1.4(c) Mechanically Powered Equipment**, DELETE ALL REMAINING PARAGRAPHS AND TABLE 500-1.1.4 (A).

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IN **500-1.1.5 Television Inspection**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"This section covers the requirements for closed circuit television (CCTV) inspection of sewers.

**500-1.1.5.1 General.** Unless otherwise specified, CCTV inspection shall be performed on all sewer projects including new sewers constructed per 306 and sewers rehabilitated per 500-1. For new sewer construction, CCTV inspection shall be performed after the sewer is installed but prior to the sewer being placed in service. For sewer rehabilitation, CCTV inspection shall be performed after sewer cleaning to document the condition of the existing host pipe, to ensure that the existing host pipe is ready to be lined or sliplined, and to verify the number, location and status of all existing local sewer or house connections. Additionally, CCTV inspection shall be performed after rehabilitation to locate and

document any defects, to confirm the work has been done in accordance with the contract documents, and to verify all the connections have been properly re-established and the end seals have been properly made up. Any defects found shall be repaired and the sewer shall be re-inspected. For segmented liner pipe installations, the pre-rehabilitation CCTV inspection shall be performed after insertion of the test section but prior to insertion of the liner pipe, and the post-rehabilitation CCTV inspection shall be performed after grouting of the annular space and reconnection of all the existing connections.

**500-1.1.5.2 Inspection.** CCTV inspection equipment to be used shall be approved by the Engineer prior to the start of the inspection. The CCTV camera shall be a pan/tilt and rotating head camera capable of providing a full view of the inside of all connections. The camera shall be mounted on a skid, floatable raft system, or transporter based on the conditions of sewer to be televised. The camera and skid, raft, or transporter shall be furnished with emergency pull-back cables of sufficient strength for all returning situations. The camera shall be specifically designed and constructed for sewer inspection environment and shall be operative in 100 percent relative humidity. Focal distance shall be adjustable through a range from 1 inch to infinity. The camera and monitor shall produce a minimum 460 lines per inch resolution. Telephones, radios, or other suitable means of communication shall be set up to ensure that adequate communication exists between members of the crew.

At the setup manhole, recording of the CCTV inspection shall begin outside of the manhole and shall continue as the camera is lowered into the manhole and shall show the general condition of the manhole. CCTV inspection shall show a clear view of the entire periphery (circumference) of the sewer including all the defects. Any problems identified during an inspection shall be immediately brought to the attention of the Engineer. For segmented liner pipe installations, the Contractor shall perform the pre- and post-rehabilitation CCTV inspection during low flow. For sewer lining, the Contractor shall perform the pre- and post-rehabilitation CCTV inspection while flow is being bypassed and/or diverted around the sewer, and without standing wastewater. For post-rehabilitation inspection, the video recording shall also include a clear view of the outside ends of the liner from each manhole upstream and downstream of the liner. Unless otherwise directed by the Engineer, the camera shall be moved through the sewer, from upstream to downstream, at a uniform rate of not more than 30 feet per minute. Distance of sewer between adjacent manholes shall be measured and recorded. The distance measurements shall be made from the centerline of the manhole that the camera is traveling from and shall be accurate to within 2 feet for every 1,000 feet inspected. If more than one manhole reach is inspected in a single run, the footage counter shall be reset to zero at all intermediate manholes.

The camera shall pause for a sufficient length of time to adequately document and provide accurate distance measurements of all the defects and the connections observed in the sewer. The camera shall rotate and look directly at each defect and look into each connection to thoroughly document the conditions and determine if the connection is in service. In the same manner, the Contractor shall identify all sewer connections at each manhole including the beginning of setup manhole, all intermediate manholes, and the end of setup manhole. The Contractor shall capture photos of any moderate and severe damage and/or abnormal conditions.

The Contractor shall submit to the Districts a detailed plan for CCTV inspection, including a description of the setup, procedures, retrieving method, list of equipment, and personnel. The Contractor shall not begin inspections until the CCTV submittal and the bypass pumping submittal, if required, are approved by the Districts. If any changes in schedule are necessary, the Contractor shall notify the Districts a minimum of 24 hours prior to performing the inspection. The Contractor shall be responsible for making all necessary arrangements for gaining access to the manholes located in private property. If the work is done in residential areas, the Contractor shall notify the residents in writing, a minimum of 7 days prior to the start of the work. The Contractor shall comply with all applicable traffic requirements. No open manhole shall be left unattended. The Contractor shall remove all equipment from the sewer and manholes at the end of each inspection run and shall reseal all previously sealed manholes at the end of each day.

### 500-1.1.5.3 Inspection Video Tapes and DVDs.

**500-1.1.5.3.1 Video.** Video recording shall be in color and shall have the best quality possible. The image shall be in focus at all times. The recording shall be done with adequate lighting to provide a clear view of the entire periphery of the sewer including any defects while keeping glare to a minimum. The image shall not be obscured by "fog" in the sewer. If any submitted recording has unacceptable focus, lighting, sound, data, imaging or interferences, the sewer shall be re-inspected at the Contractor's expense.

The inspection shall be recorded in VHS videotape and data DVD format using new high quality video tapes in the standard play (2-hour) recording mode and high quality DVD-/+ R discs. The recording on each tape and DVD shall be for a single trunk sewer, contiguous and shall be from upstream to downstream. The DVDs shall be indexed with the WinCan software as specified in 500-1.1.5.3.3. At the beginning of each inspection run, the general information of the inspection shall be displayed in the following format:

- A. Date of the recording
- B. Time of the recording
- C. Name of the Contractor performing the CCTV inspection
- D. Name of trunk sewer
- E. Direction of inspection (upstream or downstream)
- F. Pipe or liner material
- G. Pipe diameter
- H. Length of reach to be televised
- I. Manhole number from which the camera is traveling
- J. Manhole number to which the camera is traveling

In addition, each recording shall continuously display the following information:

- A. Name of trunk sewer
- B. Manhole number from which the camera is traveling
- C. Manhole number to which the camera is traveling
- D. Date of recording
- E. Pipe diameter
- F. Pipe or liner material
- G. Footage - Distance from the centerline of the manhole from which the camera is traveling shall be displayed and continuously updated

The background of the overlays showing the inspection information shall be transparent as to not block out the video. The information shall be displayed at the lower left hand corner of the image in accordance with the following format:

Name of Trunk Sewer		
MH No. (Upstream) to MH No. (Downstream)		
Pipe Size and Material	Date	Footage

All original CCTV inspection tapes and DVDs, including log sheets and reports, shall be submitted to the Engineer and shall become property of the Districts. The individual tapes and the cases containing them shall each have identifying labels on their spines and front in the following format:

District No.	Name of Sewer	Month/Day/Year
From MH No. to MH No.	Pipe Size and Material	
Name of Contractor	Pre or Post Rehabilitation Video (if applicable)	

The crystal cases containing each DVD shall each have identifying labels on their spines containing the name of the sewer. The front of the DVD crystal case and the face of the DVD shall contain identifying labels in the following format:

District No.	Name of Sewer	Month/Day/Year
From MH No. to MH No.	Pipe Size and Material	
Name of Contractor	Pre or Post Rehabilitation Video (if applicable)	

**500-1.1.5.3.2 Audio.** The recording shall include an audio portion describing the condition of the sewer with the video image. The audio portion shall be sufficiently free of background noise to produce an oral report that is clear and easily discernible. At the beginning of each inspection run, the audio shall identify the Contractor name, each crew member, date, time, street location, name of trunk sewer, pipe size, pipe or liner material, direction of inspection (upstream or downstream), and the manhole numbers at the beginning and end of each run. The audio shall note the location and condition of the pipe defects, including all cracks, breaks, cracked or misaligned joints, root intrusion, infiltration, missing pieces of pipe, corrosion, deposits, obstructions, and dips. The audio shall also note the location of the connections to the nearest foot, clock position of the connections, condition of the connections, and whether the connection is in service. The description shall be objective and shall not include inspector's estimate of severity, or assumptions about the pipe material or conditions. However, subjective observations shall be included on the inspection report.

**500-1.1.5.3.3 Digital Recording.** Continuous digital recordings of the inspection view as it appears on the monitor shall be stored. It is intended that a digital recording will be made of the complete pipe inspection. The recording shall also be used as a permanent record of defects. Unless directed otherwise by the Engineer, the recording shall be MPEG I and shall comply with ISO/IEC 11172 MPEG I specifications. The digital encoding shall include both sound and visual information that can be reproduced with an image equal to the quality of the original picture on the monitor. Compression rate shall be 1.5 Mb/s. The operator shall pause the digital recording at any time there is a delay in the inspection. The pause shall in no way effect, freeze or interrupt the replay of the video and shall not close the video file during the inspection. The operator shall store a single video file for each reach inspection. The video files shall have a resolution of 352 by 240 pixels and an interlaced frame rate of minimum 24 frames per second. The data shall be time coded using the elapsed time from the video file. The naming of the video file shall be automatic and shall match the indexing file name.

For each video file, indexing shall exist as a separate text file. The text file shall include the observation detail and the frame number at which the observation is located. The frame number shall be 150 to 200 frames prior to the feet distance the observation appears. This shall allow the user in WinCan to use the indexing feature and go to that defect with a click instead of fast forwarding or rewinding.

Separate MPEG files shall be created for each sewer manhole to manhole reach. MPEG files, picture files in TIF format, inspection data, and text files used for indexing shall be stored on DVDs for delivery to the Engineer.

**500-1.1.5.4 Submittal.** The Contractor shall submit the CCTV inspection tapes and DVDs of the sewer and a CCTV inspection report. For a given sewer manhole to manhole reach, the MPEG files, picture files in TIF format, inspection data, and text files used for indexing shall be included on the same DVD. It is intended that each DVD shall contain all of the information necessary to view digital video and data files for a given reach, and shall have functional indexing capability. Submittals that require more than one (1) DVD to view digital video and data for a given reach, or to implement the indexing function, will be rejected. For pre-rehabilitation CCTV inspection, the Contractor shall only submit the inspection tapes of the sewer; submission of DVDs and CCTV inspection reports is not required. Acceptance of the submittal is subject to review by the Engineer. If the inspection is not performed in accordance with the Districts' standards or if the quality of the inspection tapes, DVDs, or recording is found to be unacceptable, the submittal will be rejected and the sewer shall re-inspected at the Contractor's sole expense.

CCTV inspection reports shall be generated using the WinCan inspection software customized for the Districts. The reports shall be printed in color and shall include a hard copy log and computer generated graphic for each inspected sewer reach. The log shall include the appropriate District number or Joint Outfall letter, the name of the trunk sewer, the upstream manhole, the downstream manhole, the pipe diameter, the pipe or liner material, the date and time of the inspection, the footage to each defect or feature in the order observed during the inspection, a computer generated graphic for each manhole to manhole reach which indicates the location of each defect or feature found in the segment, and photos of moderate to severe damage and/or abnormal conditions. WinCan inspection software is available from WinCan America, Inc., Albuquerque, New Mexico (505) 341-0109.

The inspection data shall include data tables of observations, photographs, and video where applicable. The observation codes shall be consistent with those used by the Districts. The Contractor will be provided with customized files by the Districts for use with WinCan. These files contain the Districts' observation codes and approved fields for data collection and reporting.

**500-1.1.5.5 Payment.** Payment for all costs associated with the CCTV inspection of the sewer including all work appurtenant thereto shall be included in appropriate pipe bid item or sewer rehabilitation bid item."

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IN **500-1.1.6 Sampling, Testing, and Installation**, ADD THE FOLLOWING TO THE END:

"If the pipeline rehabilitation systems in 500-1.4, 500-1.7, or 500-1.10 are to be installed or if required in the Special Provisions, the Contractor shall implement a sampling and testing plan for compliance samples collected in the field. All samples shall be tested by an independent accredited testing laboratory to be approved by the Districts. The Contractor shall authorize and direct the approved testing laboratory, in writing, to release the test results directly to the Districts immediately after the tests for a given sample are complete. The Contractor shall submit this written authorization to the Districts for approval prior to transmittal to the laboratory. In the event that test results for a given sample are not submitted to the Districts within 15 working days of sample collection or if the samples fail to meet the specified physical properties, the Districts reserve the right to suspend all lining operations. The Districts will continue to charge working days against the Contract time during any suspension periods caused by the late submittal of test results or failure of compliance samples to meet the specified physical properties. In addition, the Districts may withhold progress payments during these delays.

All compliance samples shall be removed from the pipe or sampling location immediately after the pipe liner is installed. All samples shall be marked and tagged in the field to identify each sample and to ensure that the chain of custody of each sample can be traced. Sample tags shall be Keller Ball type seals, or equal as approved by the Engineer. The corresponding tag number for each sample shall be clearly marked on each sample with indelible ink prior to the transfer of the sample to the approved testing laboratory. The Contractor shall utilize the Liner Sample Chain of Custody Form, which is shown at the end of this section. The Contractor shall verify that the samples have been tagged, using the approved tagging system, complete the appropriate sections of the Chain of Custody Form, and have the Districts' inspector sign the form. The compliance samples and the completed Chain of Custody Form shall be transferred to the approved testing laboratory in the field on the same day that the samples are collected. Samples shall be transferred in the presence of the Districts' inspector. The original completed Chain of Custody Forms shall be submitted to the Districts with the final test report.

The Contractor shall submit a detailed sampling and testing plan to the Districts for review and approval. The Contractor shall not commence the Work until the sampling and testing plan has been approved. The sampling and testing plan shall include but not be limited to the following information: sampling methods and procedures, details of false bottoms or other sampling devices to be used, procedures for marking and tagging samples, procedures and methods to verify chain of custody, copies of current certificates of accreditation for each independent testing laboratory to be used, procedures for preparing samples into specimens, procedures for preparing specimens for testing, detailed testing procedures, and a table listing the proposed sampling locations for each liner installation showing the sewer reach to be lined, manhole number or station where the samples will be taken, nominal pipe diameter of the sewer being lined, and description of the sampling method used. The Contractor shall include actual chain of custody tags and/or seals and all other forms or materials to be used as part of the field sampling procedures with the submittal."

COUNTY SANITATION DISTRICT NO. \_\_\_\_ OF LOS ANGELES COUNTY

LINER SAMPLE CHAIN OF CUSTODY FORM

PROJECT: \_\_\_\_\_

Contractor's Name \_\_\_\_\_  
 Date Sample Taken \_\_\_\_\_  
 Date Sent to Lab \_\_\_\_\_

Contractor's Representative's Name \_\_\_\_\_  
 Inspector's Name \_\_\_\_\_

Installation No. \_\_\_\_ From MH \_\_\_\_ to MH \_\_\_\_ Length (ft) \_\_\_\_ Diam. (in.) \_\_\_\_ Installed Thickness \_\_\_\_ Or SDR \_\_\_\_

Sample Type (R, F, C)	Security Tag #	Location of Sample (See Below)	Inspector Signature	Contractor's Signature	Lab Signature*	Lab Sample Number

R = Restrained Sample  
 F = Flat Plate (only if R not possible)  
 C = Core Sample (in conjunction with F)  
 \*Verifies Lab received sample with intact security tag

Location of Sample

Project's Requirements

1. Restrained Sample: Downtube: DT  
 Intermediate MH: IMH  
 Terminating MH: TMH

Nominal Felt Thickness to be Installed \_\_\_\_\_  
 Flexural Modulus 250,000 psi  
 Flexural Strength 4,500 psi  
 (if applicable)

2. Core Sample: Core samples shall be taken at 10:00, 12:00 and 2:00 o'clock  
  
 Designate location of core and from what MH  
 e.g. 10:00 D/S of MH \_\_\_\_\_

**IN 500-1.1.7 Miscellaneous, (a) Service Connection, ADD THE FOLLOWING TO THE END:**

"The Contractor shall notify all the residents and businesses, whose service connections will be disrupted, a minimum of 14 days prior to commencing any work. The notice shall be by registered letter and shall include the date and estimated time (in hours) that the sewer service will be disrupted. The Contractor shall provide approved temporary sanitary facilities for all affected residents and businesses. Unless otherwise specified, if a cleanout is available, the Contractor shall continuously maintain the flow from all residences, apartments and multiple dwelling unit complexes by individually bypassing their flow from the cleanout. If no cleanout is available, for residences and apartments or multiple dwelling unit complexes with five (5) units or less, the Contractor shall provide one (1) sanitary facility (portable toilet) with a hand washing facility for each affected residence/unit. The Contractor may be required to place the sanitary facility in the front, side, or in the back of the affected property. Exact placement of the sanitary facilities shall be as determined by the Engineer. The Contractor shall have the sanitary facilities cleaned and emptied before they are moved to the next location. If no cleanout is available, for residences and apartments or multiple dwelling unit complexes with six (6) units or more, the Contractor shall install cleanouts at the locations as directed by the Engineer and continuously bypass the flow. Sewer service shall be reinstated within 24 hours, and the Contractor shall be responsible for limiting the length of each liner installation and having adequate equipment to ensure that this is achieved. The Contractor shall confirm the notifications verbally a minimum of 24 hours prior to the scheduled interruption. If verbal notification is not successful, a typewritten notice shall be placed on the doorknob. The Contractor shall submit notification letters and doorknob hangers to the Districts for review and approval. In addition, the Contractor shall provide the Engineer with mailing receipts for the notification letters upon request.

For segmented liner pipe installation, the Contractor shall remove a portion of the host pipe at each connection location to connect the connection to the inserted liner pipe so flow can be contained in the liner pipe. The Contractor shall not reconnect any stubs. The Contractor is limited to a maximum of seven calendar days from the date the liner pipe is sliplined past a connection to complete the tie-in to the liner pipe. Prior to grouting, the Contractor shall construct a bulkhead between the host pipe and the liner pipe at each connection. The bulkhead shall secure each connection in place during grouting and shall be constructed complete with grout injection and vent pipes. For connections that are connected to manholes, bulkheads shall be constructed at both the upstream and downstream ends of the manhole. The Contractor shall provide for containment and disposal of any spilled sewage."

**IN 500-1.1.7 Miscellaneous, (b) Segmented Liner Pipes, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:**

"After the insertion pit is constructed and accepted by the Engineer, and after cleaning, prior to commencing the sliplining operation, the Contractor shall insert a steel pipe test section, to ensure that the existing pipe is free of obstructions and ready to be sliplined. The test section shall have a minimum length and an outside diameter equal to that of the typical liner pipe section for that insertion run. A baffle plate(s) shall be attached to the test section with adequate height to trap any remaining debris which may be present. The debris shall be removed and disposed of off the site at no additional cost to the Districts. The test section shall be removed prior to actual sliplining operation. Upon successful completion of the insertion of the test section, the existing sewer shall be considered ready to receive the liner pipe and commencement of the sliplining operation. The sliplining operation shall commence within 24 hours after successful insertion of the test section. The Contractor shall submit the manufacturer's details of the pushing or pulling heads to be used. Retainer cables, clamps, or any other devices shall not be allowed in the annular space while inserting the liner pipe. The installation heads or mechanism shall incorporate a gauging system which will provide a continuous monitor of the force being applied during insertion of the liner pipe. The gauging system shall be calibrated. If the gauging system does not provide a direct reading of the force being applied, the Contractor shall furnish calibrated data in tabulated form to allow the Engineer to readily determine the force being applied in pounds. The

insertion force used by the Contractor shall not exceed the liner pipe manufacturer's recommended maximum allowable pulling or pushing force that can be exerted onto the liner pipe without damaging integrity of the pipe or pipe joints.

The curve data and angular deflection and invert elevations of the existing sewer as depicted on the Plans were based on original design drawings and have not been verified. The Contractor shall verify all the existing curve data, angular deflection and invert elevations prior to performing any work which may be affected. Unless otherwise shown or specified, liner pipe at curves shall be installed by open cut; the Contractor shall not slipline liner pipe through any curve. In addition, unless otherwise approved by the Engineer, the Contractor shall not slipline liner pipe through any angle points and through any manholes where there is a change in pipe diameter; a directional change in the sewer alignment; or an excessive change in the inlet and outlet elevations. At these manholes, special mitered fittings may be required. The Contractor shall field verify and determine the actual configuration of these manholes before ordering or fabricating the required fittings. At all other locations, the liner pipe shall be sliplined through the manholes. Unless otherwise shown or specified, final positioning of liner pipe joints in manholes is not allowed. If the Contractor sliplines liner pipe through angle points and manholes where there is a change in pipe diameter; a directional change in the sewer alignment; or an excessive change in the inlet and outlet elevations, the Contractor shall do so at his own risk and the Districts will not be responsible for any changed conditions the Contractor may encounter.

At locations where the Contractor will install the liner pipe by open cut including curves, the Contractor shall prepare and waterproof the excavation prior to the start of sawcutting. The Contractor shall order the appropriate length of liner pipe required for lining the curves. Methods and procedures for any field cutting and fabrication work shall be reviewed and approved by the liner pipe manufacturer and submitted to the Districts for review and approval. The Contractor shall retain the services of an authorized representative of the liner pipe manufacturer approved by the Districts to inspect and verify that the field work is performed in accordance with the approved methods and procedures. Costs for the inspection services shall be included in the appropriate liner pipe bid item. After the work is completed at that location, the Contractor shall reinstall the cut portion of the RCP and encase it in reinforced concrete in the same manner as an insertion pit.

For sewers where flow diversion and dewatering are possible and if allowed by the Plans, the Contractor may slipline through curves in the dry. For sliplining curves with centrifugally cast fiberglass reinforced plastic mortar liner pipe, the liner pipe shall be connected with jacking bell and spigot joints. The seal design of the jacking bell and spigot joint will accommodate limited joint angular deflection allowing the liner pipe to negotiate through curves. The maximum allowable joint angular deflection of a joint varies according to pipe diameter. After the liner pipes are assembled and prior to water testing, the Contractor shall measure the angular deflection and/or measure the gap and calculate the angular deflection of each joint. If the angular deflection at a joint is less than  $1^{\circ}$ , that joint shall be considered to have passed. If the angular deflection at a joint is  $1^{\circ}$  or greater but less than  $1.5^{\circ}$ , the joint shall be subjected to a leakage test. The test pressure shall be equivalent to the maximum allowable grout pressure and shall be maintained for 30 minutes with zero leakage. If the joint should leak or if the angular deflection at a joint is  $1.5^{\circ}$  or greater but less than  $2^{\circ}$ , the joint shall receive a joint seal layup consisting of 15 plies of resin impregnated glass reinforcement, as a minimum. If the angular deflection at a joint is greater than  $2^{\circ}$ , the joint shall receive a structural layup consisting of 30 plies of resin impregnated glass reinforcement, as a minimum, for restoring both the pipe strength and stiffness. If the liner pipe joint telescopes, the portion of the liner pipe protruding into the flow stream shall be cut out and removed as directed by the Engineer. Any resulting gap after removing the protrusion shall receive a joint seal layup or a structural layup based on the criteria established above. Instead of the jacking bell and spigot joints, the Contractor may carry in plain end mitered liner pipes and connect the liner pipes with approved closure couplings or make up the joints internally by filling the gap with resin impregnated glass reinforcement. If the gap at a joint is 1 inch or less, the gap shall receive a joint seal layup

consisting of 15 plies of resin impregnated glass reinforcement, as a minimum. If the gap at the joint is greater than 1 inch, the joint shall receive a structural layup consisting of 30 plies of resin impregnated glass reinforcement, as a minimum, for restoring both the pipe strength and stiffness. All joint seal or structural layup and all joint make up work shall be in strict conformance with the liner pipe manufacturer's recommended methods and written procedures approved by the Districts, and shall be performed in the presence of the authorized representative of the liner pipe manufacturer. In addition, supportive calculations demonstrating the adequacy of the structural layup shall be prepared by the liner pipe manufacturer and submitted to the Districts for approval. Resin used for all layup or joint makeup work shall be compatible with the resin used in the manufacture of the liner pipe. Technical data sheets of the property values of the resin shall be reviewed with and accepted by the liner pipe manufacturer in writing and submitted to the Districts for approval prior to use."

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IN **500-1.1.7 Miscellaneous (c) Access/Insertion Pits**, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Access/insertion pits, if required, shall be constructed in accordance with the Plans and as specified herein. Prior to commencing any work, as part of the construction schedule submittal, the Contractor shall submit the location and number of all the proposed access/insertion pits to the Districts for review and approval. The pits shall be located in accordance with the spacing as recommended by the liner pipe manufacturer based on maximum allowable force that can be exerted onto the liner pipe. The Contractor shall not start any pit excavation until all the liner pipe materials and equipment required to complete the sliplining to or from that pit are delivered on site. Temporary occupational right of ways and access have been obtained and existing utilities have been researched through record documents only at the areas on the Plans designated as potential pit locations. The pit locations shown do not represent the exact location nor the total number of pits required to complete the sliplining work. The potential pit locations are being identified so the Contractor is aware that these areas have been approved by the Agencies and/or property owners for use as the access or insertion pits and that existing utilities located within these areas have been researched and that pits may be located within these areas.

The odor scrubber locations shown on the Plans are based on the number and location of the potential pits shown. If the Contractor plans to complete the sliplining work with additional or less number of pits or selects pit locations other than those shown on the Plans, the Contractor shall do so at his own risk. In addition, the Contractor shall assume all the costs and shall solely be responsible for making all necessary arrangements with the Agency(ies), property owner(s), occupant(s), and utilities and acquiring any additional permits, occupational right of ways, and relocating any interfering substructures. The Contractor shall also revise and submit any required change in number and locations of odor scrubber units for approval. To be effective, an odor scrubber unit shall not be placed further than 1,000 feet away from an insertion pit. The Districts reserve the right to reject the Contractor's proposed pit locations. As a guideline, unless otherwise shown or approved by the Engineer, access/insertion pits shall be located in public right of way where there is minimum impact to local traffic and where there is minimum interference with existing utilities. Access/insertion pits shall not be located at any intersection or in front of any driveway access. All costs associated with selection of different pit locations and/or construction of any additional pits including, acquiring right of ways, and locating, identifying, protecting, and restoring utilities shall be borne by the Contractor. No additional compensation and/or extension of time will be granted due to the change in number or locations of access/insertion pits or change in number or locations of odor scrubber units.

All existing utilities and improvements disturbed shall be replaced by the Contractor and/or restored to the original condition. The Contractor shall pothole and verify the location of all the utilities shown at each pit at least 90 calendar days prior to the start of pit excavation. The Contractor shall

incorporate the actual locations of these utilities in the design of the shoring. Unless otherwise allowed by the Engineer, the existing sewer pipe shall be sawcut at the springline and ½-inch crushed rock shall be placed in the entire pit floor up to the springline. Prior to removing the sawcut pipe section, all exposed soil surfaces within the insertion pit including the floor and end walls shall be covered with a minimum of 4 inches thick gunitite or concrete up to adjacent ground surface. The Contractor shall continuously dewater and dispose of any sewage which may be present as the existing sewer may surcharge.

Insertion of test section and liner pipe shall proceed within 5 working days after the existing sewer pipe is sawcut. To reduce odor, pits shall not remain open to the atmosphere at any time except during actual liner pipe insertion. The pits shall be covered and sealed daily to prevent emission of any odor upon the cessation of liner pipe insertion, at the end of each workday, during all non-working hours, and as directed by the Engineer. Covers to be installed shall be temporary and readily removable. Minimum 50 mils thick extra heavy polyethylene sheets shall be used to cover the entire insertion pit. The edges of the sheets shall be weighed down to prevent emission of sewer gas. The Contractor shall submit the method of covering and sealing of the pit for review and approval. Unless otherwise specified or approved by the Engineer, an access/insertion pit shall be backfilled and paved within a maximum of 30 consecutive calendar days, from the date the pit was initially open."

AFTER 500-1.1.7 Miscellaneous, (d) Manhole Protection, ADD THE FOLLOWING:

"(e) **Bypassing Requirements.** When required by the process and allowed by the Plans, the Contractor shall bypass all sewage flows around sections of sewer to be rehabilitated and dewater the work area, all in accordance with 7-8.4 and 306-3.3, and as specified herein. The Contractor shall be responsible for installing, continuously monitoring, maintaining and operating the bypass pumping system at all times during the work. The Contractor shall provide a person, "Monitor", to be stationed at the mainline bypass site with no other duties than to monitor and maintain that system. If additional bypasses are required to supplement the mainline bypass, the Contractor shall provide additional Monitors with no other duties than to monitor and maintain these supplemental bypass systems. The Contractor shall provide one Monitor to maintain no more than four (4) supplemental bypass systems. Each Monitor shall maintain a log of the depth of flow in the suction manhole being monitored. Readings shall be taken and recorded every 15 minutes throughout the duration of bypass. Logs shall be signed by the Monitor and submitted weekly to the Engineer. In addition to logging the depth of flow, the Monitor's duties shall include, but not be limited to, maintaining the fuel levels in the pumps, regulating pump speed to maintain the level of flow in the manhole to a maximum of one (1) foot above the soffit of the pipe, and activating the standby pumping system if the primary pumping system fails. The Monitor shall also arrange for the immediate repair or replacement of any pump which stops operating or is not operating properly. In order to communicate with the Districts' representative, the Monitor shall be able to speak the English language. The Contractor shall identify low manholes on the local sewer system and the Districts' sewer system and continuously monitor flow levels during the work to ensure that there are no sewage spills.

The Contractor shall submit a detailed flow bypass plan to the Districts for review and approval. The Contractor shall have an approved submittal prior to commencing any work. The submittal shall indicate the locations and capacities of all pumps, sumps, suction, and discharge lines. The bypass pumping system, including all equipment and piping, shall be sized to handle peak flow of the section of sewer to be rehabilitated and shall be installed in strict conformance with local ordinances and traffic requirements. Pump size shall be selected such that the intersection of the values for the pumping system's total dynamic head and the peak flow rate is in the middle of the pump's operating envelope. All bypass pumps, except for submersible pumps, shall be self priming pumps. Non-self priming pumps shall not be used. For peak flows greater than 1 cfs, only prime assist self priming pumps shall be used. For peak flows 1 cfs or less, wet prime self priming pumps will be allowed. The Contractor shall provide a backup bypass pumping system in case of malfunction or failure of the primary system. The backup

bypass pumping system shall provide 100 percent standby capability, and shall be fully installed, laid out and ready for use. Each standby pump shall be a complete unit with its own suction and discharge piping. In addition to the backup system, the Contractor shall furnish and operate vacuum trucks when required by the Plans.

*skip* The Contractor shall utilize a manifold or cross-connection with isolation valves, as approved by the Engineer, in each mainline and local sewer bypass system if the peak flow is greater than 1 cfs or if a flow-through plug is utilized in the sewer bypass system.

*skip* All discharge pipes shall have fittings and connections for flushing and draining the pipes after the bypass is completed. The Contractor shall flush the mainline bypass system with potable water for a minimum of 30 minutes prior to cutting or disconnecting the bypass pipes and moving them to a new location. After flushing the discharge pipes with potable water, the Contractor shall vacuum-up any residual water from the pipe resulting from the breakdown of the pipes and properly dispose of the residual water.

*skip* The use of flow-through sleeves and the proposed anchoring system shall be submitted for approval. Flow-through sleeves shall typically consist of two flow-through plugs connected by a flexible wire reinforced fabric hose secured by a cable. When containing flow greater than 1 cfs, the Contractor shall anchor the flow-through sleeve with a cable via the pipe to a manhole immediately upstream of the insertion manhole. For flow less than or equal to 1 cfs, the Contractor may anchor the sleeve in the insertion manhole. The use of flow-through sleeves will not be allowed where undetected surcharging of the influent sewer could cause wastewater to backup through house connections into structures or overflow from cleanouts. Use of flow-through sleeves is acceptable only where surcharging of the influent sewer can be detected in the immediately upstream manhole without causing the aforementioned wastewater backups or as specified in the Special Provisions.

*skip* The Contractor shall secure all sewer plugs to an anchoring device with a steel cable which shall be submitted to the Engineer for approval. Flow-through plugs will not be allowed in manholes where undetected surcharging of the influent sewer could cause wastewater to backup through house connections into structures or overflow from cleanouts. Use of flow-through plugs is acceptable only where surcharging of the influent sewer can be detected in the upstream manhole without causing the aforementioned wastewater backups or as specified in the Special Provisions.

*skip* For peak flows greater than 4 cfs, a flow bypass pumping Contractor or Subcontractor shall be responsible for designing and implementing the flow bypass plan and operating the flow bypass pumping system required for the lining work. The flow bypass pumping Contractor or Subcontractor shall have at least 5 years experience designing, installing and operating flow bypass pumping operations with peak flows greater than 4 cfs and shall have completed a minimum of three (3) verifiable projects in Southern California within the last three (3) years where the bypassed flows were 10 cfs or greater. The Contractor shall submit the specialty Subcontractor or Contractor information for approval prior to submitting the flow bypass plan. The submittal shall include at a minimum the name, qualifications, experience, references and contact information for the three (3) verifiable bypass projects of the flow bypass pumping Contractor or Subcontractor.

*include* All bypass pump suction and discharge lines that extend into Districts' manholes shall be of rigid hose or hard pipe, lay flat hose will not be allowed. Lay flat hose up to and including 6 inches in diameter and PVC, HDPE, steel or aluminum piping will be allowed for discharge pipes. Heavy duty lay flat hose up to and including 4 inches in diameter will be allowed for vehicle traffic at residential driveways. For all other driveways and alleys, the discharge pipes shall be ramped or trenched as approved by the Engineer. Where crossing areas which are subject to traffic, bypass piping shall be installed in trenches with adequate cover and protected from through traffic.

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If the construction of a cleanout is required for the bypass of flow, the Contractor shall contact the owner or manager of the complex to determine placement of the cleanout and for their requirements for the bypassing of the flow. The minimum size cleanout to be constructed shall be 6 inches in diameter. The Contractor shall submit the type of cleanout to be constructed, the location of the cleanout, layout of discharge pipe and design of bypass pump system. The Contractor shall provide a person with no other duties than to monitor and maintain up to a maximum of four (4) bypass systems from cleanouts. The Contractor shall provide on site a backup pump for each bypass from a cleanout. Only one (1) discharge pipe will be required for each bypass from a cleanout.

skip

The local sewers shown on the Plans are for information only. The Districts do not guarantee the completeness or accuracy of this information. The Contractor shall research, obtain and verify any additional information as deemed necessary to prepare and implement the flow bypass plan. Prior to installing any plug in a local sewer, the Contractor shall perform a CCTV inspection of the local sewer from the manhole to the upstream manhole to verify the condition of the existing pipe and shall submit to the Engineer for approval prior to initiating the bypass. If the Districts determine that the condition of the existing pipe may be inadequate to sustain the intended bypass operation, the Districts may direct the Contractor to revise and resubmit the flow bypass plan for review and approval. After the installation of the liner and removal of the plug are completed, the Contractor shall re-televiser the local sewer and submit the inspection tapes to the Districts for approval.

skip

Unless otherwise specified, the Contractor shall not allow any sewer, including any of the Districts' or local sewers, to surcharge more than one foot above the soffit of pipe at any time. If a flow backup occurs during the rehabilitation process, the Contractor shall cut the liner or liner pipe and/or stop his operation allowing the flow to move downstream, as directed by the Engineer. The Districts will not be responsible for any subsequent delay or rework if the flow backup is caused by the Contractor's failure to install, operate and maintain the bypass system; improper implementation of the bypass procedures; faulty setup; defective materials or equipment malfunctions. In addition, if the Contractor is not responsive or unable to perform the work required to correct the problem, the Districts are empowered to implement the emergency procedures as specified in 9-3.1.

include

include

The Contractor shall prepare and implement an Emergency Spill Response Plan (ESRP) to mitigate any damage in the event a sewage spill does occur. The ESRP shall account for all storm drain systems in the vicinity of the Work that could be affected by a sewage spill. For each liner installation, the Contractor shall identify and show or describe the location in the ESRP of all storm drain catch basins and other storm drain inlets (SDIs) that could receive spilled sewage as a result of the Work. These catch basins and SDIs shall be sealed prior to operating the bypass pumping system, to minimize the potential of spilled sewage from entering the storm drain system. The Contractor shall seal the catch basins and SDIs with sand bags and plastic sheeting or other methods approved by the Engineer. The Contractor shall remove all material used to seal the catch basin when bypass pumping is completed. The storm drain systems shown on the Plans are for information only. The Districts do not guarantee the completeness or accuracy of this information. The Contractor shall research, obtain and verify any additional information on the storm drain systems as deemed necessary to prepare and implement the ESRP. The Contractor shall submit the ESRP along with the bypass plan submittal to the Districts for review and approval. The ESRP shall be site specific and shall include as a minimum, storm drain catch basin and SDI protection; procedures and locations of spill containment; including procedures in the event that sewage reaches a watercourse or storm drain system; spill control, including isolating the spill from the public and returning the wastewater to the sewer; notifications; cleanup; and spill and damage reporting. The Contractor will not be allowed to start any flow bypass without an approved ESRP.

In the event any sewage overflow occurs, the Contractor shall be fully responsible for containing the spillage, preventing any sewage from reaching a watercourse or storm drain system, washing down the spill area with potable water, recovering and returning all the spilled sewage including all the washdown water back into the sewer. Chlorine shall not be used as a means of disinfection. In the event

the Contractor is unable to satisfactorily respond to a sewage overflow as determined by the Engineer, or if the sewage enters a watercourse or storm drain system, the Districts will deploy staff and equipment in response to the sewage overflow. The Contractor shall make available its manpower and equipment resources to the Districts as directed by the Engineer.

The Contractor shall bear all of the costs associated with the sewage overflow including any costs incurred by the Districts which may include spill control, spill containment, spill recovery, laboratory sampling, cleanup and restoration, and spill and damage reporting. Additionally, the Contractor shall be responsible for any fines and penalties associated with the sewage overflow.

**(f) Odor Scrubber Units.** Where indicated on the Plans, the Districts will furnish, install and operate trailer-mounted, carbon adsorption odor scrubber unit(s) including flexible air duct. Operation of the odor scrubber unit requires 220 volts, 100 amp breaker and single phase electrical service. The Contractor shall be responsible for providing and maintaining temporary electrical services for operating the odor scrubber unit(s) and safekeeping of these unit(s). The Contractor shall make all necessary arrangements with the appropriate utility and pay for all fees and charges for providing and maintaining a temporary electrical service pole, if necessary, transformer and meter at the scrubber location. The Districts will pay for the electrical usage charges for operating the scrubbers. The Contractor shall invoice the Districts for this cost without any Contractor's markup and the Contractor will be reimbursed by purchase order. Requirements and costs for providing and maintaining temporary electrical service shall be obtained from the appropriate utility.

Unless otherwise specified or shown, the Contractor shall furnish and install 8-foot high chain link fencing with razor ribbon wire for securing each odor scrubber unit. The fence posts shall be anchored to the pavement or in concrete. The chain link fence to be installed shall be furnished with lockable gates of sufficient size for the delivery and removal of the 9 foot wide by 25 foot long trailer mounted odor scrubber unit. Unless otherwise allowed by the Engineer, the Contractor shall not commence any work which may cause the release of sewer gas to the atmosphere until after the odor scrubber unit is installed and ready to be placed into service. After the temporary electrical service pole, transformer and meter are in place and the chain link fencing and gate installed and accepted by the Engineer, the Districts will deliver the odor scrubber unit on site. The temporary electrical service pole shall be located within the chain link fence enclosure unless otherwise approved by the Engineer. The Contractor shall allow a minimum of two weeks for the Districts to arrange for the delivery, installation and completion of the electrical hookup of each odor scrubber unit. Materials and construction of chain link fencing shall be in accordance with 304-3. Upon completion of the work at a location, the Districts will move the odor scrubber unit accordingly. After the odor scrubber unit is moved, when directed by the Engineer, the Contractor shall remove the temporary service and chain link fencing and gate and restore the area in accordance with 7-9. All costs associated with providing and maintaining temporary electrical services for the odor scrubber units including installation and removal of temporary service poles, transformers, meters and chain link fence and gates shall be included in the sewer line rehabilitation bid item.

The number and location of the odor scrubber units as depicted on the Plans are based on the number and location of the potential insertion pits shown. The Districts may change the odor scrubber unit locations and/or increase the number of units operating to accommodate Contractor's access/insertion pit locations and direction of his sliplining operation. No additional compensation and/or extension of time will be granted due to the change in location and number of odor scrubber units. In addition, depending on availability, the Districts may elect to remove the odor scrubber unit(s) from the project at any time. The Contractor shall be aware that the odor scrubber unit is intended for controlling of odor only and shall not be considered as a part of the Contractor's safety equipment. Use of the odor scrubber unit is at the Districts' sole discretion; and use of the odor scrubber unit does not alleviate the Contractor's responsibility to comply with all applicable requirements as stipulated by the State Division of Occupational Safety and Health for working in existing sewerage facilities."

IN **500-1.1.9 Measurement and Payment**, THIRD PARAGRAPH, FIRST SENTENCE, DELETE THE WORDS "The price per linear meter (foot) or lump sum for" AND REPLACE WITH THE WORDS "The payment for".

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IN **500-1.2.4 Sewer Bypassing and Dewatering**, DELETE THE PARAGRAPH AND REPLACE WITH THE FOLLOWING:

"Sewer bypassing and dewatering shall conform to 500-1.1.7 (e)."

IN **500-1.3.7 Annular Space Grouting**, DELETE THE LAST SENTENCE AND THE TABLE.

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IN **500-1.4 Cured-In-Place Pipe Liner (CIPP Liner)**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**500-1.4.1 General.** This section covers the requirements for rehabilitating the sewer with a CIPP liner.

**500-1.4.2 Notifications.** Prior to commencing any work, the Contractor shall notify all the residents and businesses whose services will be disrupted per 500-1.1.7(a).

**500-1.4.3 Cleaning, Preliminary Inspection and Closed Circuit Television Inspection.** Cleaning and preliminary inspection shall be performed in accordance with 500-1.1.4. Prior to fabricating the felt tube, the Contractor shall field verify the diameter and length of the existing sewer to ensure that the tube will have sufficient wall thickness and length to cover the entire reach of lining run.

The number and location of the existing house connections depicted on the Plans are provided for bid comparison only and are not guaranteed for accuracy. After cleaning and preliminary inspection, the Contractor shall perform CCTV inspection to ensure that the sewer is ready to be lined and to verify the number and location and status of all the existing connections. Minimum guidelines for the CCTV inspection work to be performed shall be as specified in 500-1.1.5. CCTV inspection shall also be performed after the sewer is lined and existing sewer connection, if any, re-established.

The Contractor shall complete any necessary point repairs and removal of obstructions not cleared by cleaning prior to performing the CCTV inspection. Any protruding house connections that may interfere with liner installation shall be cut flush with the existing pipe by the use of an approved remote cutting device from within the sewer.

**500-1.4.4 Materials.** The CIPP liner shall comply with all applicable requirements of ASTM F1216 or ASTM F1743, except as modified herein.

The CIPP liner shall be suitable for continuous service in sewerage environments with 1 N sulfuric acid at an average wastewater temperature of 80°F and for intermittent exposure (at a frequency of 1½ hours two times a week) to sewage with a pH of 11. Unless otherwise specified, the CIPP liner shall be a structural liner consisting of a fabric tube and epoxy vinyl ester resin system. The resin system shall have structural properties listed in 500-1.4.5. The tube shall be free of defects and will be subject to

inspection prior to resin impregnation. The catalyst shall be compatible with the resin system to be utilized. Quantity and type of catalyst shall be selected based on the curing conditions and recommendations of the resin supplier.

**500-1.4.5 Design.** The CIPP liner shall have a minimum service life of 50 years and shall have, as a minimum, the following initial structural property values which the resin system shall meet:

	<u>Test Method</u>	<u>Initial</u>
Flexural Strength	ASTM D790	4,500 psi
Flexural Modulus	ASTM D790	250,000 psi
Tensile Strength	ASTM D638	3,000 psi
Tensile Modulus	ASTM D638	250,000 psi

**500-1.4.6 Submittal Data.** The Contractor shall submit CIPP liner submittals to the Districts for approval. The submittals shall include complete information on the material composition including resin and catalyst, felt tube material, material safety data sheets, design calculations, including the regression analysis of the flexural properties, if available, detailed installation procedures including equipment setup and layout, resin impregnation, insertion and access locations, compliance sampling and testing plan, flow bypass plan including schematic, and certified test reports for the qualification test. The CIPP liner installation submittal shall include a liner installation list indicating for each installation, the diameter and length of liner to be installed, the installation manhole, the terminating manhole, sampling manhole(s), and an estimate of the installation time including reinstatement of any service connections and local sewers. In addition, the Contractor shall submit manufacturer's certified Fourier Transform Infrared Spectroscopic scans of the proposed resin system with the CIPP liner submittal. The Contractor shall have approved submittals prior to commencing any work. The Contractor shall plan and allow sufficient time in his schedule for the review of submittals and for the required testing. Performance of the chemical resistance test will require a minimum of one month to complete.

**500-1.4.7 Testing.** Testing to be performed shall include a qualification test and a compliance test. The testing shall be performed by an independent accredited testing laboratory approved by the Districts. The qualification test shall be performed on fabricated specimens to verify that the design, as contained in the submittal, will meet the specified performance. The compliance test shall be performed to ensure that the installed liner complies with the specifications.

**500-1.4.7.1 Qualification Test.** Prior to actual installation, the Contractor shall fabricate cured specimens of the fabric tube, resin and catalyst system and shall have the following tests performed. Test results from prior projects are not acceptable. The specimens will be subject to inspection prior to testing.

- Flexural Strength and Flexural Modulus test per ASTM D790
- Chemical Resistance test per ASTM F1216 Appendix X2, except the test solutions shall be 10% sulfuric acid (by volume) and shall be 40 mg/l sodium hydroxide in distilled water. In addition to flexural strength and flexural modulus, weight change shall be reported. The weight of the test specimen after exposure shall be within  $\pm 1.5\%$  of the initial weight.

Each test shall be performed on a minimum of three specimens. If the result of any flexural test is less than the minimum flexural property values in 500-1.4.5, or if the result of chemical test fails to meet the criteria set forth in ASTM F1216 Appendix X-2, the liner design shall be reevaluated and the reformulated system shall be retested and the results resubmitted to the Districts for approval.

If the Contractor submits a resin system that has successfully passed the qualification test on a Districts' project within twelve (12) months prior to the bid date for the Work or if the resin and felt tube system has been tested in accordance with 211-2 and meets the requirements of 500-1.4.5, the qualification test will be waived. The Contractor must use the resin system that meets these requirements for the Work to receive a waiver from the qualifications tests.

**500-1.4.7.2 Compliance Test.** The Contractor shall collect resin samples for FT-IR scans during the wet-out procedure or from the cured resin felt composite sample for each CIPP installation. The Contractor shall notify the Engineer at least 24 hours in advance of the wet-out procedure. The Contractor shall perform FT-IR scans on the resin samples collected and submit the certified results of the scans along with the compliance test results. Samples for compliance testing of the cured resin shall be collected at an intermediate manhole. If no intermediate manhole is available, compliance samples shall be collected at the terminating manhole. Prior to commencing the Work, the Contractor shall submit a sampling and testing plan for compliance samples to the Districts per 500-1.1.6. The Contractor shall collect a minimum of one compliance sample for installations less than 1,000 feet in length and a minimum of two samples for installations that exceed 1,000 feet in length. Unless otherwise specified in the Plans, the Contractor may designate sampling manholes. Prior to liner installation, sampling manholes shall be fitted with false bottoms or other approved sampling device. The false bottoms or other approved sampling devices shall be fabricated to have the same inside diameter as the pipe to be lined, such that the cured wall thickness of the liner sample will be representative of the installed CIPP liner. In addition, the sample shall be of sufficient size to provide all the required specimens for testing. In the event that the Contractor must cut the sample into smaller pieces to facilitate removal from the sampling manholes, the Contractor shall place match marks on the sample pieces for identification so that entire sample may be reassembled into its original configuration.

The compliance samples of the cured resin shall be divided into individual specimens and outside layers of the tube and/or any plastic coatings that are not included in the structural design of CIPP liner shall be ground off prior to testing or measurements. The specimens shall be subjected to the following tests and certified test reports shall be submitted to the Districts.

- Flexural Strength and Flexural Modulus test per ASTM D790
- Measurement of Cured Wall Thickness per ASTM D5813 Section 8.1.2

A minimum of five specimens shall be tested for flexural properties. If any of the specimens fails to meet the minimum property values listed in 500-1.4.5, the entire installation length shall be considered out of compliance and the Districts have the authority to direct the Contractor to remove the installed CIPP liner and reline the entire length of the installation. For cured wall thickness measurements, the average thickness shall be calculated using eight equally spaced measurements around the circumference of the restrained sample, measured a minimum of 4 inches inside the edge of the sample pipe. Cured wall thickness measurements shall be submitted for information only. The Districts will use the cured wall thickness measurements as secondary verification that the Contractor has installed the felt tube as specified in the Special Provisions. Re-testing is not allowed unless approved by the Engineer. In the event that the Contractor fails to collect compliance samples due to his own negligence, the entire length of the installation will be considered to be out of compliance and the Districts will also have the authority to direct the Contractor to remove the installed CIPP liner and reline the entire length of the installation. Any removal of installed CIPP liner and relining, if required by the Engineer, shall be performed at no additional cost to the Districts and shall be constructed and installed in accordance with the specified liner design and thickness. No time extension will be granted.

**500-1.4.8 Installation.** The Contractor shall install the CIPP liner utilizing a felt tube having a nominal thickness as specified in the Special Provisions. The Contractor shall install the CIPP liner with the specified nominal felt tube thickness regardless of the flexural retention value of the resin. The felt

tube manufacturer shall stencil the diameter and nominal thickness of the tube on the coated side of the felt tube at 5-foot intervals so that the markings are visible along its entire reach. The Contractor will not be allowed to install any liner without a properly marked felt tube. The installation of the liner shall take place within 48 hours of cleaning the sewer. The resin-impregnated tube shall be stored under controlled temperature as recommended by the resin supplier. The resin-impregnated tube shall be either installed by inversion under a sufficient hydrostatic head to fully fill and line the interior of the sewer; or shall be pulled through the sewer and inflated by inverting a bladder inside the resin impregnated tube under a sufficient hydrostatic head for expanding the bladder and tube against the sewer pipe wall. The outer layer of the pulled tube shall be perforated, allowing surplus resin to press against the pipe wall. The hydrostatic head being applied shall be closely regulated. The Contractor shall use either an end-stop or hold back mechanism as required to prevent the resin impregnated tube from protruding into the adjacent sections of sewer which are not designated to be lined.

After the resin-impregnated tube is in place and secured, the entire lined pipe shall be heat cured with water. Temperature shall be maintained during the curing period in accordance with the recommendation of the resin supplier and the approved submittal and shall be monitored. After curing and a sufficient cool-down period, the liner shall be cut and trimmed with ends at manholes tapered with resin. A temporary two-inch diameter hole shall be cut at each house connection to return it to service immediately. The Contractor shall not disrupt service for more than 24 hours. If service is disrupted for more than 24 hours, the Contractor shall provide additional sanitary facilities to affected residents and businesses as may be necessary. The Contractor shall be responsible for any extra costs that accrue due to service not being reinstated within the first 24 hours. All existing house connections shall be re-established without excavation by the use of an approved cutting device from within the sewer. The Contractor shall not re-establish any stub. The final re-established house connection shall be equal to the original opening both in size and shape with clean and smooth edges. The Contractor shall have a back-up cutting device onsite in case of malfunction.

**500-1.4.9 End Seals.** After installation, the ends of the liner shall be cut off flush with the manhole wall and sealed. If a manhole has been lined through, the top half of the liner shall be cut even with the top of the shelf. The ends of the liner shall be sealed with a material that will bond to both the liner and the host pipe. The sealant material shall be suitable for continuous immersion in water and shall be resistant to a corrosive sewer environment. The sealant shall provide a smooth transition from the host pipe to the liner and shall not reduce the inside diameter of the liner. The sealant material to be used shall be Sikadur®31 or 35, Sika Corporation, or equivalent approved by the Engineer. The Contractor shall apply the material prior to the expiration of its shelf life and in accordance with the manufacturer's recommendations.

**500-1.4.10 Inspection and Repair.** A post CCTV inspection shall be performed to inspect the finished liner for defects. All defects found in the finished liner, including core sample holes, foreign inclusions, dry spots, pinholes, wrinkles, fins, delamination, deflections, sags, and voids between the liner and pipe, shall be repaired. The repair to be performed shall be determined by the Engineer and may include grinding, cutting, and removing the defective areas, relining, replacing with the same resin mixture, and filling voids by injecting the resin mixture. The Engineer will sound the interior of the sewer to locate any voids and areas with poor adhesion. If the lined surface is suspected to contain any voids or to have poor adhesion, the Contractor shall drill hole(s) through the liner as directed by the Engineer to determine the extent of the voids. The Contractor shall submit the repair method to the Districts for approval and shall be responsible for all costs of the repair.

**500-1.4.11 Payment.** Payment for furnishing all labor, equipment and materials to rehabilitate the existing sewer with the CIPP liner, including flow bypass, point repairs, cleaning, cutting of protruding house connections and removal of obstructions, providing temporary sanitary facilities, all testing, installation of the CIPP liner, re-establishing local sewer and house connections, physical

inspection, pre- and post-CCTV inspection, repairs including grouting of voids, and all work appurtenant thereto, shall be made under the CIPP liner bid item. Unless otherwise specified, the CIPP liner bid item quantity does not include length of liner at manhole(s). If the Contractor installs the CIPP liner through a manhole and a compliance sample is not collected at that manhole, the Districts may allow all portions of the liner within the manhole to remain in place to facilitate the manhole rehabilitation work. If the liner is allowed to remain in a manhole, the Districts will reimburse the Contractor the cost by adjusting the bid item quantity to include the length of the liner at that manhole based on the unit cost of the CIPP liner bid item. If the Engineer determines the liner within the manhole has substantial wrinkles or abnormalities or if the Contractor installs the liner through a manhole which will be used as a sample manhole, the Contractor shall cut and remove all portions of the liner within the manhole. Cost for installing and removing the liner at these manholes shall be the responsibility of the Contractor. If the CIPP liner is to be removed from a manhole, the Contractor shall cut the CIPP liner flush with the end of the existing sewer pipe at the manhole wall."

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IN **500-1.5 Polyvinyl Chloride (PVC) Pipe Lining System**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**500-1.5.1 General.** This section covers the requirements for rehabilitating the sewer with a PVC pipe lining system. The lining system shall be designed to restore the structural integrity of the existing sewer. Limits of the lining and the minimum grout thickness required shall be as shown on the Plans.

Cleaning and preliminary inspection shall be performed in accordance with 500-1.1.4. The Contractor shall televise the sewer after preparing the concrete surfaces, and after the sewer is completely lined and grouted. The inspection shall record the conditions of the existing sewer and serve as a condition for final acceptance of the work. The Contractor shall utilize the existing manhole and structure to access the sewer.

**500-1.5.2 Qualification.** The work shall be performed by contractor or subcontractor licensed by the lining system manufacturer.

**500-1.5.3 Surface Preparation.** All surfaces to be lined shall be prepared as specified herein. The Contractor shall not install any PVC liner until the prepared surfaces have been accepted by the Engineer. All materials generated by preparation of the surfaces shall be trapped, collected and removed from the sewer. The materials removed from the sewer shall be disposed of off the site on the same day.

All the surfaces to be lined shall be thoroughly cleaned to remove grease, sludge, dirt, and other foreign deposits. After the initial cleaning, the Contractor shall remove all loose and deteriorated concrete by sandblasting, high pressure water blasting (minimum 10,000 psi at a flow rate of not less 5 gpm), and/or a combination of high pressure water/sandblasting. Concrete substrates with hydrogen sulfide damage shall be removed to a depth where all the white calcium sulfate is removed and only hard grey concrete with a surface pH of 7.0 or greater remains. After the deteriorated concrete is removed, the Contractor shall thoroughly clean the surface including vacuuming to remove all fines and deleterious materials that will adversely affect the bonding of the grout.

Any reinforcing steel exposed, including those exposed after removing deteriorated concrete shall be thoroughly cleaned by sandblasting to remove all contaminated concrete and rust particles. Immediately after the cleaned reinforcing steel is inspected and accepted by the Engineer, the Contractor shall place a protective coating on the exposed reinforcing steel. The protective coating shall be 40 mils of Sikatop 108 Armatec, Sika Corporation, Master Builders Emaco-P22, or equal.

**500-1.5.4 PVC liner.** The PVC liner shall be made from unplasticized PVC compounds with a cell classification of 13354, 12344, or 13334 as defined in ASTM D1784. Additives and fillers in the PVC compounds shall not exceed 15 percent in weight. The minimum thickness of the former strip and joiner strip and the minimum profile height of the PVC liner shall be as shown on the Plans. The manufacturer shall submit a certificate of compliance with specifications including test results for the PVC liner being furnished.

**500-1.5.5 Grouting.** The grout used to fill the annulus between the exterior of the PVC liner and the interior of the prepared concrete surfaces shall be a colloidal cement, fly ash, bentonite slurry. The grout shall have a minimum compressive strength of 5,000 psi at 28 days per ASTM C39 or C109 and a maximum shrinkage not exceeding 1.0 percent by volume as measured by ASTM 1090 (28 days moist cure). The Contractor shall provide a water meter to monitor and insure the amount of water used is in accordance with the approved grout mix design. Bleed water shall be less than 5 percent.

**500-1.5.6 Installation.** The Contractor shall retain the services of a qualified and authorized representative of the lining system manufacturer to provide field instruction and direction to ensure that the work is performed in accordance with the lining system manufacturer's recommendations. Conformance of the work to the specifications shall be determined solely by the Engineer.

The Contractor shall verify the layout of the curve and angular deflection of the existing sewer prior to ordering the PVC liner. The Contractor shall utilize the maximum widths of PVC liner possible. Depending on the limits of lining required, the PVC liner shall either be furnished in coils and spiral wound to completely line the interior of the sewer or furnished in panels and installed square and perpendicular with the conduit. Edges of the adjacent liner shall be joined together with a continuous PVC joiner strip with snap-tight joint. After assembled, the joint shall be water and gas leak tight. Details for joining the leading and terminating edges shall be submitted for approval. At locations where the gap between liner sections precludes the use of joiner strips, H-strip shall be used. The H-strip and PVC liner shall be coated with a primer and sealed with SikaFlex 1A, or equal as recommended by the manufacturer and approved by the Engineer.

The Contractor shall maintain service connections in service without interruption and without excavation. The annular space between the PVC liner and the host pipe at the service connections shall be bulkheaded. The bulkhead, grout and existing RCP shall be protected from the sewage and sewer gases by a method recommended by the manufacturer and approved by the Engineer.

After the PVC liner is in place and joined, the ends of the liner shall be bulkheaded. The Contractor shall exercise extreme care during grouting. The Contractor shall stage the grouting in multiple lifts and shall provide all the bracing and supports as deemed necessary to prevent the PVC liner from buckling and floating during grouting. Grout for each lift shall be allowed to set before the succeeding lift of grout is placed. Grout holes may be drilled in the PVC liner. After grouting, the grout holes shall be plugged with PVC plugs and sealed by polyurethane sealant. All waste grout shall be removed and disposed of off the site.

A minimum of three grout samples shall be taken for each grout lift. Each grout sample shall be tested for bleeding, density and consistency, and shall conform to the approved grout mix design. In addition, a total of three samples shall be taken at locations determined by the Engineer and tested for compressive strength at 28 days. The average compressive strength of the samples shall be greater than the minimum compressive strength as specified in 500-1.5.5. If the average compressive strength is less than the specified strength or if the compressive strength of any sample is less than 85 percent of the specified strength, the entire lined sewer shall be considered to be out of compliance. All testing shall be performed by an independent testing laboratory approved by the Districts. Results of the testing shall be submitted to the Engineer for approval. Cost of the testing shall be paid for by the Contractor.

**500-1.5.7 Inspection and Testing.** After installation of the PVC liner and completion of the annular space grouting, the surface of the liner shall be cleaned and prepared for inspection and testing by the Engineer. The Engineer will sound the interior of the sewer to locate any voids and areas with poor adhesion. The Contractor shall drill hole(s) through the lined surface as directed by the Engineer to determine the extent of the voids. After the inspection, any voids and areas with poor adhesion found behind the lined surface, including all the drilled holes, shall be repaired.

**500-1.5.8 Repair of Defects.** The Contractor shall submit the repair method to the Districts for approval and shall be responsible for all costs of the repair.

**500-1.5.9 Drawings and Data.** The Contractor shall submit the following for approval:

1. Complete description of the concrete surface preparation including equipment, setup, and procedures.
2. Sequence of work and complete layout plan.
3. Certificate of compliance including a complete materials list and design of the grout mix showing proportioning of cement, water, fly ash, bentonite, admixtures and fillers; grout properties including workability, working time and temperature; and results of testing by the independent testing laboratory including consistency per the flow cone test per ASTM C939, bleeding ASTM C232 C940 or C232, setting time per ASTM C403, compressive strength per ASTM C39 or C109, density per ASTM C138 shrinkage per ASTM C157 and C1090.
4. Detailed description of the installation and grouting procedures including number of grout lifts, and maximum height allowed for each lift.

**500-1.5.10 Payment.** Payment for furnishing all labor, equipment and materials to install the PVC pipe lining system including sewer cleaning; removal and disposal of debris; surface preparation; installation of the reinforcing steel; installation of the PVC panels; grouting and appurtenant work shall be made under the appropriate sewer rehabilitation bid item."

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IN **500-1.7 Deformed/Re-Formed HDPE Pipe Liner**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**"500-1.7.1 General.** This section covers the requirements for rehabilitating the sewer with a deformed and re-formed HDPE pipe liner.

**500-1.7.2 Notifications.** Prior to commencing any work, the Contractor shall notify all the residents and businesses whose services will be disrupted per 500-1.1.7(a).

**500-1.7.3 Cleaning, Preliminary Inspection and Closed Circuit Television Inspection.** Cleaning and preliminary inspection shall be performed in accordance with 500-1.1.4. Prior to ordering the HDPE pipe liner, the Contractor shall field verify the diameter and length of the existing sewer.

The number and locations of the existing house connections depicted on the Plans are provided for bid comparison only and are not guaranteed for accuracy. After cleaning and preliminary inspection, the Contractor shall perform CCTV inspection to insure that the sewer is ready to be lined and to verify the number and locations and status of all the existing connections. Minimum guidelines for the CCTV

inspection work to be performed shall be as specified in 500-1.1.5. CCTV inspection shall also be performed after the sewer is lined and existing sewer connection, if any, re-established.

The Contractor shall complete any necessary point repairs and removal of obstructions not cleared by cleaning prior to performing the CCTV inspection. Any protruding house connections that may interfere with liner installation shall be cut flush with the existing pipe by the use of an approved remote cutting device from within the sewer.

**500-1.7.4 Materials.** Deformed HDPE pipe liner shall be made from PE resins with a cell classification of 345434 C, D or E as defined in ASTM D3350. The liner shall have undergone and met the chemical resistance and minimum physical property values as specified in 207-19.5, at the time of bid. Requirements shall be met with samples taken from pipe liner that has undergone the de-forming and re-forming process. Upon request, proof of meeting these requirements shall be submitted to the Districts within two days after receipt of bids.

The Contractor shall submit to the Districts certified test results from the manufacturer to verify that the resin material used for the extrusions of the pipe liner will meet the specified requirements, including the quality control records during the extrusion process.

**500-1.7.5 Marking.** Marking shall conform to 207-19.4 except the material shall be designated by cell classification.

**500-1.7.6 Design.** The deformed and re-formed HDPE pipe liner shall have a minimum service life of 50 years and shall be designed by the manufacturer based on the assumption that the existing sewer is fully deteriorated. Calculations shall be based on a modulus of soils reaction ( $E_s$ ) value of 700 psi, a unit weight of soil of 120 lb/cf, and percentage of ovality of original pipe ( $q$ ) of 2 percent.

The deformed pipe liner shall have the standard diameter ratio (SDR) as specified in the Plans. The SDR and minimum wall thicknesses specified are calculated based on an initial flexural modulus of 110,000 psi and a long-term creep modulus of 27,500 psi based on a 25 percent retention factor. If a liner has undergone and completed flexural testing per ASTM D790 and if justified by the test results, the Districts may allow the use of a higher initial flexural modulus for calculating the long-term creep modulus and resulting in a design wall thickness less than the specified wall thickness. The flexural testing shall be done by an independent accredited testing laboratory and shall be completed at the time of bid. In any event, the highest initial flexural modulus that can be used in calculating the long-term creep modulus under the cell classification being specified shall be 160,000 psi and the 25 percent retention factor shall remain constant.

**500-1.7.7 Submittal Data.** The Contractor shall submit a deformed/re-formed HDPE pipe liner submittal to the Districts for approval. The submittal shall include material certification per 4-1.5 including cell classification, chemical resistance and physical properties; design calculations; cleaning procedures; flow bypass plan and schematic; detailed installation procedures which are specific to the project including equipment setup and layout, insertion and access manhole locations, details and dimensions of the sampler, and the recommended temperature and pressure limits; and method of and materials used for providing end seals. The Contractor shall have approved submittals prior to commencing any work.

**500-1.7.8 Testing.** To ensure the material used in the manufacture of the pipe liner complies with the specified cell classifications, the Contractor shall submit test results in accordance with Section 10 of ASTM D3350 to the Districts for approval. Testing shall be performed once per shift, change in material batch or coil. The Contractor shall have approved test results prior to installing the liner. In addition, the wall thickness of the liner shall be measured and submitted with the test results. Liner wall thickness

shall be measured in accordance with ASTM D2122 and shall meet the minimum specified wall thickness or the wall thickness in the approved submittal.

Two compliance samples shall be collected from each insertion/lining run. The Contractor shall submit a sampling and testing plan for the field samples to the Districts per 500-1.1.6. One of the samples from each of the insertion/lining runs will be selected by the Engineer and subject to the following tests to ensure that the installed liner complies with the specifications. The testing shall be performed by an independent accredited testing laboratory approved by the Districts.

- Flexural Modulus per ASTM D790
- Wall Thickness Measurement per ASTM D2122

The Contractor shall submit four copies of the certified test report to the Districts for approval. If any of the test values from a sample fails to meet the specified values or values in the approved submittal, specimens from the second sample shall be prepared and subject to retest. If any of the test values of the second sample fails to meet the specified values or values in the approved submittal, the lined sewer reach shall be considered to be out of compliance and the Districts shall have the authority to direct the Contractor to reline the entire sewer reach. The relining, if required by the Engineer, shall be performed at no additional cost to the Districts. No time extension will be granted.

**500-1.7.9 Installation.** Installation of the deformed and re-formed HDPE pipe liner shall be in strict conformance of the installation procedures recommended by the manufacturer and shall take place within 48 hours of cleaning the sewer. The Contractor shall retain the services of a qualified authorized representative of the manufacturer to assist the Contractor during preparation and installation and to certify that the work has been performed in accordance with the manufacturer's recommendations. The existing sewer shall be cleared of any obstructions, cleaned and televised, and the condition shall be approved by the Engineer prior to the start of installation. Deformed HDPE pipe liner shall be pulled into the sewer by cable through existing manholes from upstream to downstream, without excavation. Appropriate sleeves and rollers shall be installed to protect and prevent the liner from damage during installation.

After the deformed HDPE liner is in place and secured, the liner shall undergo a thermo-pressurization rerounding process. Temperature and pressure measuring instruments shall be attached to both ends of the liner to continuously monitor the temperature and pressure being applied. Through the use of steam and air pressure, the deformed pipe liner shall be progressively reformed to conform to the interior of the existing sewer pipe. The reformed pipe liner shall be cooled in accordance with the manufacturer's recommendations. Temperatures and pressures shall be recorded to ensure that each phase of the process is achieved at the manufacturer's recommended temperature and pressure limits.

Service connections shall be re-established within 10 hours after the completion of each liner installation. If service is disrupted for more than 24 hours, the Contractor shall provide additional sanitary facilities to affected residents and businesses as may be necessary. The Contractor shall be responsible for any extra costs that accrue due to service not being reinstated within the first 24 hours. The connections shall be re-established without excavation by the use of an approved remote control cutting device from within the sewer. The Contractor shall not re-establish any stub. The final re-established house connection shall be equal to the original opening both in size and shape with clean and smooth edges. The Contractor shall have a fully operational backup device on site in case of malfunction.

**500-1.7.10 End Seals.** After installation, the ends of the liner shall be cut off flush with the manhole wall and sealed. If a manhole has been lined through, the top half of the liner shall be cut even with the top of the shelf. The ends of the liner shall be sealed with a material that will bond to both the liner and the host pipe. The sealant material shall be suitable for continuous immersion in water and shall be resistant to a corrosive sewer environment. The sealant shall provide a smooth transition from the host

pipe to the liner and shall not reduce the inside diameter of the liner. The sealant material to be used shall be Sikadur®31 or 35, Sika Corporation, or equivalent approved by the Engineer. The Contractor shall apply the material prior to the expiration of its shelf life and in accordance with the manufacturer's recommendations.

**500-1.7.11 Inspection and Repair.** A post CCTV inspection shall be performed to inspect the finished liner for defects. All defects found in the finished liner shall be repaired. The repair to be performed shall be determined by the Engineer and may include excavating, removing and replacing the lined sewer, or relining. The Contractor shall submit the repair method to the Districts for approval and shall be responsible for all costs of the repair.

**500-1.7.12 Payment.** Payment for furnishing all labor, equipment and materials to rehabilitate the existing sewer with the deformed and re-formed HDPE pipe liner, including flow bypass, point repairs, cleaning, cutting of protruding house connections and removal of obstructions, providing temporary sanitary facilities, all testing, installation of the liner, re-establishing local sewer and house connections, physical inspection, pre- and post-CCTV inspection, repairs including relining, and all work appurtenant thereto, shall be made under the deformed and re-formed HDPE pipe liner bid item.

Unless otherwise specified, the deformed and reformed HDPE pipe liner bid item quantity does not include length of liner at manhole(s). If the Contractor installs the liner through a manhole and a compliance sample is not collected at that manhole, the Districts may allow all portions of the liner within the manhole to remain in place to facilitate the manhole rehabilitation work. If the liner is allowed to remain in a manhole, the Districts will reimburse the Contractor the cost by adjusting the bid item quantity to include the length of the liner at that manhole based on the unit cost of the deformed and reformed HDPE pipe liner bid item. If the Engineer determines the liner within the manhole has abnormalities or if the Contractor installs the liner through a manhole which will be used as a sample manhole, the Contractor shall cut and remove all portions of the liner within the manhole. Cost for installing and removing the liner at these manholes shall be the responsibility of the Contractor. If the HDPE pipe liner is to be removed from a manhole, the liner shall be cut flush with the ends of the existing sewer pipes at the manhole wall."

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IN **500-1.8 Centrifugally Cast Fiberglass Reinforced Plastic Mortar (CCFRPM) Liner Pipe**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**"500-1.8.1 General.** Fiberglass liner pipes, joints, and fittings, shall be designed and manufactured in accordance with AWWA M45, Manual of Water Supply Practices, Chapter 5 and ASTM D3262, Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Sewer Pipe.

Fiberglass liner pipes, joints and fittings shall be suitable for continuous service in sewerage environments with 1N sulfuric acid at an average wastewater temperature of 80°F and for intermittent exposure (at a frequency of 1½ hours two times a week) to sewage with a pH of 11.

**500-1.8.2 Design.** The fiberglass liner pipe shall have a minimum service life of 50 years and shall be designed by the manufacturer to withstand the total loads, including, but not limited to, soil load, live load, hydrostatic loads, and construction loads. Design shall be based on prism load and AASTO H-20 live load and the assumption that the existing sewer is fully deteriorated and that the grout placed in the annular space provide no structural support to the liner pipe, except for transmitting loads.

The liner pipe shall be designed such that the pipe shall not fail by crushing, collapsing, buckling, cracking, delamination or excessive deflection under loads. The long-term (50 years) vertical deflection anticipated under all loads shall not exceed five (5) percent. The ring bending strain at the maximum allowable long-term vertical deflection developed in pipe wall shall be less than the long-term (50 years) ring-bending strain, with a minimum design factor of 1.5. Determination of the long-term ring bending strain shall be as defined in AWWA C950, AWWA Standard for Fiberglass Pressure Pipe. Unless otherwise specified, the liner pipe shall have a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D2412.

**500-1.8.3 Materials.** Fiberglass liner pipes shall be centrifugally cast fiberglass-reinforced resin design. Unless otherwise specified, the resin used in the manufacture of the pipe shall be polyester resin systems. The reinforced glass fibers shall be commercial grade, type E chopped glass fibers. Aggregate, when used as a filler, shall be siliceous sand conforming to ASTM C33 except the requirements for gradation do not apply. Sand shall be 98 percent silica with a maximum moisture content of 0.2 percent. The interior surface of the pipe shall be a resin rich liner, minimum 40 mils thick, with no fillers.

**500-1.8.4 Dimensions.** Unless otherwise specified, the diameters of the liner pipe called for in the Plans are the nominal and the minimum inside diameters required. The 14- through 54-inch pipe outside diameters shall be in accordance with the dimensions for the outside diameter control pipe with cast iron pipe equivalent in ASTM D3262. Outside diameters of other pipe sizes shall be as specified on the Plans. Unless otherwise specified or required, liner pipes shall be furnished in 10 or 20-foot lengths.

**500-1.8.5 Pipe Joints.** Unless otherwise specified, the liner pipe shall be connected with jacking bell and spigot joint by utilizing a proper elastomeric sealing gasket to maintain a leak-proof joint when deflected per ASTM D4161. The assembled joint shall be designed to withstand the total loads during the specified service life. The joint shall have an outside diameter same as the pipe, so when assembled, the joint will be flush with the outside diameter of the pipe. Elastomeric gaskets shall be EPDM and shall conform to ASTM F477.

**500-1.8.6 Submittal Data and Drawings.** A Confirmation Test shall be performed to verify that the pipe design, as contained in the submittal, will meet the specified performance. No pipe shall be manufactured until this submittal is reviewed and accepted by the Districts.

The liner pipe submittal shall include the following:

1. Name of the manufacturer and complete information on the material composition including resins, reinforcing materials, and fillers.
2. Certification of the materials including the cell classifications, grades, resin type, glass fibers, and other materials used in the manufacture of the liner pipe.
3. Design calculations including list of parameters, formulas, and all other technical data used in the design of the liner pipe. Calculations submitted shall include, but not be limited to: pipe stiffness (PS), wall crushing strength, initial and long-term (50 years) vertical pipe deflection, ring-bending strain, hydrostatic collapse resistance, constrained buckling strength, maximum allowable jacking force, and maximum allowable grout pressure. Unless otherwise specified, the calculations shall be based on a composite modulus of soil reaction ( $E'$ ) of 700 psi, a design temperature of 80°F, a specific weight of soil of 120 lb/cf, a wheel load of 16,000 lbs, a shape factor  $D_f$  of 5.0, a deflection coefficient  $K_x$  of 0.103, and a deflection lag factor  $D_L$  of 1.0 (initial) and 1.5 (long-term).
4. Regression analysis for allowable long-term ring bending strain.

5. Drawings showing the pipe cross section and dimensions and pipe joint details including manufacturer's allowable tolerances on joint dimensions.
6. Fittings and special pieces including details of closure couplings and saddles.
7. Installation, storage, and handling procedures.

#### **500-1.8.7 Inspection and Testing.**

**500-1.8.7.1 General.** Liner pipe shall be tested in accordance with all applicable ASTM and AWWA Standards and as specified herein. The Districts shall not be held liable for any subsequent delay to the project or be responsible for any costs as a result of the testing or retesting of the liner pipe as designed by the manufacturer, should it fail. All costs for the testing shall be borne by the Contractor.

**500-1.8.7.2 Inspection.** All materials to be used in the manufacture of the liner pipe shall be inspected by the authorized representative of the Districts. This representative is authorized by the Districts to reject all materials or workmanship not conforming to the Plans and Specifications and the approved liner pipe submittal. After receipt of the approved submittal, the Contractor shall give the Engineer a minimum of five (5) days advance written notice prior to the start of the manufacturing operations and/or conducting the confirmation test, to permit ample time for inspection of the materials. Pipe produced prior to the inspection will not be accepted.

**500-1.8.7.3 Testing.** Testing to be performed shall include a confirmation test, a quality control test, and a joint leakage test. The Districts reserve the right to have the authorized representative, or employ an independent testing laboratory to witness all testing to be performed. Prior to scheduling the testing, the Contractor shall submit to the Districts detailed testing procedures, including the testing setups and the make and calibration data of the testing equipment for approval. All testing equipment shall be calibrated not more than six (6) months prior to the testing.

**500-1.8.7.3.1 Confirmation Test.** The following tests shall be performed to verify that the liner pipe to be furnished will meet or exceed the specified performance based on design and dimensions submitted by the manufacturer. Test results from prior projects are not acceptable.

- Pipe Stiffness test per ASTM 2412
- Workmanship and dimension test per ASTM D3567
- Flattening test per ASTM D2412

The Contractor shall submit the certified test reports in triplicate to the Districts for approval. The manufacturer shall not commence pipe production until the confirmation test is performed and the results are accepted by the Districts. If the first specimen fails the testing requirements, an additional specimen shall be made and tested. If the second specimen fails the testing requirements, the liner pipe design shall be reevaluated and a new design shall be submitted to the Districts for approval and the pipe retested.

**500-1.8.7.3.2 Quality Control Test.** After successful completion of the confirmation test, the following tests shall be performed to ensure that the pipe produced will continue to comply with the accepted pipe design and project specifications.

- Workmanship and dimensions per ASTM D3567 as stipulated in Section 8.1 of ASTM D3262
- Pipe stiffness test per ASTM D2412 and Section 8.3 of ASTM D3262
- Flattening test per ASTM D2412 and Section 8 of ASTM D3262

One length out of each lot of pipe produced will be selected for testing by the Districts' authorized representative. A lot is defined as 100 lengths of pipe or 2,000 feet of pipe (20 feet per length of pipe). Certified copies of all manufacturer and quality control records shall be submitted to the Districts. If the tested specimen of a designated lot passes the test, then all the pipes from that lot shall be considered as complying with the requirements. If the tested specimen of a designated lot fails to pass the test, then five additional specimens from the same lot shall be selected for retesting. If all five specimens pass the test, then the lot will be considered as complying with the requirements, except for the previous tested specimen that failed. If any of these five specimens fails to pass the test, then the entire lot will be rejected. The Contractor will be allowed to downgrade pipe from a rejected lot to a lower pipe strength, provided that the lower pipe strength still meets the minimum required stiffness specified and the intended use would be justified by the inspection report to be submitted. Downgrading of pipe shall be in accordance with 207-2.9.4. The liner pipe which passed the test will be stamped by the Districts' authorized representative. Any liner pipe shipped without the inspector's stamp will not be accepted at the project site.

**500-1.8.7.3.3 Joint Leakage Test.** A leakage test shall be performed, if required by the Engineer, to verify the design of the pipe joint. Two sections of pipe will be selected by the Districts' authorized representative. The pipes shall be joined together and the ends of the pipe shall be bulkheaded and sealed. The assembled joint shall be deflected 2 percent, secured and subjected to a test pressure equivalent to the maximum allowable grout pressure. The pipe shall be saturated with water before the test. The test pressure shall be maintained for a minimum of 30 minutes with zero leakage.

**500-1.8.8 Marking.** Each length of pipe delivered to the project site shall be clearly marked with the name of manufacturer, pipe sizes, type of resins, cell classification, pipe stiffness, production code, lot number, and the marking of ASTM D3262.

**500-1.8.9 Payment.** Payment for furnishing all labor, equipment and materials and performing all work associated with furnishing and installing the liner pipe shall be made under the liner pipe bid item. Unless otherwise approved by the Engineer, no pipe shall be installed and no partial payment will be made until the liner pipe has successfully completed and passed the required quality control testing."

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IN **500-1.10 Folded and Re-formed PVC Pipe Liner**, DELETE ALL PARAGRAPHS EXCEPT TABLES 500-1.10.2 (B) and 500-1.10.3(B) AND REPLACE WITH THE FOLLOWING:

**"500-1.10.1 General.** This section covers the requirements for rehabilitating the sewer with a folded and re-formed PVC pipe liner.

**500-1.10.2 Notifications.** Prior to commencing any work, the Contractor shall notify all the residents and businesses whose services will be disrupted per 500-1.1.7(a).

**500-1.10.3 Cleaning, Preliminary Inspection and Closed Circuit Television Inspection.** Cleaning and preliminary inspection shall be performed in accordance with 500-1.1.4. Prior to ordering the PVC pipe liner, the Contractor shall field verify the diameter and length of the existing sewer.

The number and locations of the existing house connections depicted on the Plans are provided for bid comparison only and are not guaranteed for accuracy. After cleaning and preliminary inspection, the Contractor shall perform CCTV inspection to insure that the sewer is ready to be lined and to verify the number and locations and status of all the existing connections. Minimum guidelines for the CCTV inspection work to be performed shall be as specified in 500-1.1.5. CCTV inspection shall also be performed after the sewer is lined and existing sewer connection, if any, re-established.

The Contractor shall complete any necessary point repairs and removal of obstructions not cleared by cleaning prior to performing the CCTV inspection. Any protruding house connections that may interfere with liner installation shall be cut flush with the existing pipe by the use of an approved remote cutting device from within the sewer.

**500-1.10.4 Materials.** Folded PVC pipe liner shall be made from PVC compounds having a cell classification of 13223, 12334, or 12111 as defined in ASTM D1784. The liner shall have undergone and met the chemical resistance and minimum physical property values as specified in 207-15.3 except as modified by 211-2 and Tables 500-1.10.2 (B) and 500-1.10.3(B) at the time of bid. Upon request, proof of meeting these requirements shall be submitted to the Districts within two days after the receipt of the bids. Requirements shall be met with samples taken from the pipe liner that has undergone the folding and re-forming process. Upon request, proof of meeting these requirements shall be submitted to the Districts within two days after receipt of bids.

The Contractor shall submit to the Districts certified test results from the manufacturer to verify that the resin material used for the extrusions of the pipe liner will meet the specified requirements, including the quality control records during the extrusion process.

**500-1.10.5 Marking.** Marking shall conform to all applicable provisions of 207-17.2.1.

**500-1.10.6 Design.** The folded and re-formed PVC pipe liner shall have a minimum service life of 50 years and shall be designed by the manufacturer based on the assumption that the existing sewer is fully deteriorated. Calculations shall be based on a modulus of soils reaction ( $E_s'$ ) value of 700 psi, a unit weight of soil of 120 lb/cf, and percentage of ovality of original pipe ( $q$ ) of 2 percent.

The folded PVC pipe liner shall have the standard dimension ratio (SDR) as specified in the Plans. The SDR and minimum wall thicknesses specified for deformed pipe liner with the cell classification of 13223-B and 12334-B are calculated based on an initial flexural modulus of 280,000 psi and a long-term creep modulus of 106,400 psi based on a 38 percent retention factor. The SDR and minimum wall thicknesses specified for deformed pipe liner with the cell classification of 12111-C are calculated based on an initial flexural modulus of 145,000 psi and a long-term creep modulus of 55,100 psi based on a 38 percent retention factor.

**500-1.10.7 Submittal Data.** The Contractor shall submit a folded/re-formed PVC pipe liner submittal to the Districts for approval. The submittal shall include material certification per 4-1.5 including cell classification, chemical resistance and physical properties; design calculations; cleaning procedures; flow bypass plan and schematic; detailed installation procedures which are specific to the project, including equipment setup and layout, insertion and access manhole locations, details and dimensions of the sampler, and the recommended temperature and pressure limits; and methods of and materials used for providing end seals. The Contractor shall have approved submittal prior to commencing any rehabilitation work.

**500-1.10.8 Testing.** To ensure the material used in the manufacture of the pipe liner complies with the specified cell classifications, the Contractor shall submit test results in accordance with Section 11 of ASTM D1784 to the Districts for approval. Testing shall be performed once per shift, change in material batch or coil. The Contractor shall have approved test results prior to installing the liner. In addition, the wall thickness of the liner shall be measured and submitted with the test results. Liner wall thickness shall be measured in accordance with ASTM D2122 and shall meet the minimum specified wall thickness or the wall thickness in the approved submittal.

Two compliance samples shall be collected from each insertion/lining run. The Contractor shall submit a sampling and testing plan for the field samples to the Districts per 500-1.1.6. One of the samples from each of the insertion/lining runs will be selected by the Engineer and subject to the

following tests to ensure that the installed liner complies with the specifications. The testing shall be performed by an independent accredited testing laboratory approved by the Districts.

- Flexural Modulus per ASTM D790
- Wall Thickness Measurement per ASTM D2122

The Contractor shall submit certified test reports in triplicate to the Districts for approval. If any of the test values from a sample fails to meet the specified values or values in the approved submittal, the second sample shall be prepared and subject to testing. If any of the test values of the second sample fails to meet the specified values or values in the approved submittal, the lined sewer reach shall be considered to be out of compliance and the Districts shall have the authority to direct the Contractor to reline the entire sewer reach. The relining, if required by the Engineer, shall be performed at no additional cost to the Districts. No time extension will be granted.

**500-1.10.9 Installation.** Installation of the folded and reformed PVC pipe liner shall be in strict conformance of the installation procedures recommended by the manufacturer and shall take place within 48 hours of cleaning the sewer. The Contractor shall retain the services of a qualified authorized representative of the manufacturer to assist the Contractor during preparation and the installation to certify that the work has been performed in accordance with the manufacturer's recommendations. The existing sewer shall be cleared of any obstructions, cleaned and televised, and the condition shall be approved by the Engineer prior to the start of installation. Folded PVC pipe liner shall be pulled into the sewer by cable through existing manholes from upstream to downstream, without excavation. Appropriate sleeves and rollers shall be installed to protect and prevent the liner from damage during installation.

After the folded PVC pipe liner is in place and secured, the liner shall undergo a thermo-pressurization reforming process allowing the folded liner to reform. Temperature and pressure measuring instruments shall be attached to both ends of the liner to continuously monitor the temperature and pressure being applied. Through the use of steam and air pressure, the folded PVC pipe liner shall be progressively reformed to conform to the interior of the existing sewer pipe. The reformed liner shall be cooled in accordance with the manufacturer's recommendations. Temperatures and pressures shall be recorded to ensure that each phase of the process is achieved at the manufacturer's recommended temperature and pressure limits. Use of a rounding device may be permitted if the rounding process will not cause any damage to the liner.

Service connections shall be re-established within 10 hours after the completion of each liner installation. If service is disrupted for more than 24 hours, the Contractor shall provide additional sanitary facilities to affected residents and businesses as may be necessary. The Contractor shall be responsible for any extra costs that accrue due to service not being reinstated within the first 24 hours. The connections shall be re-established without excavation by the use of an approved remote control cutting device from within the sewer. The Contractor shall have a fully operational backup device on site. The Contractor shall not re-establish any stub. The final re-established house connection shall be equal to the original opening both in size and shape with clean and smooth edges.

**500-1.10.10 End Seals.** After installation, the ends of the liner shall be cut off flush with the manhole wall and sealed. If a manhole has been lined through, the top half of the liner shall be cut even with the top of the shelf. The ends of the liner shall be sealed with a material that will bond to both the liner and the host pipe. The sealant material shall be suitable for continuous immersion in water and shall be resistant to a corrosive sewer environment. The sealant shall provide a smooth transition from the host pipe to the liner and shall not reduce the inside diameter of the liner. The sealant material to be used shall be Sikadur®31 or 35, Sika Corporation, or equivalent approved by the Engineer. The Contractor shall

apply the material prior to the expiration of its shelf life and in accordance with the manufacturer's recommendations.

**500-1.10.11 Inspection and Repair.** A post CCTV inspection shall be performed to inspect the finished liner for defects. All defects found in the finished liner shall be repaired. The repair to be performed shall be determined by the Engineer and may include excavating, removing and replacing the lined sewer, or relining. The Contractor shall submit the repair method to the Districts for approval and shall be responsible for all costs of the repair.

**500-1.10.12 Payment.** Payment for furnishing all labor, equipment and materials to rehabilitate the existing sewer with the folded and re-formed PVC pipe liner pipe liner, including flow bypass, point repairs, cleaning, cutting of protruding house connections and removal of obstructions, providing temporary sanitary facilities, all testing, installation of the liner, re-establishing local sewer and house connections, physical inspection, pre- and post-CCTV inspection, repairs including grouting of voids, and all work appurtenant thereto, shall be made under the folded and reformed PVC pipe liner bid item.

Unless otherwise specified, the folded and reformed PVC pipe liner bid item quantity does not include length of liner at manhole(s). If the Contractor installs the liner through a manhole and a compliance sample is not collected at that manhole, the Districts may allow all portions of the liner within the manhole to remain in place to facilitate the manhole rehabilitation work. If the liner is allowed to remain in a manhole, the Districts will reimburse the Contractor the cost by adjusting the bid item quantity to include the length of the liner at that manhole based on the unit cost of the folded and reformed PVC pipe liner bid item. If the Engineer determines the liner within the manhole has abnormalities or if the Contractor installs the liner through a manhole which will be used as a sample manhole, the Contractor shall cut and remove all portions of the liner within the manhole. Cost for installing and removing the liner at these manholes shall be the responsibility of the Contractor. If the PVC pipe liner is to be removed from a manhole, the liner shall be cut flush with the ends of the existing sewer pipes at the manhole wall."

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**IN 500-1.12 Polyvinyl Chloride (PVC) Closed Profile Liner Pipe, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:**

**"500-1.12.1 General.** Polyvinyl Chloride (PVC) closed profile segmented liner pipe shall conform to the requirements of ASTM F794.

PVC liner pipes, joints and fittings shall be suitable for continuous service in sewerage environments with 1N sulfuric acid at an average wastewater temperature of 80°F and for intermittent exposure (at a frequency of 1½ hours two times a week) to sewage with a pH of 11.

**500-1.12.2 Design.** PVC liner pipe shall have a minimum service life of 50 years and shall be designed by the manufacturer to withstand the total loads, including, but not limited to, soil load, live load, hydrostatic loads, and construction loads. Design shall be based on prism load and AASTO H-20 live load and the assumption that the existing sewer is fully deteriorated and that the grout placed in the annular space provide no structural support to the liner pipe, except for transmitting loads.

The liner pipe shall be designed such that the pipe shall not fail by crushing, collapsing, buckling, cracking, or excessive deflection under loads. The long-term (50 years) vertical deflection anticipated under all loads shall not exceed five (5) percent. The ring bending strain at the maximum allowable long-term vertical deflection developed in pipe wall shall be less than the long-term (50 years) ring-bending strain, with a minimum design factor of 1.5. Unless otherwise specified, the liner pipe shall have a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D2412.

**500-1.12.3 Materials.** The material for the pipe and fittings shall be made from unplasticized PVC compounds having a cell classification of 12364 as defined in ASTM D1784. Elastomeric sealing gaskets shall conform to the requirements of 208-4 and ASTM F477.

**500-1.12.4 Dimensions.** Unless otherwise specified, the diameters of the liner pipe called for in the Plans are the nominal and the minimum inside diameters required. Outside diameters of other pipe sizes shall be as specified on the Plans. Unless otherwise specified or required, liner pipes shall be furnished in 10 or 20-foot lengths.

**500-1.12.5 Pipe Joints.** The liner pipe shall be furnished no-bell gasketed joints and shall be connected with gasketed couplings. The assembled joint shall be designed to withstand the total loads during the specified service life. The joint shall be designed so that neither the outside diameter of the pipe is increased nor the internal diameter decreased at the joint.

**500-1.12.6 Submittal Data and Drawings.** A confirmation test shall be performed to verify that the pipe design, as contained in the submittal, will meet the specified performance. No pipe shall be manufactured until this submittal is reviewed and accepted by the Districts.

The liner pipe submittal shall include the following:

1. Name of the manufacturer and complete information on the material composition including resins, reinforcing materials, and fillers.
2. Certification of the materials including the cell classifications, grades, resin type, glass fibers, and other materials used in the manufacture of the liner pipe.
3. Design calculations including list of parameters, formulas, and all other technical data used in the design of the liner pipe. Calculations submitted shall include, but not be limited to: pipe stiffness (PS), wall crushing strength, initial and long-term (50 years) vertical pipe deflection, ring-bending strain, hydrostatic collapse resistance, constrained buckling strength, maximum allowable jacking force, and maximum allowable grout pressure. Unless otherwise specified, the calculations shall be based on a composite modulus of soil reaction ( $E'$ ) of 700 psi, a design temperature of 80°F, a specific weight of soil of 120 lb/cf, a wheel load of 16,000 lbs, a shape factor  $D_f$  of 5.0, a deflection coefficient  $K_x$  of 0.103, and a deflection lag factor  $D_L$  of 1.0 (initial) and 1.5 (long-term).
4. Regression analysis for allowable long-term ring bending strain.
5. Drawings showing the pipe cross section and dimensions and pipe joint details including manufacturer's allowable tolerances on joint dimensions.
6. Fittings and special pieces including details of closure couplings and saddles. Closure couplings shall be made of rigid material or shall have stainless steel bands.
7. Installation, storage, and handling procedures.

**500-1.12.7 Inspection and Testing.**

**500-1.12.7.1 General.** Liner pipe shall be tested in accordance with all applicable ASTM standards and as specified herein. The Districts shall not be held liable for any subsequent delay to the project or be responsible for any costs as a result of the testing or retesting of the liner pipe as designed by the manufacturer, should it fail. All costs for the testing shall be borne by the Contractor.

The liner pipe shall be free from cracks, holes, blisters, foreign inclusions or other defects that would, due to their nature, degree, or extent, have a deleterious effect on the pipe performance as determined by the Engineer. For testing purposes, a production lot shall consist of all liner pipe having the same lot marking number, but shall not exceed two shifts of production. Pipe length, wall thickness and joint dimensions shall be verified by testing for each lot in accordance with ASTM F794. Records of this testing shall be made available when requested by the Engineer.

Liner pipe shall conform to 207-17.5 except as modified herein.

Property	ASTM Test Method	Value (Initial and After 112-Day Exposure) Cell Class 12364A
Tensile Strength (Yield), psi, min.	D638	6000
Impact Strength Ft.-lbs./in. notch min	D256 Method A (Size ½" x ⅛" x 2½")	0.65
Weight Change % Unconditioned Conditioned	D543	±1.5 max ±1.0 max

Verification shall be provided that physical testing of the product confirms conformance to ASTM F794 and ASTM D2412.

**500-1.12.7.2 Inspection.** All materials to be used in the manufacture of the liner pipe shall be inspected by the authorized representative of the Districts. This representative is authorized by the Districts to reject all materials or workmanship not conforming to the Plans and Specifications and the approved liner pipe submittal. After receipt of the approved submittal, the Contractor shall give the Engineer a minimum of five (5) days advance written notice prior to the start of the manufacturing operations and/or conducting the confirmation test, to permit ample time for inspection of the materials. Pipe produced prior to the inspection will not be accepted.

**500-1.12.7.3 Testing.** Testing to be performed shall include a confirmation test, a quality control test, and a joint leakage test. The Districts reserve the right to have the authorized representative, or employ an independent testing laboratory to witness all testing to be performed. Prior to scheduling the testing, the Contractor shall submit to the Districts detailed testing procedures, including the testing setups and the make and calibration data of the testing equipment for approval. All testing equipment shall be calibrated not more than six (6) months prior to the testing. All costs for the testing shall be borne by the Contractor.

**500-1.12.7.3.1 Confirmation Test.** The following tests shall be performed to verify that the liner pipe to be furnished will meet or exceed the specified performance based on design and dimensions submitted by the manufacturer. Test results from prior projects are not acceptable.

- Pipe Stiffness test per ASTM 2412
- Workmanship and dimension test per ASTM D2122
- Flattening test per ASTM D2412

The Contractor shall submit the certified test reports in triplicate to the Districts for approval. The manufacturer shall not commence pipe production until the confirmation test is performed and the results are accepted by the Districts. If the first specimen fails the testing requirements, an additional specimen shall be made and tested. If the second specimen fails the testing requirements, the liner pipe design shall be reevaluated and a new design shall be submitted to the Districts for approval and the pipe retested.

**500-1.12.7.3.2 Quality Control Test.** After successful completion of the confirmation test, the following tests shall be performed to ensure that the pipe produced will continue to comply with the accepted pipe design and project specifications.

- Workmanship and dimensions per ASTM D2122 as stipulated in Section 8.4 of ASTM F794
- Pipe stiffness test per ASTM D2412 and Section 8.7 of ASTM F794
- Flattening test per ASTM D2412 and Section 8.5 of ASTM F794

One length out of each lot of pipe produced will be selected for testing by the Districts' authorized representative. A lot is defined as 100 lengths of pipe or 1,500 feet of pipe (feet per length of pipe). Certified copies of all manufacturer and quality control records shall be submitted to the Districts. If the tested specimen of a designated lot passes the test, then all the pipes from that lot shall be considered as complying with the requirements. If the tested specimen of a designated lot fails to pass the test, then five additional specimens from the same lot shall be selected for retesting. If all five specimens pass the test, then the lot will be considered as complying with the requirements, except for the previous tested specimen that failed. If any of these five specimens fails to pass the test, then the entire lot will be rejected. The liner pipe which passed the test will be stamped by the Districts' authorized representative. Any liner pipe shipped without the inspector's stamp will not be accepted at the project site.

**500-1.12.7.3.3 Joint Leakage Test.** A leakage test shall be performed, if required by the Engineer, to verify the design of the pipe joint. Two sections of pipe will be selected by the Districts' authorized representative. The pipes shall be joined together and the ends of the pipe shall be bulkheaded and sealed. The assembled joint shall be deflected 2 percent, secured and subjected to a test pressure equivalent to the maximum allowable grout pressure. The pipe shall be saturated with water before the test. The test pressure shall be maintained for a minimum of 30 minutes with zero leakage.

**500-1.12.8 Installation.** The existing sewer shall be maintained in operation during sliplining. The host pipeline shall be cleaned of any obstructions and televised per 500-1.1.4 and 500-1.1.5. Liner pipe installation shall conform to 500-1.1.7(b) except as modified herein. The pushing force shall be applied to the grooved end of the pipe. The pushing load shall not exceed 10 tons nor the maximum allowable pushing load recommended by the liner pipe manufacturer, whichever is less.

The first section of slipliner pipe shall follow a tapered nose cone to allow for passage past any slight obstruction or offset joint. All sections of slipliner pipe shall be restrained by full circle clamps from premature insertion into the existing sewer pipe until the slipliner joint is completed. A joint is completed when less than one inch of gasketed coupling is visible.

Closure of the liner pipe inside an insertion pit shall be accomplished by a special closure kit recommended by the manufacturer and shall be submitted to the Engineer for approval. At locations where the liner pipe will be installed by open cut for lining curves, either mitered flush joints or fabricated gasketed bell x bell fittings made from the PVC liner pipe shall be used as recommended by the pipe manufacturer.

**500-1.12.9 Marking.** Each pipe section shall be marked at one end on the inside and every 5 feet on the outside showing the manufacturer's name, manufacturing number (identifies production plant, date, shift), cell classification, lot number, nominal diameter, pipe stiffness and ASTM F-794. Internally the pipe shall have a numbered air testing certificate (sticker) that can be correlated through plant records to each piece of pipe. A key of the manufacturer's production and lot codes shall be submitted to the Engineer prior to delivery.

**500-1.12.10 Payment.** Payment for furnishing all labor, equipment and materials and performing all work associated with furnishing and installing the liner pipe shall be made under the liner pipe bid item. Unless otherwise approved by the Engineer, no pipe shall be installed and no partial payment will be made until the liner pipe has successfully completed and passed the required quality control testing."

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IN **500-2 MANHOLE AND STRUCTURE REHABILITATION**, DELETE THE WORDS "AND STRUCTURE" FROM THE TITLE.

IN **500-2.1.1 General**, FIRST SENTENCE, DELETE THE WORDS "and structure".

IN **500-2.1.2 Measurement and Payment**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

"Payment for manholes shall be made at the contract unit price for each type of manhole and shall include full compensation for furnishing all labor, equipment and materials as required to rehabilitate each manhole including all other appurtenant work."

IN **500-2.2.1 General**, DELETE THE SECOND AND THIRD SENTENCES AND REPLACE WITH THE FOLLOWING:

"The form shall have sufficient stiffness and strength to preclude shifting and/or collapse during concrete placement and to ensure safe man-entry."

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IN **500-2.2.5 Installation and Field Inspection**, FIRST PARAGRAPH, THIRD SENTENCE, ADD THE FOLLOWING TO THE END:

"and provide a minimum clear manhole opening of not less than 24 inches in diameter. For manholes with shafts less than 30 inches in diameter, the Contractor shall excavate and replace the existing manhole shafts until the specified minimum manhole opening can be attained."

IN **500-2.2.5 Installation and Field Inspection**, FIRST PARAGRAPH, FIFTH SENTENCE, AFTER THE WORDS "The installation", ADD THE WORDS "and inspection".

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AFTER **500-2.4.10 Applicable Standards**, ADD THE FOLLOWING:

**"500-2.5 Cured-in-Place Fiberglass Manhole Lining System.**

**500-2.5.1 General.** This section covers the requirements for installing a cured-in-place fiberglass manhole lining system.

**500-2.5.2 Materials.** The lining system shall be suitable for continuous service in sewerage environments with 1N sulfuric acid at an average wastewater temperature of 80 degrees F and intermittent exposure to a pH of 11. The lining system shall consist of a 4-ply fiberglass reinforcing fabric and an integral non-porous PVC membrane. The fiberglass reinforcing shall be impregnated with a modified epoxy resin, and the entire lining system shall have a minimum cured wall thickness of 90 mils. The fiberglass fabric shall be a layered product of Type E glass stitched with chopped strand and bound with styrene-soluble binder. The surfacing veil shall be woven and made of Type E glass with volan finish and styrene-soluble binder. The modified epoxy resin shall be a two components resin/mastic system cross-linked with a modified polyamide curing agent.

**500-2.5.3 Pre-inspection and Surface Preparation.** Prior to commencing any work, the Contractor shall inspect and verify all dimensions and the locations and number of all sewer connections entering each manhole, and examine the condition of the existing manholes. Any areas of apparent structural damage shall be reported to the Engineer. Outside dimensions of the reinforcing fabric shall be sized properly allowing for stretch to fit the contour and shape of the interior of the manhole.

All surfaces to be lined shall be cleaned by water blasting to remove all loose deteriorated concrete, dirt, grease, sand and other foreign matter. All materials generated by preparation of surfaces shall be trapped and collected for disposal off site; no materials will be allowed to enter into the sewer at any time. If a degreasing compound is used, the surface shall be thoroughly rinsed prior to the installation of the lining system. All large voids and spalled areas shall be filled and patched to provide a relatively smooth surface. The cementitious patching/plugging compound shall be Renderoc HBA as manufactured by Fosroc, Inc., or equal. New concrete shall contain no curing membranes or hardeners and shall be cured for a minimum of 14 days prior to installing the liner system. All connection sewers protruding into the manhole shall be cut flush with the interior manhole wall or prepared using hydraulic cement and fiberglass, per the manufacturer's recommendation. All stubs shall be bulkheaded and mortared smooth flush with interior manhole wall. Pull rings shall be left in place and sealed with resin and fiberglass. Any other obstructions including manhole steps shall be cut flush with the interior manhole wall. All infiltration shall be stopped using Scotch Seal Brand #5610 as manufactured by 3M Concrete Products, or equal.

**500-2.5.4 Installation.** Installation of the lining system shall be performed by a licensed subcontractor or contractor certified by the manufacturer to install the system. Unless otherwise shown on the Plans, limits of the lining shall extend from the manhole frame down to include the shelf area. If the existing manhole does not have a shelf, the lining shall extend down to the low water level as directed by the Engineer.

Installation of the lining system shall be scheduled and coordinated with the sewer rehabilitation work. To ensure proper installation of the lower limits of the lining system, the Contractor shall schedule installation during low flow hours. If bypassing of flow is allowed in the Special Provisions, the Contractor may bypass flow in accordance with 500-1.1.7(e) in order to facilitate the lining system installation." Unless otherwise allowed by the Engineer, for segmented liner pipe installations, installation of the manhole lining system shall not start until after the cleaning and surface preparation are completed and the liner pipe sliplined through the manhole and grouted in place, and when approved by the Engineer. For cured-in-place pipe liner or PVC pipe lining installations, installation of manhole lining system shall be scheduled after the sewer is lined.

The reinforcing fabric shall be saturated with the properly mixed resin system and lowered into the manhole and secured in place. The liner system shall be inflated with air pressure to fit the interior of the manhole and allowed to cure under suitable heat and controlled temperature. After curing and after an

adequate cool down period, the lining system shall be cut and trimmed with all services restored. The perimeter of the system shall be fully sealed with compatible resin and fiberglass to form a structurally sound and vapor tight joint with the liner pipe and the lined sewer. The completed product shall be a permanent, monolithic, lined and impervious structure shaped to the interior of the manhole. The lined manhole shall be completely water tight and free of any joints or openings other than pipe inlets, pipe outlets and the rim opening. All defective areas and imperfections including, but not limited to poor adhesion, excessive voids, air bubbles, and exposed glass shall be repaired in strict conformance with the recommendation of the manufacturer and subject to the approval of the Engineer.

**500-2.5.5 Drawings and Data.** The Contractor shall submit a complete manhole rehabilitation submittal to the Districts for review and approval. The submittal shall include, but shall not be limited to the following:

1. Name of the manufacturer and product data including the safety data sheets, certifications of materials, and the physical properties and chemical resistance testing of the resin system.
2. Name of the manufacturer and product data including the safety data sheets for the patching/plugging compound and the chemical sealant, if infiltration exists.
3. Plan of construction including schedule, equipment setup, inspection, preparation, cleaning, and complete installation procedures and details.
4. Qualifications of the installer including certification by the manufacturer.

**500-2.5.6 Payment.** Payment for furnishing all labor, equipment and materials and performing all work associated with the rehabilitation of manholes shall be made under the appropriate manhole rehabilitation bid item."

IN **500-3 ANNULAR SPACE GROUTING**, DELETE ALL PARAGRAPHS AND REPLACE WITH THE FOLLOWING:

**"500-3.1 General.** This section covers the requirements for grouting the annular space between the exterior of the liner pipe and interior of the existing sewer pipe or manhole shaft.

**500-3.2 Grout.** The grout shall be a cement and bentonite slurry mix. The grout shall have low viscosity and high fluidity capable of filling the annular space between the liner pipe and the host pipe under low injection pressure. The grout shall have a specific weight of not less than 64 pcf to displace any residual water trapped in the annular space. The grout shall be sulfate resistant and shall not deteriorate due to fluctuations in moisture content or temperature in the annular space. The minimum compressive strength of the grout shall not be less than 100 psi at 7 days and 300 psi at 28 days per ASTM C109 or C495.

**500-3.3 Grouting Requirements.** To prevent buildup of debris which could be trapped in the annular space, upon completion of the sliplining of a sewer reach, the Contractor shall immediately construct an approved bulkhead between the existing host pipe and the inserted liner pipe at the downstream end of the upstream-most manhole. The Contractor shall not construct the bulkhead at the downstream manhole until after all the existing connections upstream of the manhole have been connected to the inserted liner pipe. In addition, the Contractor shall construct a bulkhead between the host pipe and the liner pipe at each connection. The bulkhead shall secure each connection in place during grouting and shall be constructed complete with grout injection and vent pipes. All bulkheads constructed shall be tested and shall be leak tight and be built to withstand the maximum allowable grouting pressure. Prior to grouting, the Contractor shall flush the annular space and inject clear water into the annular space and pressurize to the maximum allowable grout pressure to test all the bulkheads.

and the integrity of the liner pipe installed. The test pressure shall be maintained for a minimum of 10 minutes and the liner pipe and the bulkheads shall show no signs of leakage. Non-toxic dye provided by the Contractor shall be used to locate submerged leaks. Any section of line that does not pass the initial pressure test for whatever reason shall be retested at low flow while conducting an internal CCTV inspection of the liner pipe joint. The retest and additional CCTV inspection work including any field verification work shall be performed at no additional cost to the Districts. Upon successful completion of the pressure test, the Contractor shall completely dewater the annular space and proceed with the grouting operation. Grouting operations for each reach of sewer shall be completed within 60 calendar days after sliplining the reach.

The Contractor shall determine the length of grouting run, the number and spacing of all the grout injection and vent locations required to completely fill the annular space based on grout supplier's recommendation. The grout pressure shall not exceed 12 psi nor the maximum allowable pressure recommended by the liner pipe manufacturer, whichever is lower. Bulkheads shall be provided at all grout injection and vent locations. Each bulkhead installed shall be complete with all the grout injection and vent pipes with adequate height. If the Engineer determines that the bulkheads installed could break or leak during grouting, the Engineer shall have the authority to direct the Contractor to reinforce or replace the bulkheads at no additional cost to the Districts. Grout pressure shall be continuously monitored and regulated. The liner pipe will float during grouting. The amount of flotation depends on the grout density and the grout pressure used, and the depth of flow in the sewer, which varies with time. Excessive flotation will cause the liner pipe to deflect and the joints to leak. To prevent leakage, the Contractor shall verify with the liner pipe manufacturer and limit the grout pressure to ensure that the maximum allowable joint deflection is not exceeded. The Contractor shall not restrict flow in the sewer and shall not cause any flow blockage in the sewer at any time. All waste grout shall be removed by pumping or vacuum truck method; no grout will be allowed to be dumped into the sewer at anytime. Grout density shall be within 2 percent of the design density at the injection and vent points to insure that the grout is properly batched. The Contractor shall provide a scale accurate to 0.01 pounds to verify grout densities.

**500-3.4 Submittal Data and Drawings.** The Contractor shall submit a complete grouting submittal, including number and location of the proposed grouting points. Confirmation tests shall be conducted to verify that the grout design contained in the submittal will meet the specified performance.

The grout submittal shall include, but shall not be limited to the following:

1. Design of the grout mix showing the proportioning of cement, water, and chemical admixtures; and grout properties including consistency per the flow cone test ASTM C939, workability and working time, bleeding test per ASTM C232, setting time per ASTM C403, compressive strength per ASTM C109 or C495, shrinkage per ASTM C1090, and working temperature.
2. Detailed description of the grouting procedures including mix equipment, grout pressure, number and spacing of grout injection and vent locations, dewatering procedure, and grout pressure regulating equipment.
3. Shop drawings showing details of the bulkheads, grout injection piping including pressure gauges and regulators, vent piping, and waste grout recovery system.

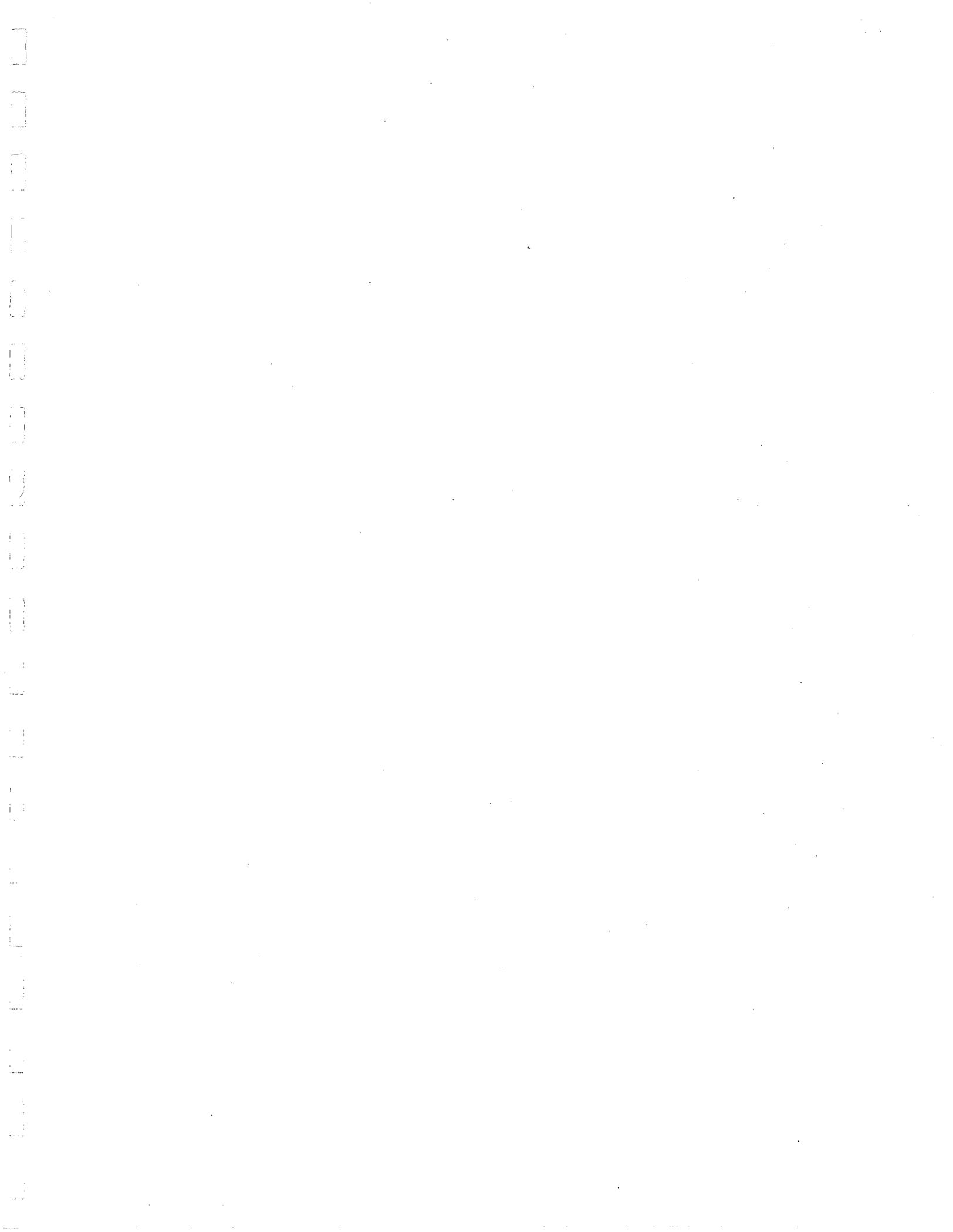
To ensure that the grout mix to be used will meet or exceed the specified requirements, after the Districts' acceptance of the grout submittal, the Contractor shall submit certified test result of the sample of the approved grout mix to the Districts for approval. The grout sample shall be tested for compressive strength at 28 days, shrinkage, density and consistency. The testing shall be performed by an independent accredited testing laboratory approved by the Districts. Test results from prior projects are not acceptable. If the grout sample fails to meet any of the specified requirements or the approved submittal,

a new grout mix design shall be submitted to the Districts for approval and a sample of the new grout mix shall be tested. The Contractor shall not start any grouting until the test is performed and the results are accepted by the Districts. The Contractor shall plan and allow sufficient time in the schedule for the testing. Any subsequent delay to the project and all costs associated with the testing shall be the responsibility of the Contractor.

**500-3.5 Confirmation Testing.** A minimum of one grout sample from each grout run shall be collected from the grout injected into the annular space each day. The grout sample shall be collected at the downstream end of the grout runs. Each grout sample shall be tested for compressive strength at 28 days, shrinkage, bleeding, density, and consistency. The Contractor shall provide the Engineer a flow cone as required by ASTM C939 to allow spot testing of the grout consistency. The Contractor shall furnish the Districts with the "mud balance" for each reach of sewer. All testing shall be performed by an independent testing laboratory approved by the Districts. Results of the testing shall be submitted to the Engineer for approval. Cost for testing shall be borne by the Contractor.

**500-3.6 Payment.** For bidding purposes, the Contractor shall utilize the anticipated volume of annular space in the sewer after sliplining provided in the Special Provisions. Measurement of payment shall be based on volume of grout actually placed in the annular space, in cubic yards, and in accordance with the accepted design mix of the grout. Quantities will be computed based on the accepted grout mix design and the volume of water and the dry weight of the materials actually used. The dry weight used shall be verified by weigh tickets signed by an independent certified weighmaster. The actual volume of grout placed in the annular space shall be the difference between the total volume of grout mixed and the volume of waste grout as determined by the Engineer. The Contractor shall furnish a container on site, at a location approved by the Engineer, to collect the waste grout generated from his operation. Volume of waste grout will be determined by the Engineer. Prior to commencing any grouting, the Contractor shall submit to the Districts for approval the method of collecting, handling, storage and disposal of waste grout.

In the event that the Contractor has to place grout in excess of the volume indicated, the Districts will reimburse the Contractor for furnishing all labor, equipment and materials for the placement of the additional grout on the criteria set forth above including overhead and profit, the unit price of \$180 per cubic yard. If a foaming agent is used, the volume of grout measured and used for determining the payment shall be the volume prior to mixing with the foam. If the measured volume of grout is less than the volume indicated, the Contractor shall credit the Districts at the unit price of \$180 per cubic yard."



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## STANDARD DRAWINGS FOR CONSTRUCTION

APPROVED

*Stephen R. Maguin*

STEPHEN R. MAGUIN  
CHIEF ENGINEER - C. E. No. 23089

### LIST OF DRAWINGS

S-a-79	STANDARD METHOD OF INSTALLING SADDLES
S-a-86	STANDARD METHOD FOR CONNECTION TO PIPES AND STRUCTURES
S-a-201	STANDARD MANHOLE, TYPE "A"
S-a-202	STANDARD MANHOLE, TYPE "B"
S-a-203	STANDARD MANHOLE, TYPE "C"
S-a-204	STANDARD MANHOLE, TYPE "D"
S-a-205	STANDARD DROP MANHOLE
S-a-206	STANDARD MANHOLE, TYPE "E"
S-a-207	STANDARD 24" LOCKING MANHOLE FRAME AND COVER
S-a-208	STANDARD 24" PRESSURE MANHOLE FRAME AND COVER
S-a-209	STANDARD MANHOLE STEP
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S-a-211	STANDARD TRAP CASTING
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S-a-216	STANDARD HOUSE CONNECTION GAS TRAP
S-a-217	STANDARD CONCRETE PIPE SUPPORT
S-a-218	STANDARD ABANDONMENT OF EXISTING MANHOLES TYPE "A" OR "D"
S-a-219	STANDARD RECONSTRUCTION OF BRICK MANHOLES
S-a-220	STANDARD PULL RING
S-a-221	STANDARD PROJECT SIGN
S-a-222	STANDARD TEMPORARY PIPE SUPPORT
S-a-223	STANDARD 30" MANHOLE FRAME AND COVER
S-a-224	STANDARD PIPE BARREL
S-a-225	STANDARD CONCRETE COLLAR
S-a-226	STANDARD 36" MANHOLE FRAME WITH 30" COVER
S-a-227	STANDARD CONCRETE BEAM FOR HOUSE CONNECTIONS
S-a-228	STANDARD 24" TRAFFIC MANHOLE FRAME AND COVER
S-a-229	STANDARD 36" PRESSURE MANHOLE FRAME AND COVER
S-a-230	STANDARD LIFTING EYE

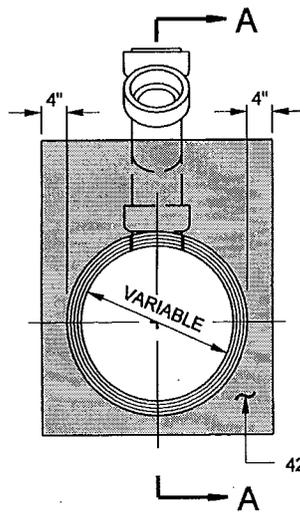


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CHIEF ENGINEER

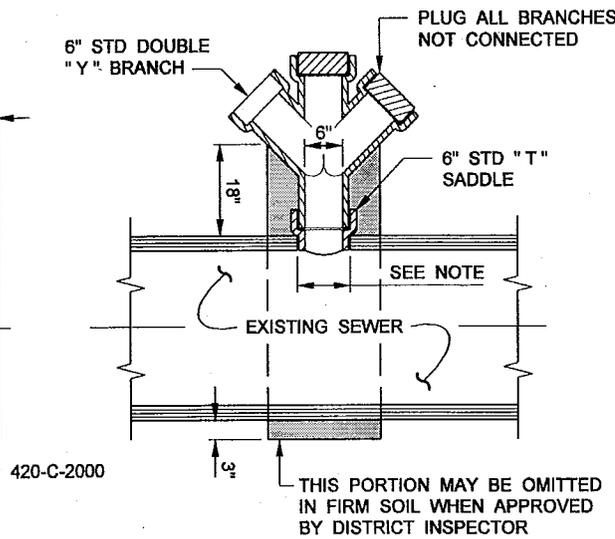
STANDARD METHOD OF  
INSTALLING SADDLES

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STANDARD DRAWING  
2006 EDITION  
S - a - 7 9  
SHEET 1 OF 1

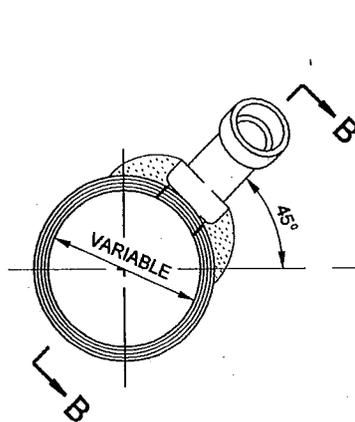


END VIEW

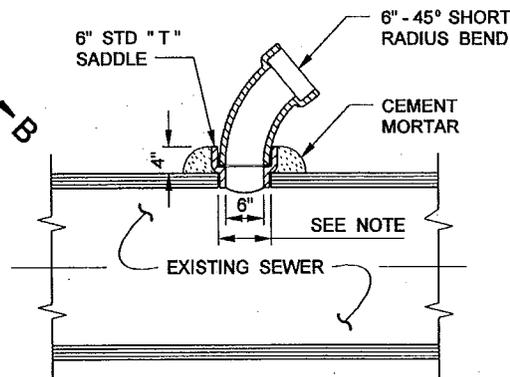


SECTION A-A

STANDARD "T" SADDLE  
(SHALLOW LINE)



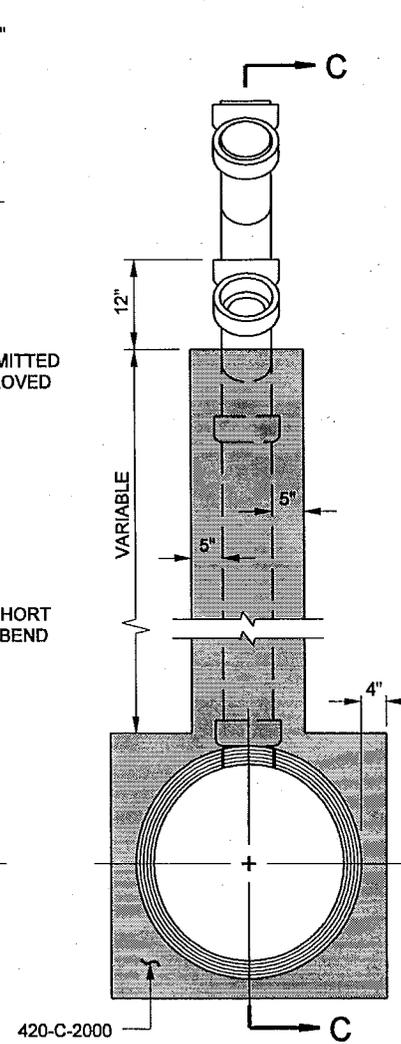
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SECTION B-B

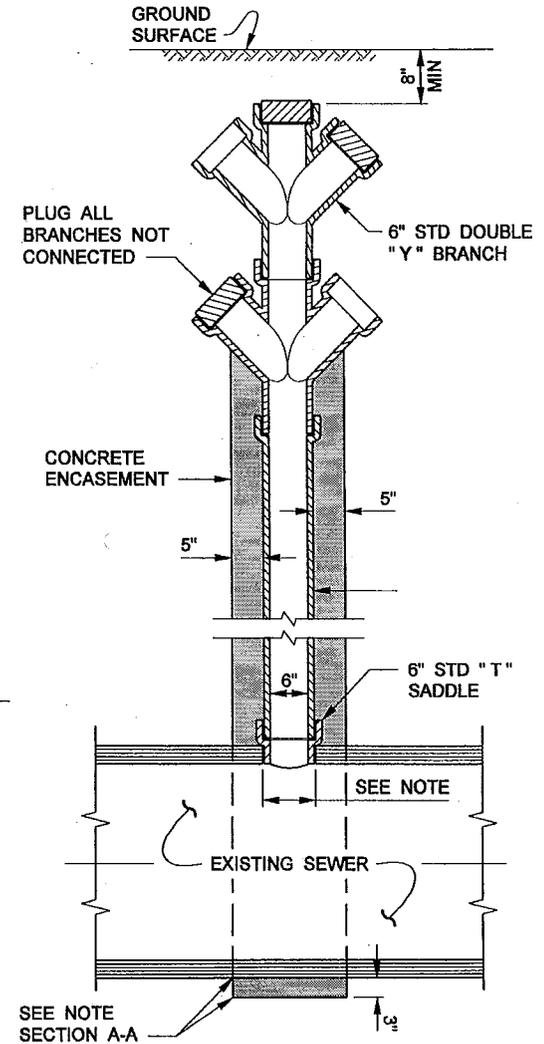
STANDARD "Y" SADDLE

NOTE:  
HOLES IN RC PIPES AND IN NRCP AND VCP PIPES  
LARGER THAN 18" SHALL BE MADE BY CORE DRILLING  
PER S-a-86. HOLES IN NRCP AND VCP 18" AND SMALLER  
MAY BE MADE BY CHIPPING THE PIPE.



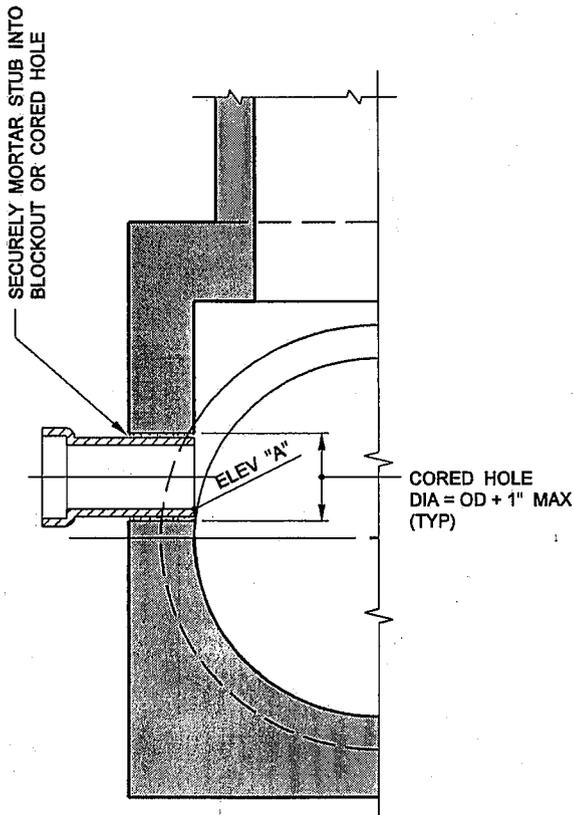
END VIEW

STANDARD "T" SADDLE  
(DEEP LINE)

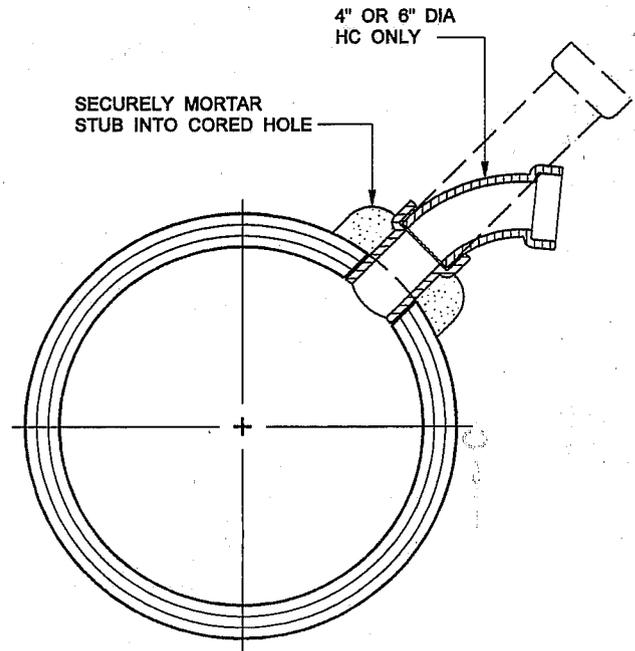


SECTION C-C

THIS DRAWING DOES NOT APPLY TO CONNECTIONS TO LINED PIPE



**CONNECTION TO REINFORCED  
CONCRETE STRUCTURE**



**CONNECTION TO RCP (ALL SIZES)  
& NRCP & VCP 21" OR LARGER**

**NOTES:**

1. ELEVATION "A" FOR LATERAL SEWER CONNECTIONS SHALL BE AS SHOWN ON APPROVED LATERAL SEWER DRAWINGS.
2. HOUSE CONNECTION TO THE PIPE SHALL BE AS SHOWN ON S-a-79 EXCEPT AS SHOWN HEREON.
3. THE CORED HOLE SHALL BE MADE WITH EQUIPMENT SPECIALLY DESIGNED TO CUT A SMOOTH HOLE WITHOUT SPALLING OR DAMAGE TO THE REINFORCING STEEL, PIPE OR STRUCTURE.
4. THE CORING OF THE HOLE AND THE PLACING OF THE STUB SHALL BE DONE IN THE PRESENCE OF THE DISTRICT INSPECTOR.
5. NO CONNECTION SHALL BE MADE TO THE STUB UNTIL DISTRICT INSPECTOR HAS APPROVED THE STUB.

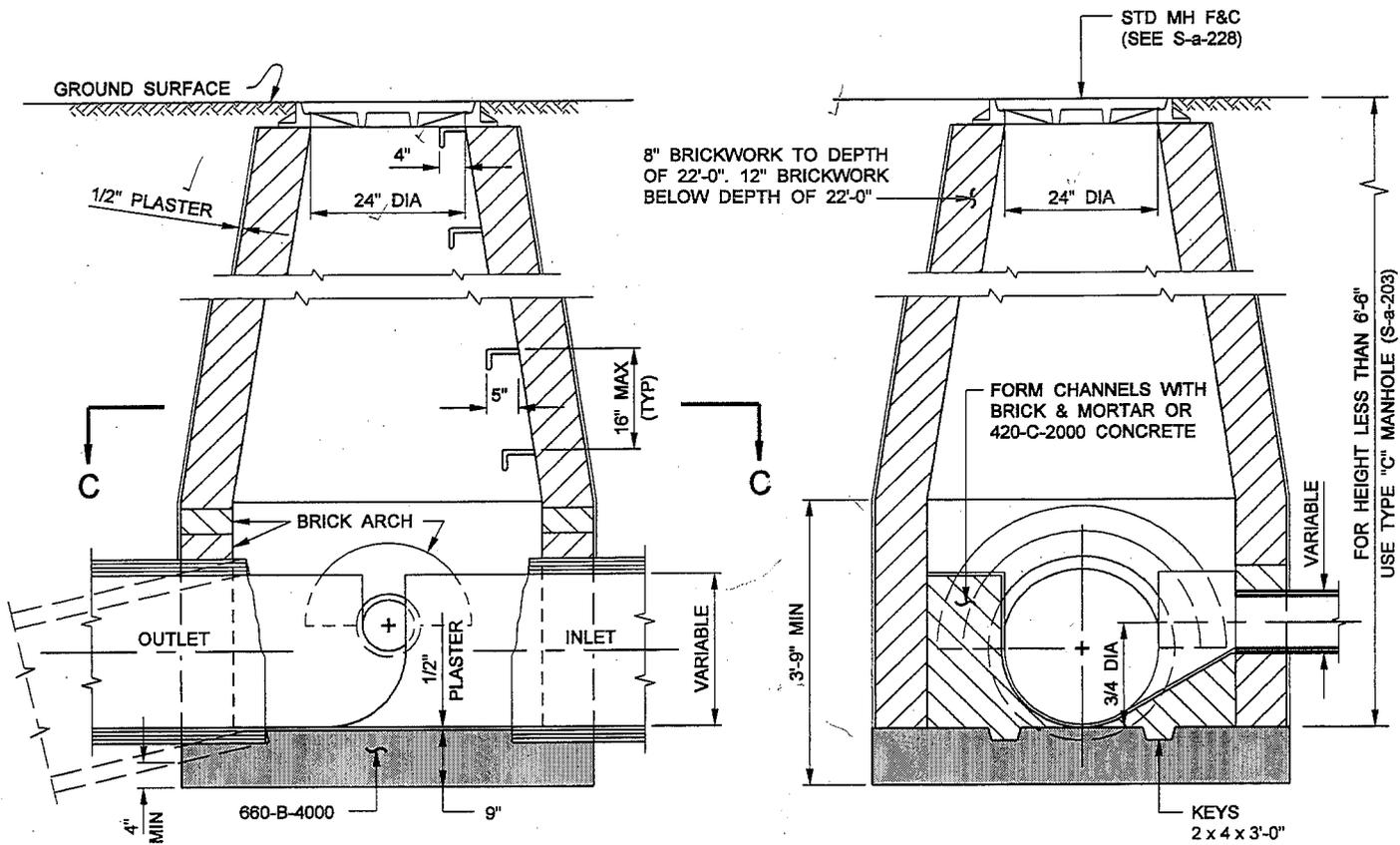
**THIS DRAWING DOES NOT APPLY TO CONNECTIONS TO  
LINED PIPES OR STRUCTURES**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

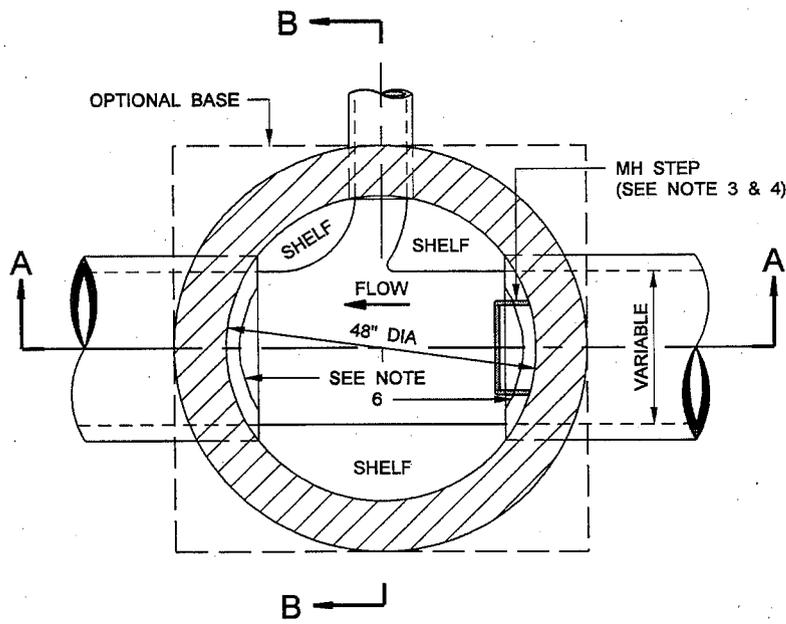
**STANDARD METHOD FOR CONNECTION  
TO PIPES AND STRUCTURES**

STANDARD DRAWING  
2006 EDITION  
**S-a-86**  
SHEET 1 OF 1



SECTION A-A

SECTION B-B



PLAN SECTION C-C

NOTES:

1. FOR 15" SEWERS AND LARGER, TURN 8" ARCH OVER PIPE.
2. FOR 12" SEWERS AND SMALLER, TURN 4" ARCH OVER PIPE.
3. THE LOWEST MANHOLE STEP SHALL BE PLACED NOT LESS THAN 8" NOR MORE THAN 24" ABOVE SHELF.
4. THE UPPER MANHOLE STEP SHALL BE PLACED BETWEEN THE TOP OF MANHOLE AND MANHOLE COVER FRAME AND SHALL PROJECT NOT MORE THAN 4" INSIDE MANHOLE. ALL OTHERS SHALL PROJECT 5".
5. FOR LAYING BRICK OR PLASTERING, THE MORTAR SHALL CONFORM WITH SECTION 201-5.1 (CLASS "D") OF THE STANDARD SPECIFICATIONS.
6. FOR 30" PIPE AND LARGER, THE TOP PORTION OF THE PIPES WITHIN THE MANHOLE SHALL BE CUT OUT TO PROVIDE A CIRCULAR OPENING BETWEEN THE PIPE ENDS OF NOT LESS THAN 42". THE CUT EDGES SHALL BE PLASTERED SMOOTH WITH CEMENT MORTAR FOR CONCRETE PIPE AND EPOXY FOR CLAY PIPE. THE CIRCULAR OPENING SHALL BE CUT PRIOR TO INSTALLATION OF THE RISER SECTIONS.

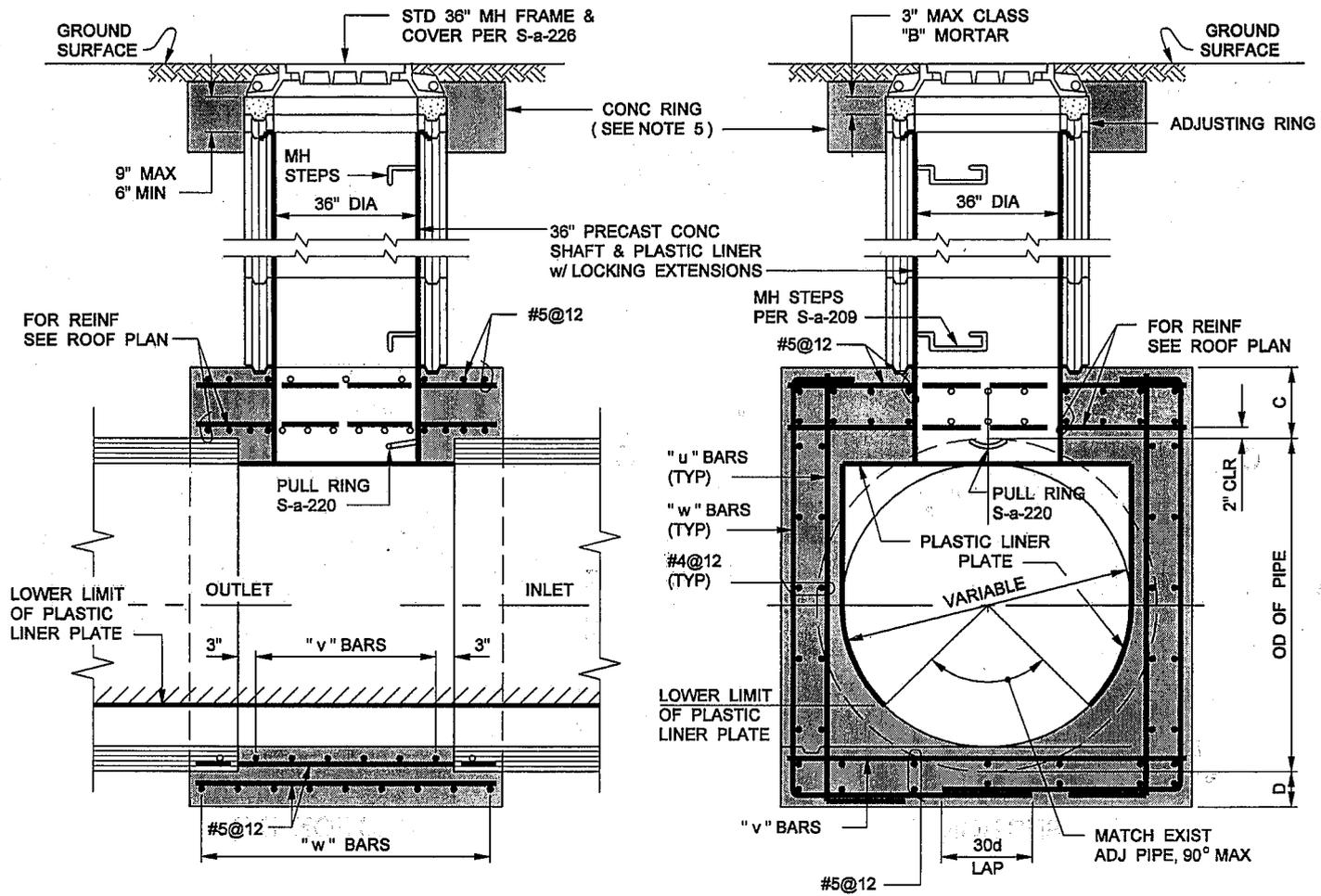
FOR 8" TO 30" PIPE

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
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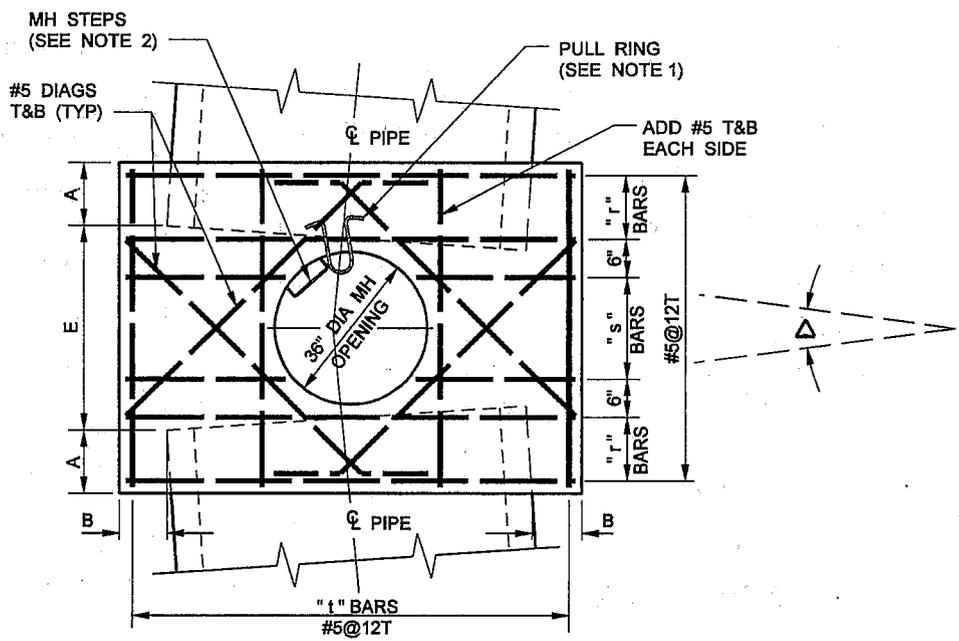
STANDARD MANHOLE, TYPE "A"

STANDARD DRAWING  
2006 EDITION  
S - a - 201  
SHEET 1 OF 1



**LONGITUDINAL SECTION**

**CROSS SECTION**



**ROOF PLAN 0° TO 15°**

**FOR 48" TO 96" PIPE**

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**STANDARD MANHOLE, TYPE "B"**

STANDARD DRAWING  
2006 EDITION  
**S - a - 2 0 2**  
SHEET 1 OF 3

TABLE OF DIMENSIONS AND REINFORCING BARS

PIPE DIA	DEPTH TO INV	DIMENSIONS						REINFORCING BARS					
		A	B	C	D	E	Δ (MAX)	"r"	"s"	"t"	"u"	"v"	"w"
48"	UP TO 30'	8"	6"	12"	6"	4'-0"	15°	3 - #6	#6@6	#5@12	#4@6	#4@6	#4@6
	31' TO 50'			15"		4'-0"	15°	3 - #7	#7@6	#6@12	#4@6	#5@6	#5@6
51" TO 60"	UP TO 30'	8"	6"	15"	6"	4'-0"	10°	3 - #7	#7@6	#5@12	#4@6	#5@6	#5@6
	31' TO 50'	8"	6"	18"	6"	4'-4"	15°	3 - #8	#8@6	#6@12	#5@6	#5@6	#6@6
63" TO 72"	UP TO 30'	10"	7"	15"	7"	4'-0"	10°	4 - #7	#7@6	#5@12	#4@6	#6@6	#5@6
	31' TO 50'	10"	7"	18"	7"	4'-8"	15°	4 - #8	#8@6	#6@12	#5@6	#7@6	#7@6
75" TO 84"	UP TO 30'	10"	7"	16"	7"	4'-0"	8°	4 - #7	#7@6	#5@12	#5@6	#6@6	#6@6
	31' TO 50'	10"	7"	18"	7"	4'-10"	15°	5 - #7	#7@6	#6@12	#6@6	#8@6	#7@6
90" TO 96"	UP TO 30'	12"	8"	18"	8"	4'-0"	7°	4 - #8	#8@6	#5@12	#5@6	#7@6	#7@6
	31' TO 50'	12"	8"	20"	8"	5'-2"	15°	5 - #8	#8@6	#6@12	#6@6	#8@6	#8@6

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
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STANDARD MANHOLE, TYPE "B"

STANDARD DRAWING  
2006 EDITION  
S - a - 202  
SHEET 2 OF 3

**NOTES:**

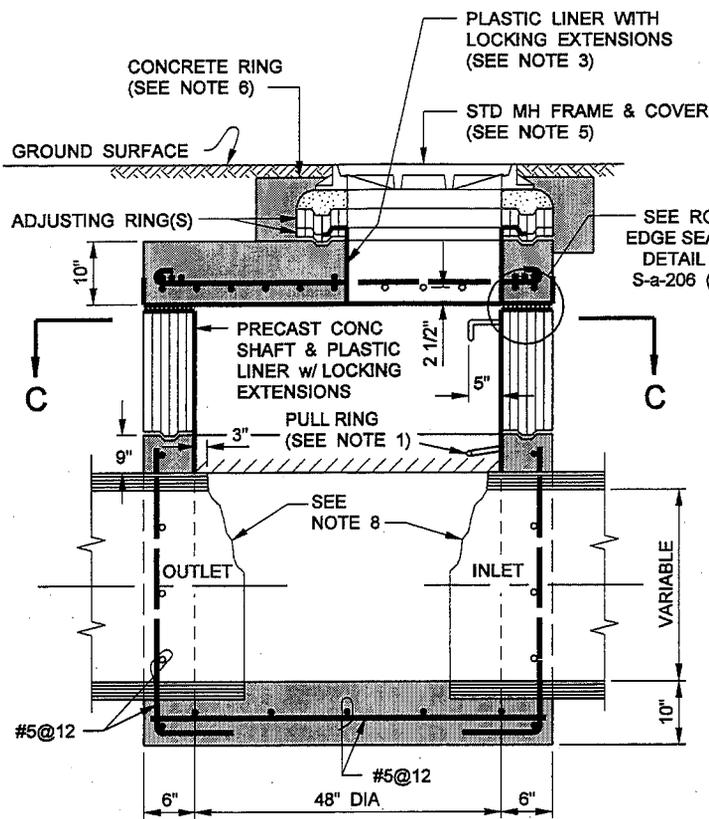
1. ALL MANHOLES SHALL BE PROVIDED WITH A STANDARD PULL RING IN ACCORDANCE WITH S-a-220. THE PULL RING SHALL BE LOCATED 6" ABOVE THE SOFFIT ON THE UPSTREAM SIDE OF THE MANHOLE AND ALONG THE AXIS OF THE DOWNSTREAM OUTLET. WHERE THE MANHOLE IS TO BE USED AS A DOWNSTREAM SIPHON MANHOLE, IT SHALL BE PROVIDED WITH AN ADDITIONAL STANDARD PULL RING, BUT LOCATED 6" ABOVE THE SOFFIT ON THE DOWNSTREAM SIDE OF THE MANHOLE AND ON THE CENTERLINE OF THE UPSTREAM SIPHON PIPE.
2. MANHOLE STEPS SHALL BE IN ACCORDANCE WITH S-a-209 AND SHALL BE UNIFORMLY SPACED NOT MORE THAN 16" APART. THE TOP STEP SHALL BE PLACED WITHIN 16" BELOW THE MANHOLE FRAME. THE BOTTOM MANHOLE STEP SHALL BE PLACED WITHIN 16" ABOVE THE TOP OF THE PIPE. THE MANHOLE STEP SHALL PROJECT 5". THE MANHOLE STEPS SHALL BE PLACED SUCH THAT THEY ARE ADJACENT TO BUT NOT INTERFERING WITH ACCESS TO THE PULL RING.
3. THE MANHOLE SHALL BE PROVIDED WITH PLASTIC LINER WITH LOCKING EXTENSIONS. THE PLASTIC LINER AND THE PLASTIC LINER INSTALLATION SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. THE LINER SHALL EXTEND FROM THE BOTTOM OF THE ADJUSTING RINGS TO A POINT IN THE CHANNEL MATCHING THE BOTTOM OF THE LINER IN THE LINED PIPE. LINER RETURNS SHALL BE PROVIDED WHERE THE LINER TERMINATES AT THE ADJUSTING RING. THE JOINT BETWEEN THE LINER AND THE STAINLESS STEEL STEPS AND PULL RINGS SHALL BE THOROUGHLY SEALED WITH MASTIC SEAM MATERIAL AS MANUFACTURED BY LINABOND INC., SYLMAR, CALIFORNIA (818) 362-7373, OR EQUAL. APPLICATION OF SEALANT AND PREPARATION OF SURFACES SHALL BE IN STRICT CONFORMANCE WITH THE MANUFACTURER'S DIRECTIONS.
4. UNLESS OTHERWISE SPECIFIED, ALL CONCRETE SHALL BE 660-B-4000 AND ALL REINFORCING BARS SHALL BE DEFORMED BARS CONFORMING TO ASTM-A706 GRADE 60.
5. A 12" WIDE BY 12" HIGH CONCRETE RING SHALL BE PROVIDED AROUND THE MANHOLE FRAME. IN UNPAVED AREAS, THE CONCRETE RING SHALL BE PROVIDED WITH #3 REBAR, 30 DIAMETER LAP.
6. EXCEPT AS NOTED HEREON, THE PRECAST UNITS SHALL BE MANUFACTURED AND TESTED IN ACCORDANCE WITH ASTM C478. THE CURING OF THE PRECAST UNITS SHALL CONFORM TO SECTION 207-2.7 OF THE STANDARD SPECIFICATIONS. AS AN ALTERNATE, THE UNITS MAY BE CURED USING SATURATED STEAM FOR A MINIMUM OF 12 HOURS FOLLOWED BY 6 DAYS OF WATER CURING OR MEMBRANE CURING. IF THE UNITS ARE CURED BY THE ALTERNATE METHOD, THEY SHALL NOT BE SHIPPED PRIOR TO 8 DAYS AFTER CASTING NOR UNTIL THE CONCRETE HAS ATTAINED A MINIMUM STRENGTH OF 4,000 PSI. THE RISER SECTIONS MAY BE REINFORCED OR UNREINFORCED. REINFORCED SECTIONS SHALL HAVE A MINIMUM WALL THICKNESS OF 5" AND UNREINFORCED SECTIONS SHALL HAVE A MINIMUM WALL THICKNESS OF 6". JOINTS SHALL BE TONGUE AND GROOVE AND SHALL BE ASSEMBLED USING CLASS "B" MORTAR. THE MORTARED JOINTS SHALL BE FLUSH AND TROWELED SMOOTH.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

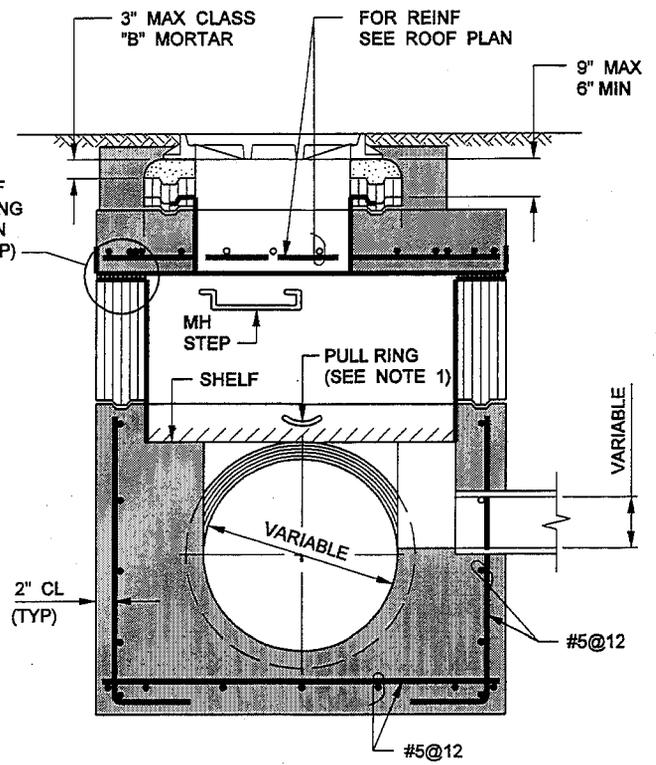
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "B"**

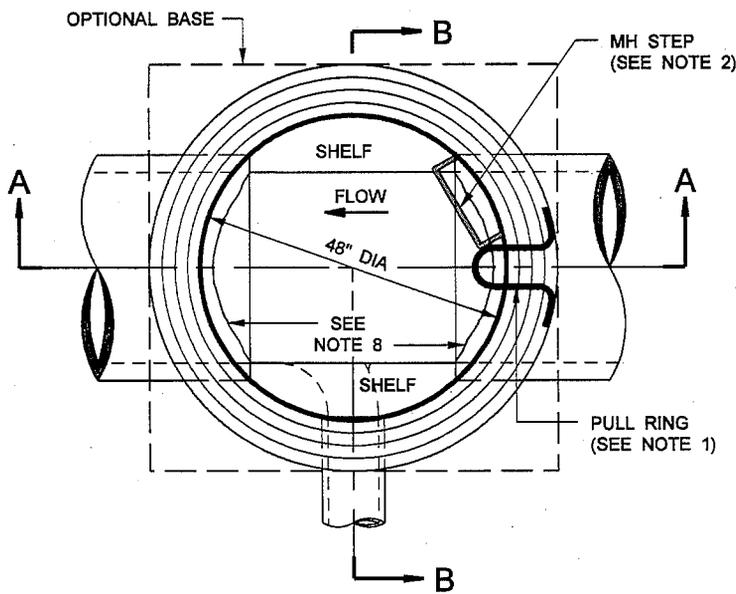
STANDARD DRAWING  
2006 EDITION  
**S-a-202**  
SHEET 3 OF 3



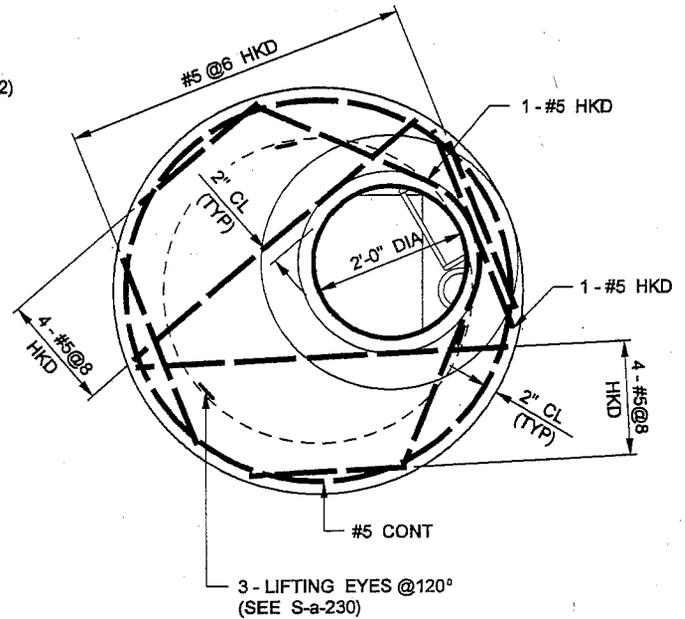
SECTION A-A



SECTION B-B



PLAN SECTION C-C



ROOF PLAN

FOR 8" TO 30" PIPE

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

STANDARD MANHOLE, TYPE "C"

STANDARD DRAWING  
2006 EDITION  
S-a-203  
SHEET 1 OF 3

NOTES:

1. ALL MANHOLES SHALL BE PROVIDED WITH A STANDARD PULL RING IN ACCORDANCE WITH S-a-220. THE PULL RING SHALL BE LOCATED 5" ABOVE THE TOP OF THE PIPE ON THE UPSTREAM SIDE OF THE MANHOLE AND ALONG THE AXIS OF THE DOWNSTREAM OUTLET. WHERE THE MANHOLE IS TO BE USED AS A DOWNSTREAM SIPHON MANHOLE, IT SHALL BE PROVIDED WITH AN ADDITIONAL STANDARD PULL RING, BUT LOCATED 5" ABOVE THE TOP OF THE PIPE ON THE DOWNSTREAM SIDE OF THE MANHOLE AND ON THE CENTERLINE OF THE UPSTREAM SIPHON PIPE.
2. MANHOLE STEPS SHALL BE IN ACCORDANCE WITH S-a-209 AND SHALL BE UNIFORMLY SPACED NOT MORE THAN 16" APART. THE TOP STEP SHALL BE PLACED WITHIN 16" BELOW THE MANHOLE FRAME. THE BOTTOM MANHOLE STEP SHALL BE PLACED WITHIN 16" ABOVE THE SHELF. THE MANHOLE STEP SHALL PROJECT 5". THE MANHOLE STEPS SHALL BE PLACED SUCH THAT THEY ARE ADJACENT TO BUT NOT INTERFERING WITH ACCESS TO THE PULL RING.
3. THE MANHOLE SHALL BE PROVIDED WITH PLASTIC LINER WITH LOCKING EXTENSIONS. PLASTIC LINER WITH LOCKING EXTENSIONS SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. THE LINER SHALL EXTEND FROM THE BOTTOM OF THE ADJUSTING RINGS TO THE TOP OF THE SHELF. LINER RETURNS SHALL BE PROVIDED WHERE THE LINER TERMINATES AT THE ADJUSTING RING AND THE SHELF. THE JOINT BETWEEN THE LINER AND THE STAINLESS STEEL STEPS AND PULL RING SHALL BE THOROUGHLY SEALED WITH MASTIC SEAM MATERIAL AS MANUFACTURED BY LINABOND INC., SYLMAR, CALIFORNIA (818) 362-7373, OR EQUAL. APPLICATION OF SEALANT AND PREPARATION OF SURFACES SHALL BE IN STRICT CONFORMANCE WITH THE MANUFACTURER'S DIRECTIONS.
4. UNLESS OTHERWISE SPECIFIED, ALL CONCRETE SHALL BE 660-B-4000 ALL REINFORCING BARS SHALL BE DEFORMED BARS CONFORMING TO ASTM-A706 GRADE 60.
5. IN PAVED AREAS SUBJECT TO TRAFFIC, A 24" TRAFFIC MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-228 SHALL BE PROVIDED. IN ALL OTHER AREAS, A 24" LOCKING MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-207 SHALL BE PROVIDED.
6. A 12" WIDE BY 12" HIGH CONCRETE RING SHALL BE PROVIDED AROUND THE MANHOLE FRAME. IN UNPAVED AREAS, THE CONCRETE RING SHALL BE PROVIDED WITH #3 REBAR, 30 DIAMETER LAP.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
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**STANDARD MANHOLE, TYPE "C"**

STANDARD DRAWING  
2006 EDITION

**S-a-203**

SHEET 2 OF 3

NOTES:

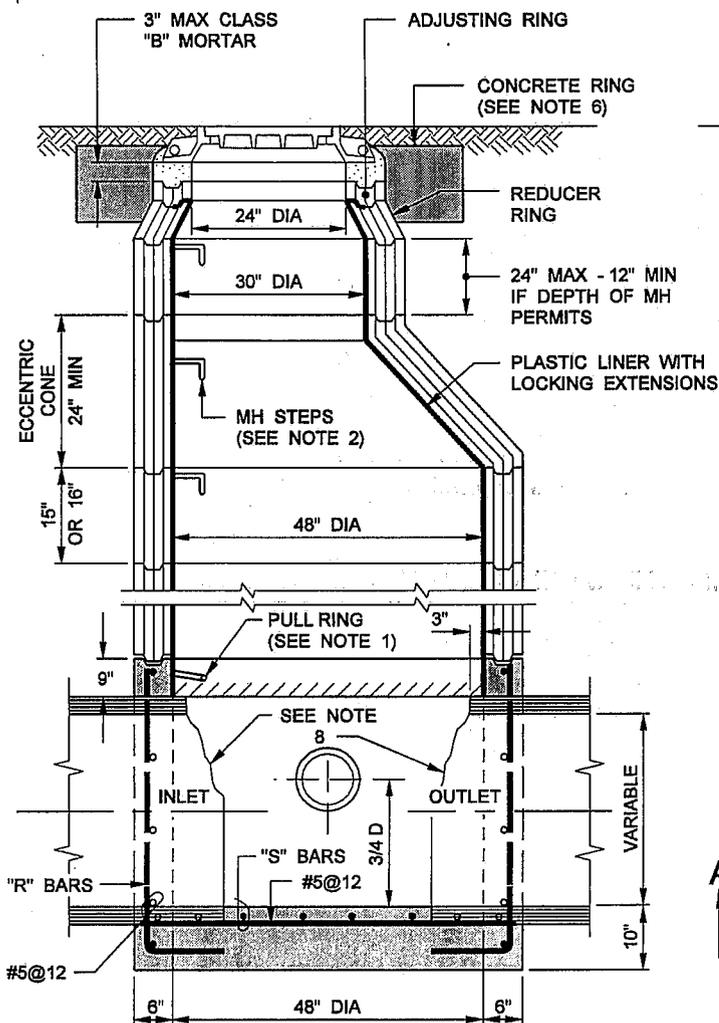
7. EXCEPT AS NOTED HEREON, THE PRECAST UNITS SHALL BE MANUFACTURED AND TESTED IN ACCORDANCE WITH ASTM C478. THE CURING OF THE PRECAST UNITS SHALL CONFORM TO SECTION 207-2.7 OF THE STANDARD SPECIFICATIONS. AS AN ALTERNATE, THE UNITS MAY BE CURED USING SATURATED STEAM FOR A MINIMUM OF 12 HOURS FOLLOWED BY 6 DAYS OF WATER CURING OR MEMBRANE CURING. IF THE UNITS ARE CURED BY THE ALTERNATE METHOD, THEY SHALL NOT BE SHIPPED PRIOR TO 8 DAYS AFTER CASTING NOR UNTIL THE CONCRETE HAS ATTAINED A MINIMUM STRENGTH OF 4,000 PSI. THE RISER SECTIONS MAY BE REINFORCED OR UNREINFORCED. REINFORCED SECTIONS, INCLUDING ECCENTRIC CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 5" AND UNREINFORCED SECTIONS, INCLUDING CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 6". JOINTS SHALL BE TONGUE AND GROOVE AND SHALL BE ASSEMBLED USING CLASS "B" MORTAR. THE MORTARED JOINTS SHALL BE FLUSH AND TROWELED SMOOTH.
  
8. THE TOP PORTION OF THE PIPES WITHIN THE MANHOLE SHALL BE CUT OUT AS NECESSARY TO PROVIDE A CIRCULAR OPENING BETWEEN THE PIPE ENDS OF AT LEAST 42". THE CUT ENDS SHALL BE PLASTERED SMOOTH WITH CEMENT MORTAR FOR CONCRETE PIPE AND EPOXY FOR CLAY PIPE. THE CIRCULAR OPENING SHALL BE CUT PRIOR TO INSTALLATION OF THE RISER SECTIONS.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

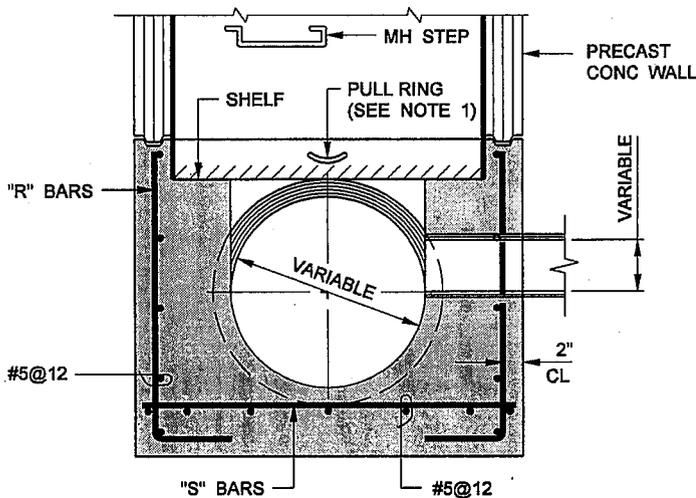
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "C"**

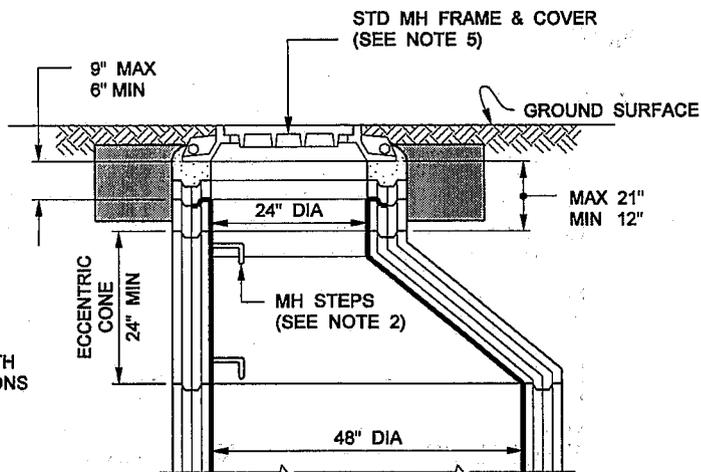
STANDARD DRAWING  
2006 EDITION  
**S-a-203**  
SHEET 3 OF 3



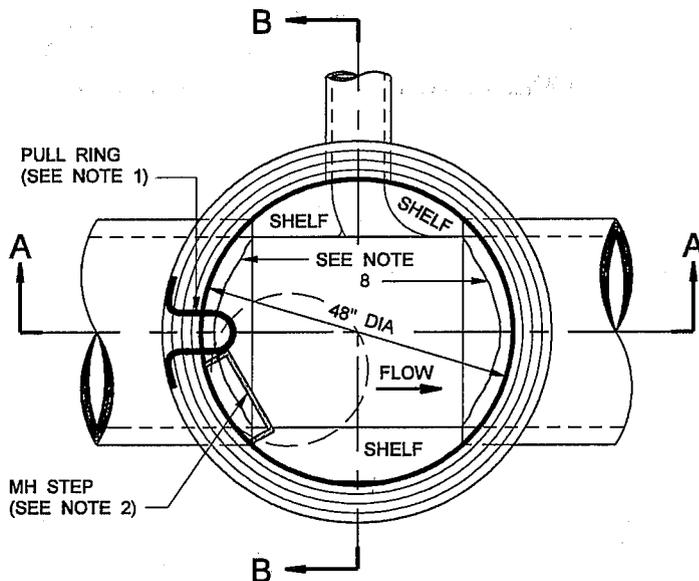
**SECTION A-A**



**SECTION B-B**



ALTERNATE SECTION MAY BE USED IF SPECIFIED IN BID DOCUMENTS



**PLAN**

TABLE OF REINFORCING BARS			
PIPE DIA	DEPTH TO INV	BARS "R"	BARS "S"
8" TO 21"	UP TO 15'	#5@12	#5@12
	16' TO 30'	#6@12	#6@12
24" TO 30"	UP TO 15'	#5@12	#5@12
	16' TO 30'	#7@12	#6@12

**FOR 8" TO 30" PIPE**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "D"**

STANDARD DRAWING  
2006 EDITION  
**S - a - 204**  
SHEET 1 OF 3

NOTES:

1. ALL MANHOLES SHALL BE PROVIDED WITH A STANDARD PULL RING IN ACCORDANCE WITH S-a-220. THE PULL RING SHALL BE LOCATED 5" ABOVE THE TOP OF PIPE ON THE UPSTREAM SIDE OF THE MANHOLE AND ALONG THE AXIS OF THE DOWNSTREAM OUTLET. WHERE THE MANHOLE IS TO BE USED AS A DOWNSTREAM SIPHON MANHOLE, IT SHALL BE PROVIDED WITH AN ADDITIONAL STANDARD PULL RING, BUT LOCATED 5" ABOVE THE TOP OF PIPE ON THE DOWNSTREAM SIDE OF THE MANHOLE AND ON THE CENTERLINE OF THE UPSTREAM SIPHON PIPE.
2. MANHOLE STEPS SHALL BE IN ACCORDANCE WITH S-a-209 AND SHALL BE UNIFORMLY SPACED NOT MORE THAN 16" APART. THE TOP STEP SHALL BE PLACED WITHIN 16" BELOW THE MANHOLE FRAME. THE BOTTOM MANHOLE STEP SHALL BE PLACED WITHIN 16" ABOVE THE SHELF. IN MANHOLE SHAFTS 36" IN DIAMETER AND LARGER, THE MANHOLE STEP SHALL PROJECT 5". IN MANHOLE SHAFTS SMALLER THAN 36" IN DIAMETER, THE MANHOLE STEP SHALL PROJECT 4". THE MANHOLE STEPS SHALL BE PLACED SUCH THAT THEY ARE ADJACENT TO BUT NOT INTERFERING WITH ACCESS TO THE PULL RING.
3. THE MANHOLE SHALL BE PROVIDED WITH PLASTIC LINER WITH LOCKING EXTENSIONS. PLASTIC LINER WITH LOCKING EXTENSIONS SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. THE LINER SHALL EXTEND FROM THE BOTTOM OF THE ADJUSTING RINGS TO THE TOP OF THE SHELF. LINER RETURNS SHALL BE PROVIDED WHERE THE LINER TERMINATES AT THE ADJUSTING RING AND THE SHELF. THE JOINT BETWEEN THE LINER AND THE STAINLESS STEEL STEPS AND PULL RING SHALL BE THOROUGHLY SEALED WITH MASTIC SEAM MATERIAL AS MANUFACTURED BY LINABOND INC., SYLMAR, CALIFORNIA (818) 362-7373, OR EQUAL. APPLICATION OF SEALANT AND PREPARATION OF SURFACES SHALL BE IN STRICT CONFORMANCE WITH THE MANUFACTURER'S DIRECTIONS.
4. UNLESS OTHERWISE SPECIFIED, ALL CONCRETE SHALL BE 660-B-4000 ALL REINFORCING BARS SHALL BE DEFORMED BARS CONFORMING TO ASTM-A706 GRADE 60.
5. IN PAVED AREAS SUBJECT TO TRAFFIC, A 24" TRAFFIC MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-228 SHALL BE PROVIDED. IN ALL OTHER AREAS, A 24" LOCKING MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-207 SHALL BE PROVIDED. IF A 30" MANHOLE FRAME AND COVER IS REQUIRED, A FRAME AND COVER IN ACCORDANCE WITH S-a-223 SHALL BE PROVIDED AND INSTALLED WHERE THE REDUCER RING IS SHOWN AND THE REDUCER RING, 24" ADJUSTING RINGS, AND 24" FRAME AND COVER SHALL BE OMITTED.
6. A 12" WIDE BY 12" HIGH CONCRETE RING SHALL BE PROVIDED AROUND THE MANHOLE FRAME. IN UNPAVED AREAS, THE CONCRETE RING SHALL BE PROVIDED WITH #3 REBAR, 30 DIAMETER LAP.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "D"**

STANDARD DRAWING  
2006 EDITION  
**S-a-204**  
SHEET 2 OF 3

NOTES:

7. EXCEPT AS NOTED HEREON, THE PRECAST UNITS SHALL BE MANUFACTURED AND TESTED IN ACCORDANCE WITH ASTM C478. THE CURING OF THE PRECAST UNITS SHALL CONFORM TO SECTION 207-2.7 OF THE STANDARD SPECIFICATIONS. AS AN ALTERNATE, THE UNITS MAY BE CURED USING SATURATED STEAM FOR A MINIMUM OF 12 HOURS FOLLOWED BY 6 DAYS OF WATER CURING OR MEMBRANE CURING. IF THE UNITS ARE CURED BY THE ALTERNATE METHOD, THEY SHALL NOT BE SHIPPED PRIOR TO 8 DAYS AFTER CASTING NOR UNTIL THE CONCRETE HAS ATTAINED A MINIMUM STRENGTH OF 4,000 PSI. THE RISER SECTIONS MAY BE REINFORCED OR UNREINFORCED. REINFORCED SECTIONS, INCLUDING ECCENTRIC CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 5" AND UNREINFORCED SECTIONS, INCLUDING CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 6". JOINTS SHALL BE TONGUE AND GROOVE AND SHALL BE ASSEMBLED USING CLASS "B" MORTAR. THE MORTARED JOINTS SHALL BE FLUSH AND TROWELED SMOOTH.
  
8. THE TOP PORTION OF THE PIPES WITHIN THE MANHOLE SHALL BE CUT OUT AS NECESSARY TO PROVIDE A CIRCULAR OPENING BETWEEN THE PIPE ENDS OF AT LEAST 42". THE CUT ENDS SHALL BE PLASTERED SMOOTH WITH CEMENT MORTAR FOR CONCRETE PIPE AND EPOXY FOR CLAY PIPE. THE CIRCULAR OPENING SHALL BE CUT PRIOR TO INSTALLATION OF THE RISER SECTIONS.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

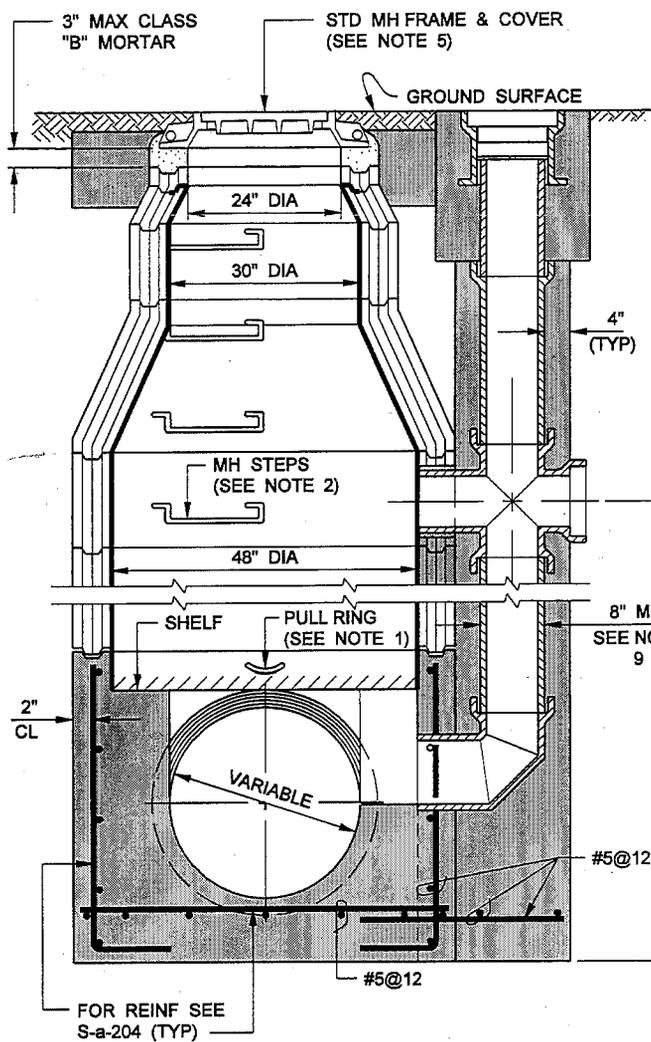
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "D"**

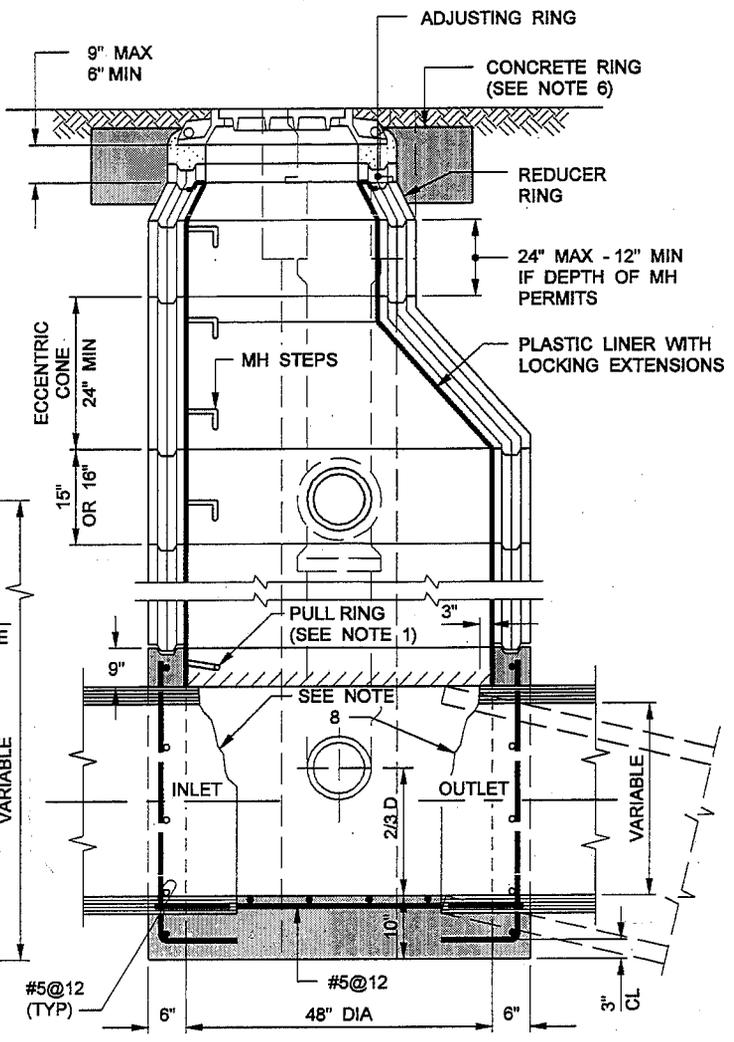
STANDARD DRAWING  
2006 EDITION

**S-a-204**

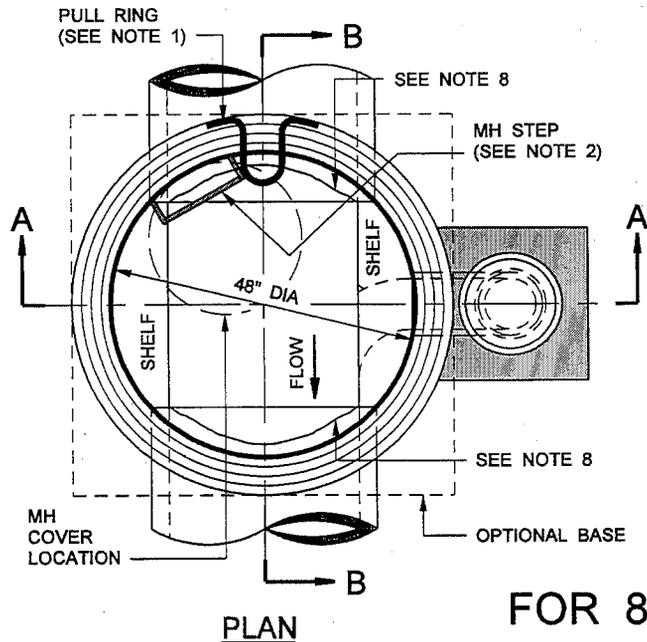
SHEET 3 OF 3



**SECTION A-A**



**SECTION B-B**



**PLAN**

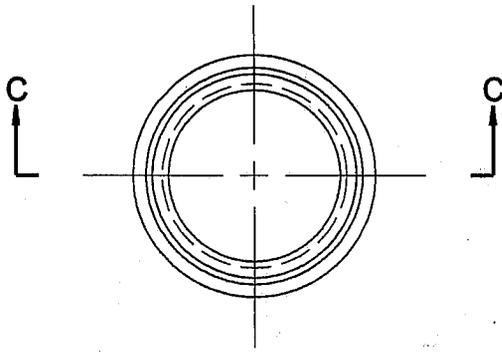
**FOR 8" TO 30" PIPE**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

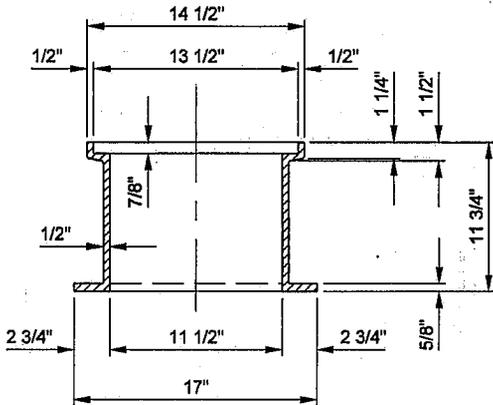
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD DROP MANHOLE**

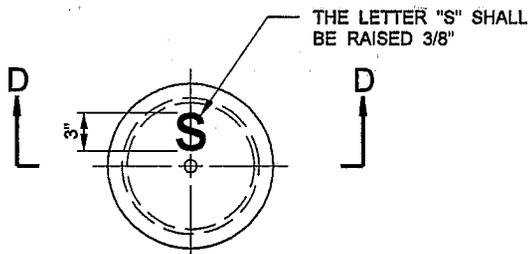
STANDARD DRAWING  
2006 EDITION  
**S - a - 205**  
SHEET 1 OF 4



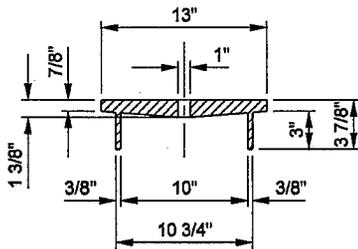
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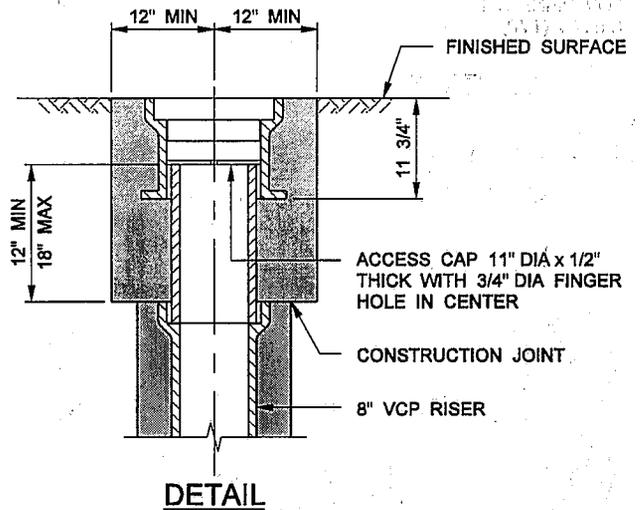
**SECTION C-C**



**ACCESS COVER**



**SECTION D-D**



**DETAIL**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD DROP MANHOLE**

STANDARD DRAWING  
2006 EDITION  
**S - a - 205**  
SHEET 2 OF 4

NOTES:

1. ALL MANHOLES SHALL BE PROVIDED WITH A STANDARD PULL RING IN ACCORDANCE WITH S-a-220. THE PULL RING SHALL BE LOCATED 5" ABOVE THE TOP OF PIPE ON THE UPSTREAM SIDE OF THE MANHOLE AND ALONG THE AXIS OF THE DOWNSTREAM OUTLET. WHERE THE MANHOLE IS TO BE USED AS A DOWNSTREAM SIPHON MANHOLE, IT SHALL BE PROVIDED WITH AN ADDITIONAL STANDARD PULL RING, BUT LOCATED 5" ABOVE THE TOP OF PIPE ON THE DOWNSTREAM SIDE OF THE MANHOLE AND ON THE CENTERLINE OF THE UPSTREAM SIPHON PIPE.
2. MANHOLE STEPS SHALL BE IN ACCORDANCE WITH S-a-209 AND SHALL BE UNIFORMLY SPACED NOT MORE THAN 16" APART. THE TOP STEP SHALL BE PLACED WITHIN 16" BELOW THE MANHOLE FRAME. THE BOTTOM MANHOLE STEP SHALL BE PLACED WITHIN 16" ABOVE THE SHELF. IN MANHOLE SHAFTS 36" IN DIAMETER AND LARGER, THE MANHOLE STEP SHALL PROJECT 5". IN MANHOLE SHAFTS SMALLER THAN 36" IN DIAMETER, THE MANHOLE STEP SHALL PROJECT 4". THE MANHOLE STEPS SHALL BE PLACED SUCH THAT THEY ARE ADJACENT TO BUT NOT INTERFERING WITH ACCESS TO THE PULL RING.
3. THE MANHOLE SHALL BE PROVIDED WITH PLASTIC LINER WITH LOCKING EXTENSIONS. PLASTIC LINER WITH LOCKING EXTENSIONS SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. THE LINER SHALL EXTEND FROM THE BOTTOM OF THE ADJUSTING RINGS TO THE TOP OF THE SHELF. LINER RETURNS SHALL BE PROVIDED WHERE THE LINER TERMINATES AT THE ADJUSTING RING AND THE SHELF. THE JOINT BETWEEN THE LINER AND THE STAINLESS STEEL STEPS AND PULL RINGS SHALL BE THOROUGHLY SEALED WITH MASTIC SEAM MATERIAL AS MANUFACTURED BY LINABOND INC., SYLMAR, CALIFORNIA (818) 362-7373, OR EQUAL. APPLICATION OF SEALANT AND PREPARATION OF SURFACES SHALL BE IN STRICT CONFORMANCE WITH THE MANUFACTURER'S DIRECTIONS.
4. UNLESS OTHERWISE SPECIFIED, ALL CONCRETE SHALL BE 660-B-4000 AND ALL REINFORCING BARS SHALL BE DEFORMED BARS CONFORMING TO ASTM-A706 GRADE 60.
5. IN PAVED AREAS SUBJECT TO TRAFFIC, A 24" TRAFFIC MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-228 SHALL BE PROVIDED. IN ALL OTHER AREAS, A 24" LOCKING MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-207 SHALL BE PROVIDED. IF A 30" MANHOLE FRAME AND COVER IS REQUIRED, A FRAME AND COVER IN ACCORDANCE WITH S-a-223 SHALL BE PROVIDED AND INSTALLED WHERE THE REDUCER RING IS SHOWN AND THE REDUCER RING, 24" ADJUSTING RINGS, AND 24" FRAME AND COVER SHALL BE OMITTED.
6. A 12" WIDE BY 12" HIGH CONCRETE RING SHALL BE PROVIDED AROUND THE MANHOLE FRAME. IN UNPAVED AREAS, THE CONCRETE RING SHALL BE PROVIDED WITH #3 REBAR, 30 DIAMETER LAP.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

## STANDARD DROP MANHOLE

STANDARD DRAWING  
2006 EDITION

S-a-205

SHEET 3 OF 4

**NOTES:**

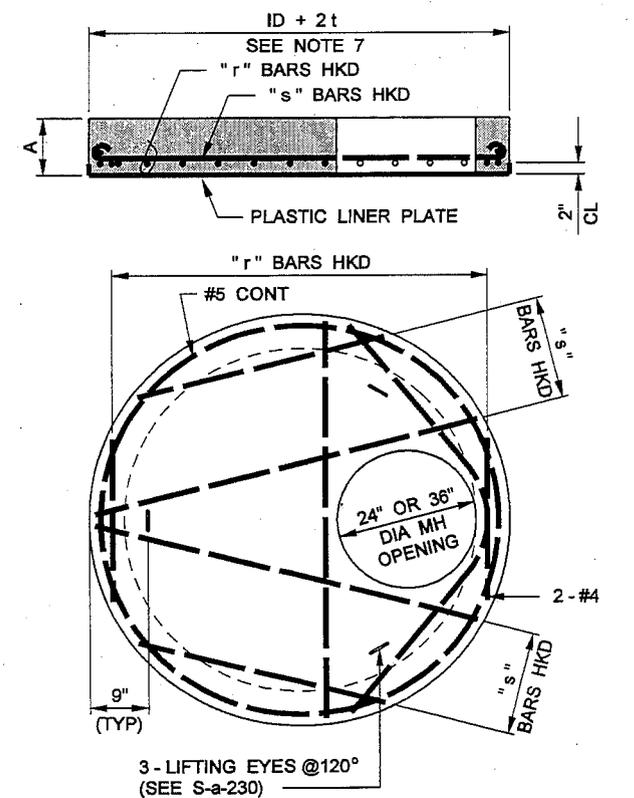
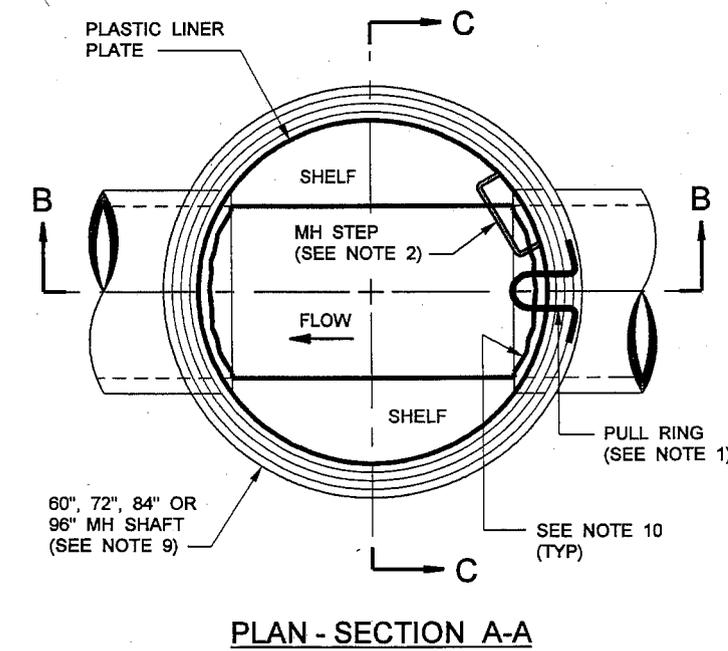
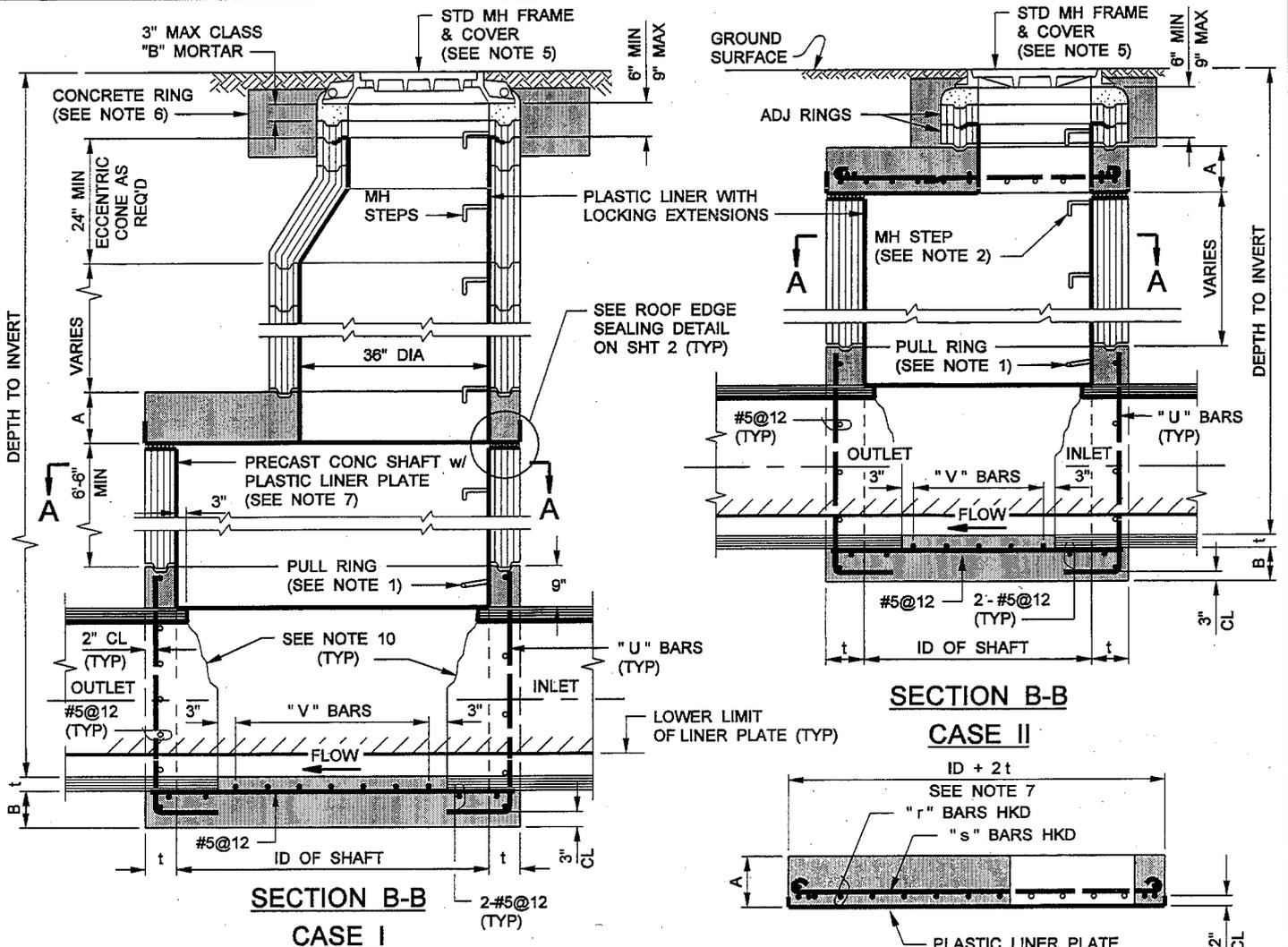
7. EXCEPT AS NOTED HEREON, THE PRECAST UNITS SHALL BE MANUFACTURED AND TESTED IN ACCORDANCE WITH ASTM C478. THE CURING OF THE PRECAST UNITS SHALL CONFORM TO SECTION 207-2.7 OF THE STANDARD SPECIFICATIONS. AS AN ALTERNATE, THE UNITS MAY BE CURED USING SATURATED STEAM FOR A MINIMUM OF 12 HOURS FOLLOWED BY 6 DAYS OF WATER CURING OR MEMBRANE CURING. IF THE UNITS ARE CURED BY THE ALTERNATE METHOD, THEY SHALL NOT BE SHIPPED PRIOR TO 8 DAYS AFTER CASTING NOR UNTIL THE CONCRETE HAS ATTAINED A MINIMUM STRENGTH OF 4,000 PSI. THE RISER SECTIONS MAY BE REINFORCED OR UNREINFORCED. REINFORCED SECTIONS, INCLUDING ECCENTRIC CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 5" AND UNREINFORCED SECTIONS, INCLUDING CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 6". JOINTS SHALL BE TONGUE AND GROOVE AND SHALL BE ASSEMBLED USING CLASS "B" MORTAR. THE MORTARED JOINTS SHALL BE FLUSH AND TROWELED SMOOTH.
  
8. THE TOP PORTION OF THE PIPES WITHIN THE MANHOLE SHALL BE CUT OUT AS NECESSARY TO PROVIDE A CIRCULAR OPENING BETWEEN THE PIPE ENDS OF AT LEAST 42". THE CUT ENDS SHALL BE PLASTERED SMOOTH WITH CEMENT MORTAR FOR CONCRETE PIPE AND EPOXY FOR CLAY PIPE. THE CIRCULAR OPENING SHALL BE CUT PRIOR TO INSTALLATION OF THE RISER SECTIONS.
  
9. THE DROP CONNECTION INTO THE MANHOLE SHALL BE VCP AND SHALL BE THE SAME SIZE AS THE LATERAL SEWER OR A MINIMUM OF 8" IN DIAMETER, WHICHEVER IS LARGER. THE RISER SHALL BE 8" VCP.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD DROP MANHOLE**

STANDARD DRAWING  
2006 EDITION  
**S-a-205**  
SHEET 4 OF 4

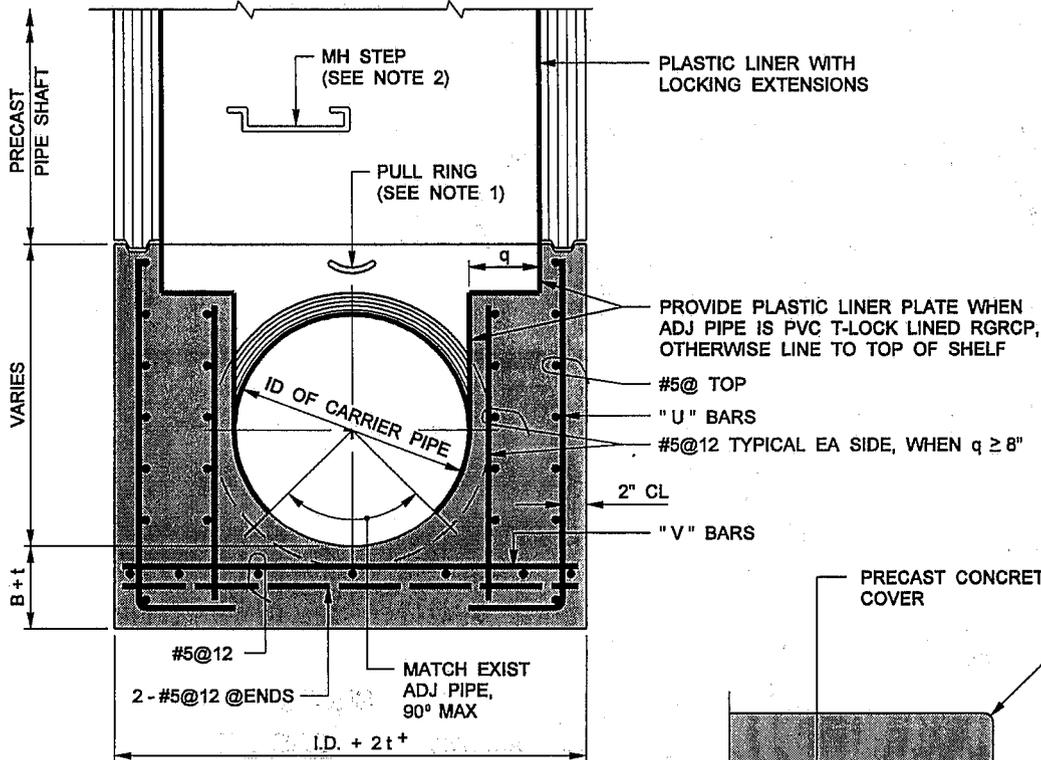


COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
 OFFICE OF CHIEF ENGINEER

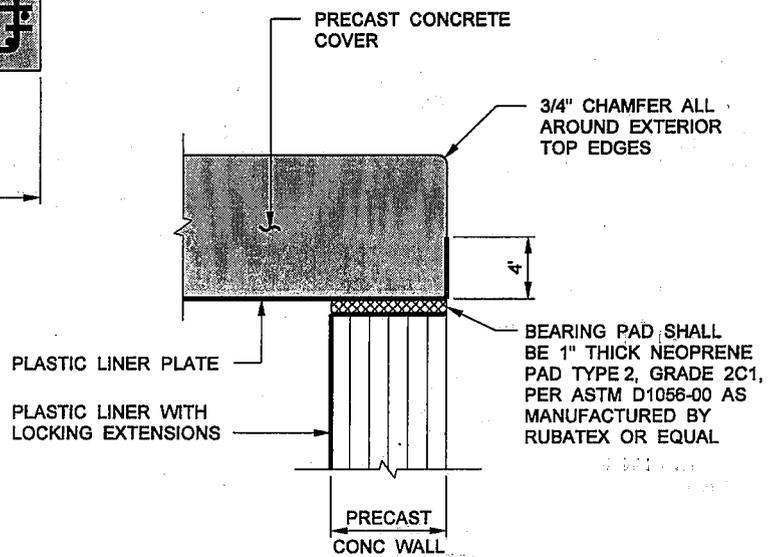
STEPHEN R. MAGUIN  
 CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "E"**

STANDARD DRAWING  
 2006 EDITION  
**S - a - 206**  
 SHEET 1 OF 4



**SECTION C-C**



**ROOF EDGE SEALING DETAIL**

TABLE OF REINFORCING BARS							
SHAFT DIA	DEPTH TO INV	DIMENSIONS		REINFORCING BARS			
		A	B	"r"	"s"	"u"	"v"
60"	UP TO 15'	10"	8"	#6@6	#6@6	#5@12	#5@12
	16' TO 30'	12"	10"	#7@6	#7@6	#6@10	#6@12
72"	UP TO 15'	10"	8"	#6@6	#6@6	#5@12	#5@12
	16' TO 30'	12"	10"	#8@6	#8@6	#7@12	#7@12
84"	UP TO 15'	10"	10"	#7@6	#7@6	#5@12	#5@12
	16' TO 30'	14"	10"	#8@6	#8@6	#7@12	#8@12
96"	UP TO 15'	12"	10"	#7@6	#7@6	#6@12	#6@12
	16' TO 30'	15"	12"	#8@6	#8@6	#7@6	#8@12

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "E"**

STANDARD DRAWING  
2006 EDITION  
**S - a - 206**  
SHEET 2 OF 4

**NOTES:**

1. ALL MANHOLES SHALL BE PROVIDED WITH A STANDARD PULL RING IN ACCORDANCE WITH S-a-220. THE PULL RING SHALL BE LOCATED 5" ABOVE THE TOP OF PIPE ON THE UPSTREAM SIDE OF THE MANHOLE AND ALONG THE AXIS OF THE DOWNSTREAM OUTLET. WHERE THE MANHOLE IS TO BE USED AS A DOWNSTREAM SIPHON MANHOLE, IT SHALL BE PROVIDED WITH AN ADDITIONAL STANDARD PULL RING, BUT LOCATED 5" ABOVE THE TOP OF PIPE ON THE DOWNSTREAM SIDE OF THE MANHOLE AND ON THE CENTERLINE OF THE UPSTREAM SIPHON PIPE.
2. MANHOLE STEPS SHALL BE IN ACCORDANCE WITH S-a-209 AND SHALL BE UNIFORMLY SPACED NOT MORE THAN 16" APART. THE TOP STEP SHALL BE PLACED WITHIN 16" BELOW THE MANHOLE FRAME. THE BOTTOM MANHOLE STEP SHALL BE PLACED WITHIN 16" ABOVE THE SHELF. IN MANHOLE SHAFTS 36" IN DIAMETER AND LARGER, THE MANHOLE STEP SHALL PROJECT 5". IN MANHOLE SHAFTS SMALLER THAN 36" IN DIAMETER, THE MANHOLE STEP SHALL PROJECT 4". THE MANHOLE STEPS SHALL BE PLACED SUCH THAT THEY ARE ADJACENT TO BUT NOT INTERFERING WITH ACCESS TO THE PULL RING.
3. THE MANHOLE SHALL BE PROVIDED WITH PLASTIC LINER WITH LOCKING EXTENSIONS. PLASTIC LINER WITH LOCKING EXTENSIONS SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. THE LINER SHALL EXTEND FROM THE BOTTOM OF THE ADJUSTING RINGS TO THE TOP OF THE SHELF UNLESS THE ADJACENT PIPE IS LINED. IF THE ADJACENT PIPE IS LINED, THE LINER SHALL EXTEND TO A POINT IN THE CHANNEL MATCHING THE BOTTOM OF THE LINER IN THE LINED PIPE. LINER RETURNS SHALL BE PROVIDED WHERE THE LINER TERMINATES AT THE ADJUSTING RING AND THE SHELF. THE JOINT BETWEEN THE LINER AND THE STAINLESS STEEL STEPS AND PULL RINGS SHALL BE THOROUGHLY SEALED WITH MASTIC SEAM MATERIAL AS MANUFACTURED BY LINABOND INC., SYLMAR, CALIFORNIA (818) 362-7373, OR EQUAL. APPLICATION OF SEALANT AND PREPARATION OF SURFACES SHALL BE IN STRICT CONFORMANCE WITH THE MANUFACTURER'S DIRECTIONS.
4. UNLESS OTHERWISE SPECIFIED, ALL CONCRETE SHALL BE 660-B-4000 AND ALL REINFORCING BARS SHALL BE DEFORMED BARS CONFORMING TO ASTM-A706 GRADE 60.
5. IN PAVED AREAS SUBJECT TO TRAFFIC, A 24" TRAFFIC MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-228 SHALL BE PROVIDED. IN ALL OTHER AREAS, A 24" LOCKING MANHOLE FRAME AND COVER IN ACCORDANCE WITH S-a-207 SHALL BE PROVIDED. IF A 36" MANHOLE FRAME WITH 30" COVER IS REQUIRED, A FRAME AND COVER IN ACCORDANCE WITH S-a-226 SHALL BE PROVIDED.
6. A 12" WIDE BY 12" HIGH CONCRETE RING SHALL BE PROVIDED AROUND THE MANHOLE FRAME. IN UNPAVED AREAS, THE CONCRETE RING SHALL BE PROVIDED WITH #3 REBAR, 30 DIAMETER LAP.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE, TYPE "E"**

STANDARD DRAWING  
2006 EDITION

**S-a-206**

SHEET 3 OF 4

NOTES:

7. EXCEPT AS NOTED HEREON, THE PRECAST UNITS SHALL BE MANUFACTURED AND TESTED IN ACCORDANCE WITH ASTM C478. THE CURING OF THE PRECAST UNITS SHALL CONFORM TO SECTION 207-2.7 OF THE STANDARD SPECIFICATIONS. AS AN ALTERNATE, THE UNITS MAY BE CURED USING SATURATED STEAM FOR A MINIMUM OF 12 HOURS FOLLOWED BY 6 DAYS OF WATER CURING OR MEMBRANE CURING. IF THE UNITS ARE CURED BY THE ALTERNATE METHOD, THEY SHALL NOT BE SHIPPED PRIOR TO 8 DAYS AFTER CASTING NOR UNTIL THE CONCRETE HAS ATTAINED A MINIMUM STRENGTH OF 4,000 PSI. THE RISER SECTIONS MAY BE REINFORCED OR UNREINFORCED. REINFORCED SECTIONS, INCLUDING ECCENTRIC CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 5" AND UNREINFORCED SECTIONS, INCLUDING CONES, SHALL HAVE A MINIMUM WALL THICKNESS OF 6". JOINTS SHALL BE TONGUE AND GROOVE AND SHALL BE ASSEMBLED USING CLASS "B" MORTAR. THE MORTARED JOINTS SHALL BE FLUSH AND TROWELED SMOOTH.

8. UNLESS OTHERWISE INDICATED ON THE DRAWINGS, CASE I OR II MAY BE USED BY THE CONTRACTOR AT HIS OPTION CONSISTENT WITH DIAMETER COVER LIMITATIONS INDICATED HEREON.

CASE I SHALL NOT BE USED FOR COVER ON PIPE LESS THAN 12'.

CASE II SHALL NOT BE USED FOR COVER ON PIPE MORE THAN 12'.

9. RISER SECTIONS 60" THROUGH 96" I.D. SHALL BE REINFORCED IN ACCORDANCE WITH ASTM C 478 AND SHALL HAVE THE FOLLOWING MINIMUM WALL THICKNESS (t).

60" I.D. - 5"; 72" I.D. - 6"; 84" I.D. - 7"; 96" I.D. - 8".

10. THE TOP PORTION OF THE PIPES WITHIN THE MANHOLE SHALL BE CUT OUT AS NECESSARY TO PROVIDE A CIRCULAR OPENING BETWEEN THE PIPE ENDS OF AT LEAST 54" IN THE 60" DIAMETER MANHOLE AND 66" IN THE 72" DIAMETER MANHOLE, 78" IN THE 84" DIAMETER MANHOLE AND 90" IN THE 96" DIAMETER MANHOLE. THE CUT ENDS SHALL BE PLASTERED SMOOTH WITH CEMENT MORTAR FOR CONCRETE PIPE AND EPOXY FOR CLAY PIPE. THE CIRCULAR OPENING SHALL BE CUT PRIOR TO INSTALLATION OF THE RISER SECTIONS.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY OFFICE  
OF CHIEF ENGINEER

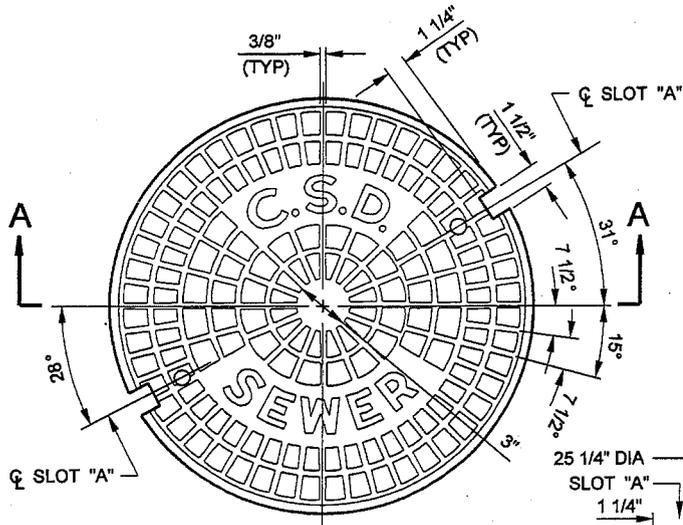
STEPHEN R. MAGUIN  
CHIEF ENGINEER

STANDARD MANHOLE, TYPE "E"

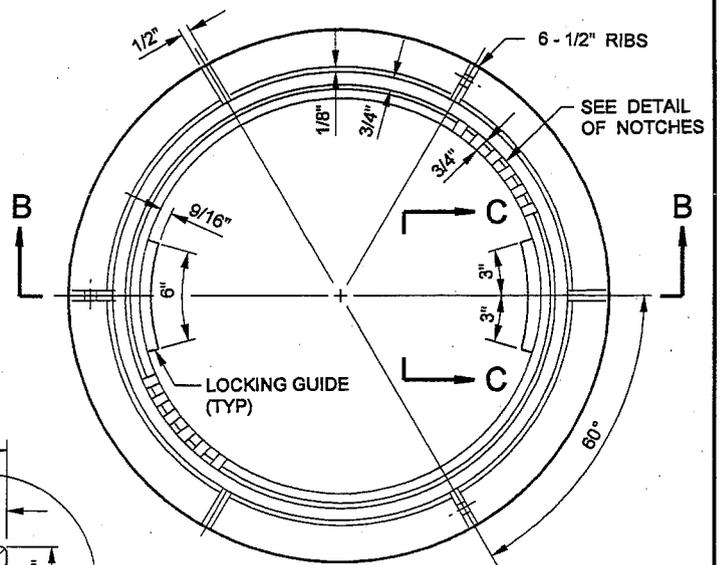
STANDARD DRAWING  
2006 EDITION

S-a-206

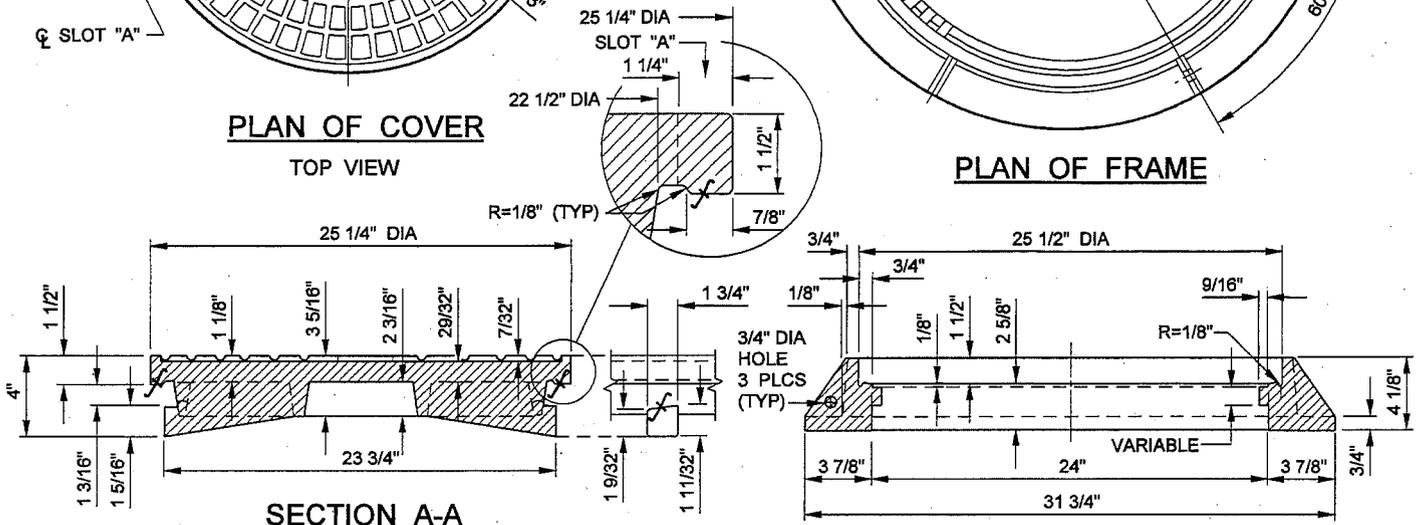
SHEET 4 OF 4



**PLAN OF COVER**  
TOP VIEW



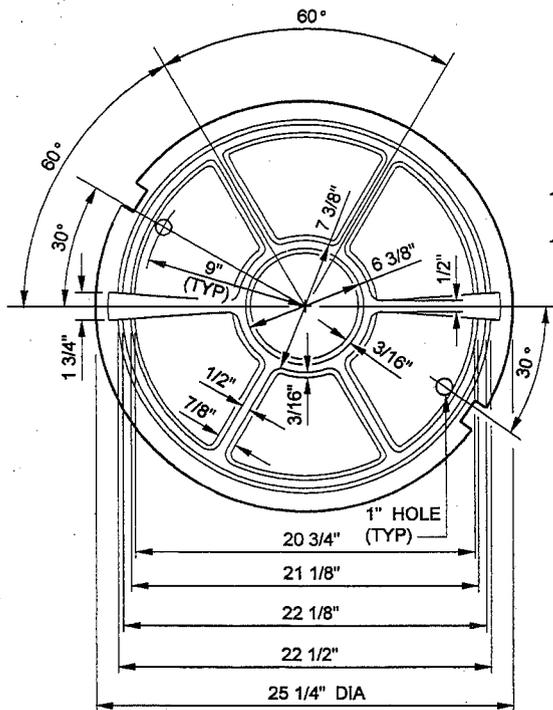
**PLAN OF FRAME**



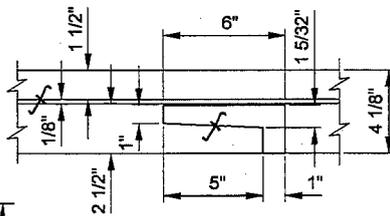
**SECTION A-A**

**SECTION B-B**

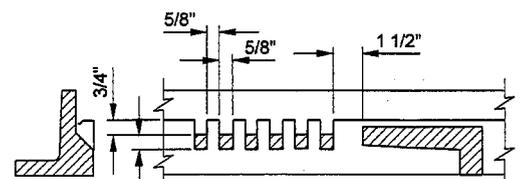
**END VIEW  
COVER LUG**



**PLAN OF COVER**  
BOTTOM VIEW



**SIDE VIEW C-C  
LOCKING GUIDE**



**DETAIL OF NOTCHES**

**NOTES:**

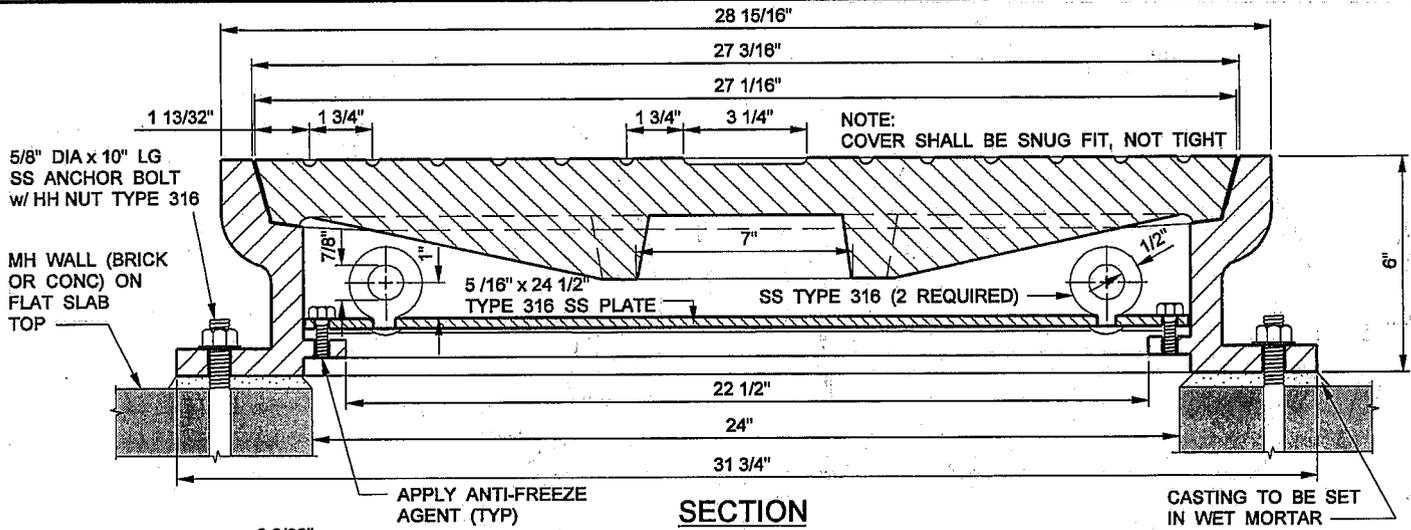
1. CAST IRON USED SHALL CONFORM WITH ASTM A-48 CLASS 35B.
2. FRAME AND COVER SHALL BE COATED WITH ASPHALTUM OR BITUMINOUS PAINT AFTER TESTING AND INSPECTION.
3. FRAME AND COVER SHALL BE TESTED FOR ACCURATE FIT PRIOR TO DELIVERY AND SHALL BE MARKED IN SETS.
4. ALL CASTINGS SHALL COMPLY WITH SECTION 206-3 OF THE STANDARD SPECIFICATIONS.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

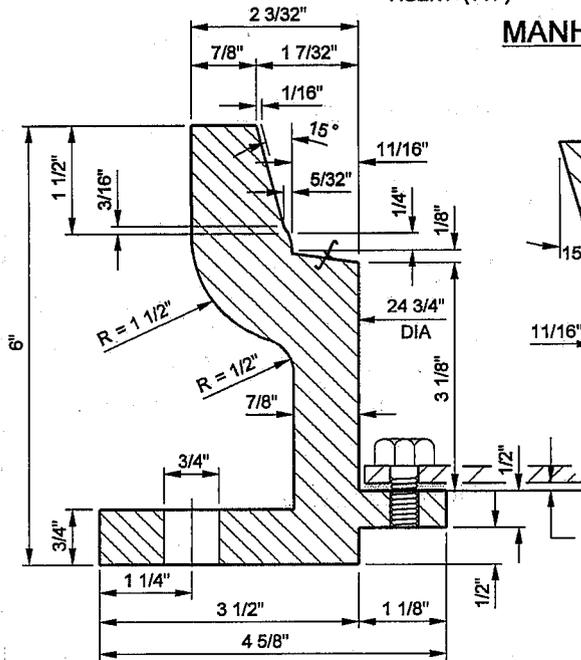
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD 24" LOCKING MANHOLE  
FRAME AND COVER**

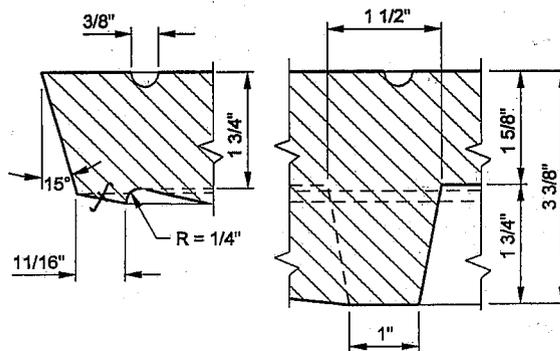
STANDARD DRAWING  
2006 EDITION  
**S - a - 207**  
SHEET 1 OF 1



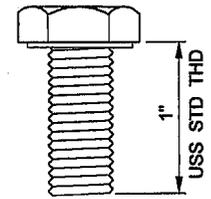
**SECTION  
MANHOLE FRAME AND COVER**



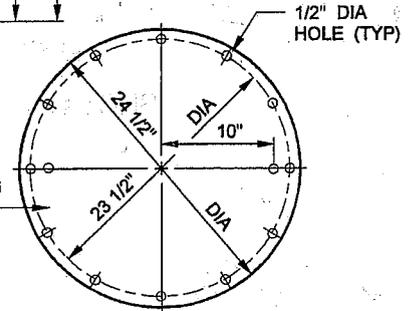
**SECTION A-A**



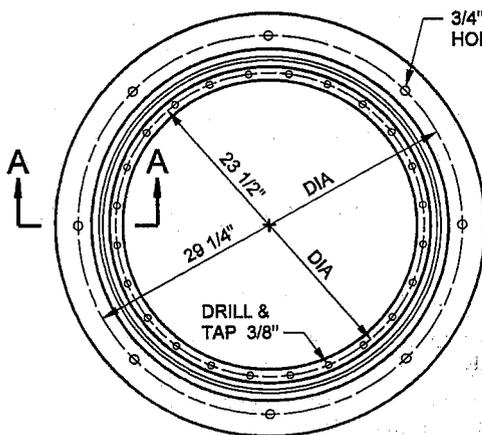
**SECTION B-B**



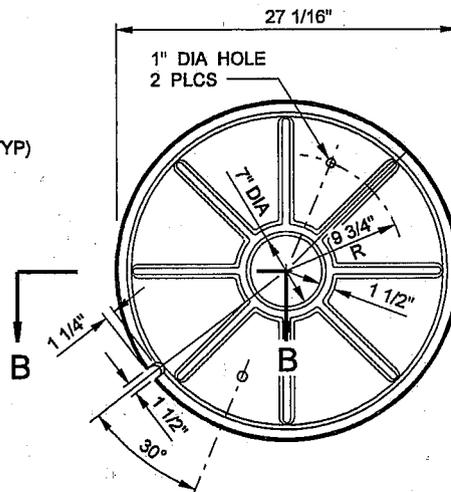
**3/8" x 1" TYPE 316  
SS CAP SCREW  
(12 REQUIRED)**



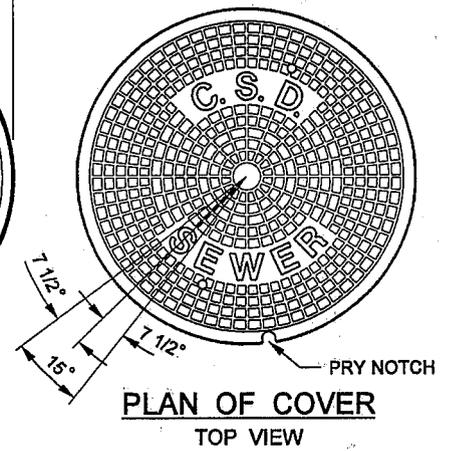
**PRESSURE PLATE**



**PLAN OF FRAME**



**PLAN OF COVER  
BOTTOM VIEW**



**PLAN OF COVER  
TOP VIEW**

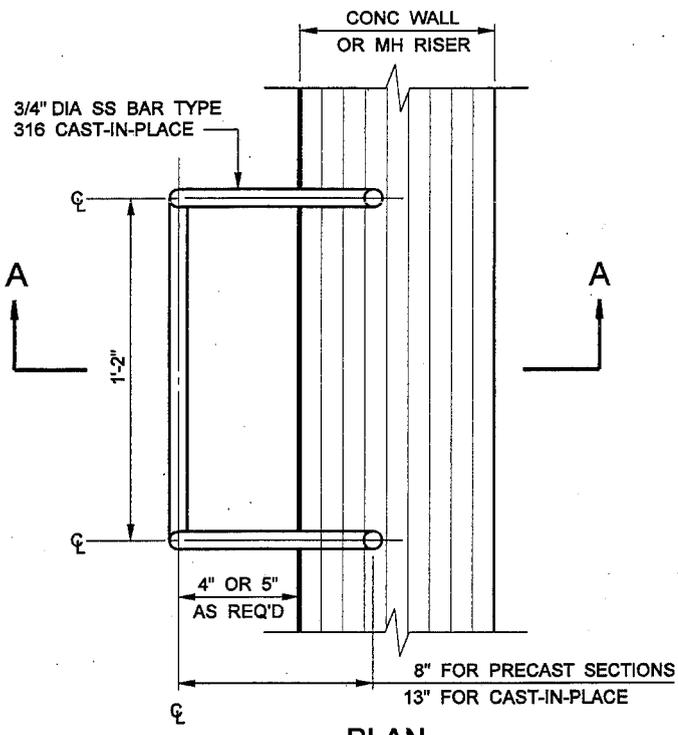
**NOTE:  
FOR NOTES SEE S-a-207.**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

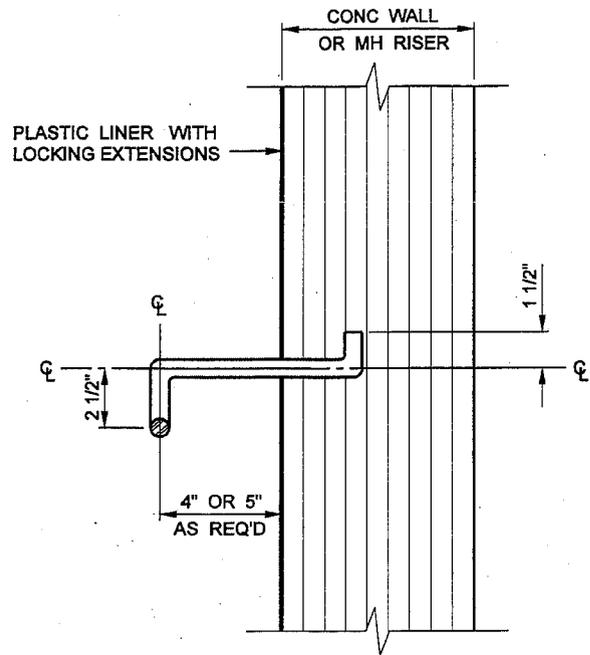
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD 24" PRESSURE MANHOLE  
FRAME AND COVER**

STANDARD DRAWING  
2006 EDITION  
**S - a - 208**  
SHEET 1 OF 1

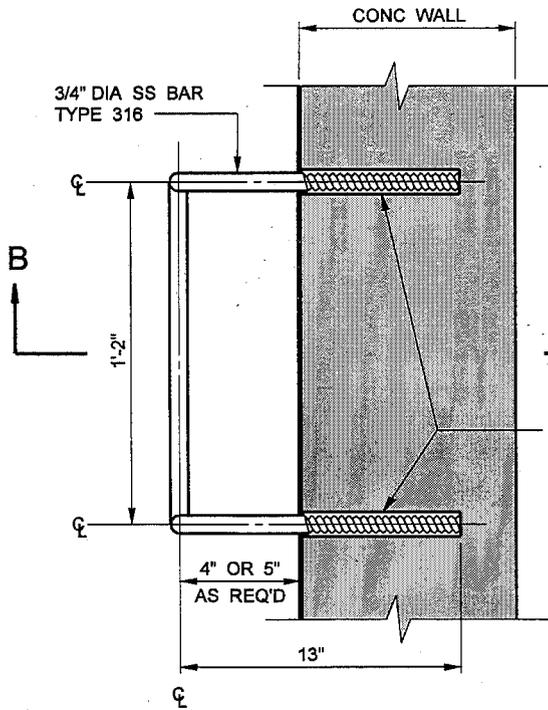


**PLAN**

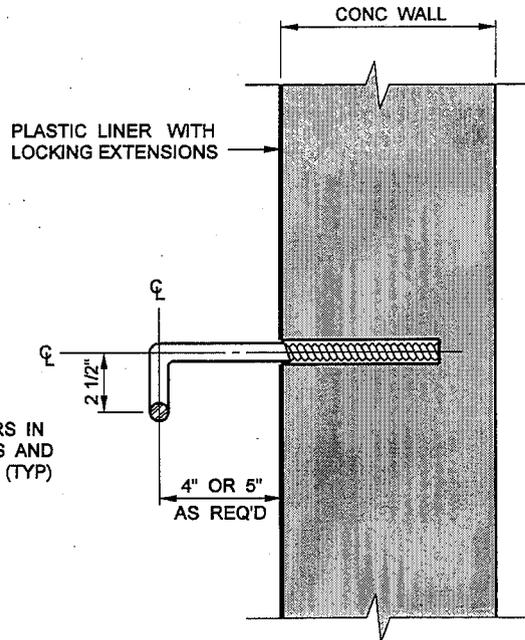


**SECTION A-A**

**TYPE I MANHOLE STEP**



**PLAN**



**SECTION B-B**

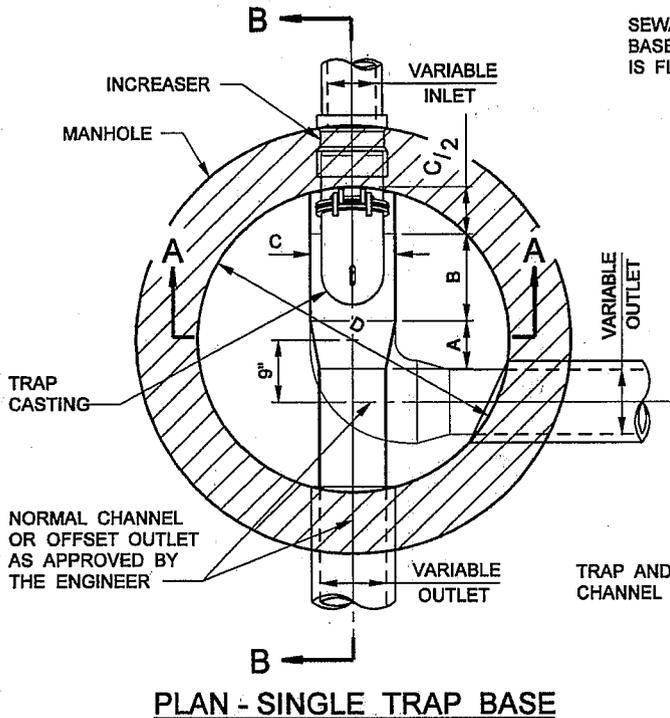
**TYPE II MANHOLE STEP**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

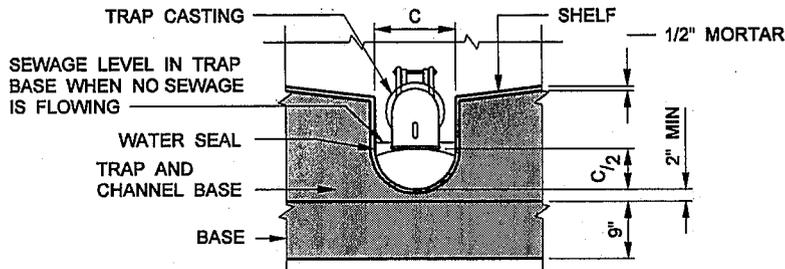
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD MANHOLE STEP**

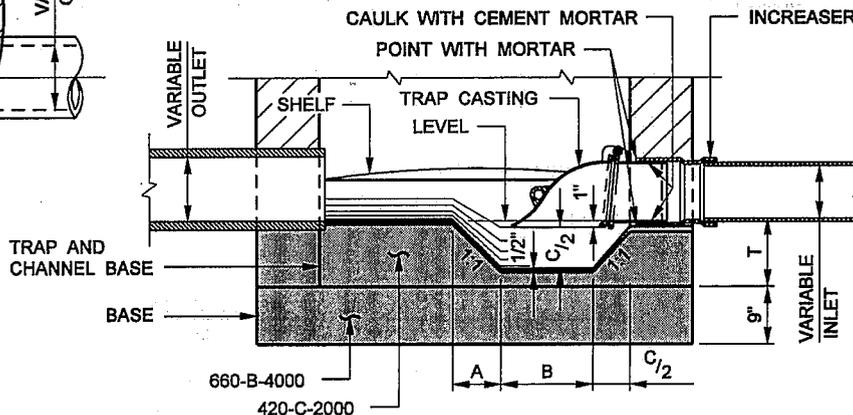
STANDARD DRAWING  
2006 EDITION  
**S - a - 209**  
SHEET 1 OF 1



**PLAN - SINGLE TRAP BASE**



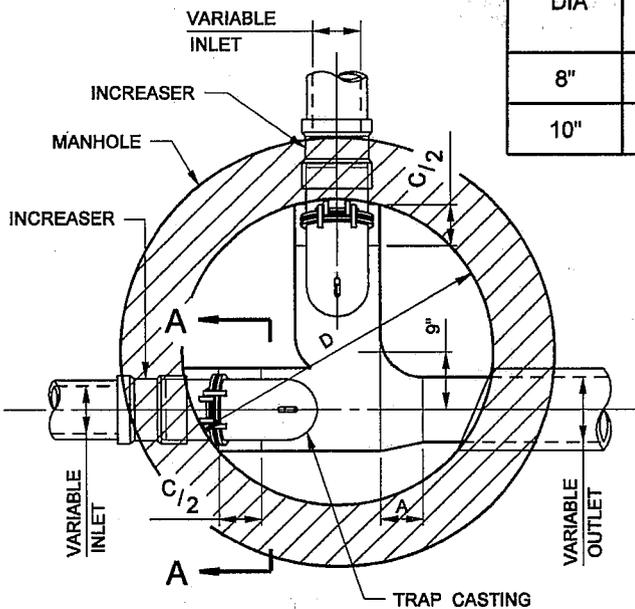
**SECTION A-A**



**SECTION B-B**

TABLE OF DIMENSIONS						
INLET DIA	INLET INCREASER	TRAP SIZE	TRAP PER	DIA OF MANHOLE BASE (D)		
				OUTLET DIAMETER		
				8"	10"	12"
8"	8" x 10"	10"	S-a-211	4'	4'	4'
10"	10" x 12"	12"	S-a-211	—	4'	4'

(FOR 12" INLETS AND LARGER SEE CONSTRUCTION DRAWINGS)



**PLAN - DOUBLE TRAP BASE**

TRAP BASE DIMENSIONS					
TRAP DIA	A	B	C	A + B + C/2	T MIN
10"	7 1/2"	14 1/2"	13"	28 1/2"	9"
12"	8 1/2"	16 1/2"	15"	32 1/2"	10"

**NOTES:**

- WHERE A TRAP IS NECESSARY IN AN EXISTING STRUCTURE, BREAK OUT CONCRETE AND CONSTRUCT NEW BASE.
- FOR GENERAL NOTES AND CONSTRUCTION DETAILS OF BRICKWORK, SEE S-a-201.

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CHIEF ENGINEER

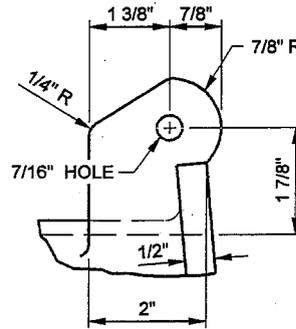
**STANDARD TRAP MANHOLE BASE**

STANDARD DRAWING  
2006 EDITION  
**S - a - 210**  
SHEET 1 OF 1

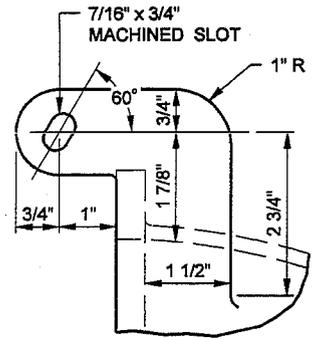
DIMENSIONS OF CASTINGS				
INLET DIA	A	B	R	L
10"	6"	9"	11"	14 3/4"
12"	7"	11"	13"	17 3/4"

**NOTES:**

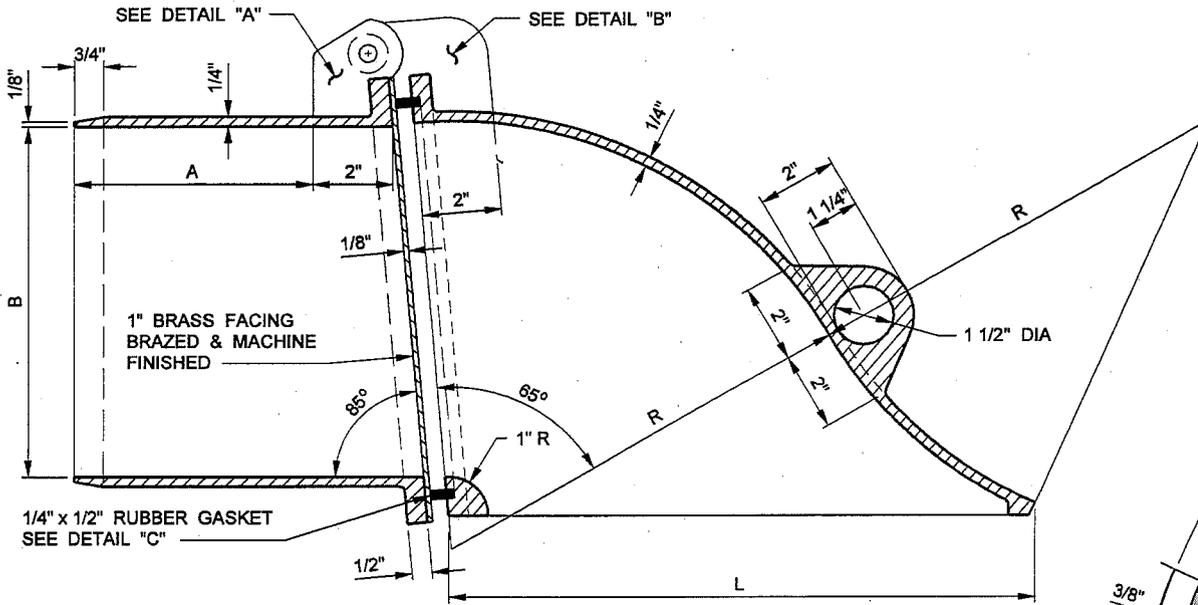
1. CAST IRON USED SHALL CONFORM WITH ASTM A-48 CLASS 35B.
2. FLANGES OF CASTING SHALL BE MACHINED FACED.
3. CASTINGS SHALL BE DIPPED TWICE IN HOT ASPHALT PAINT.
4. RUBBER GASKET SHALL BE NEOPRENE 35-50 SHORE.



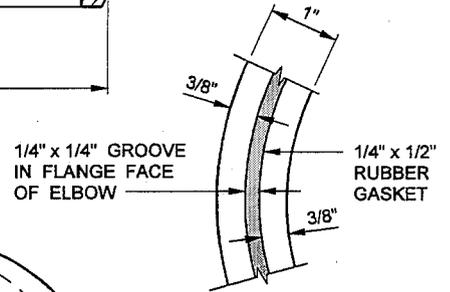
**DETAIL "A"**



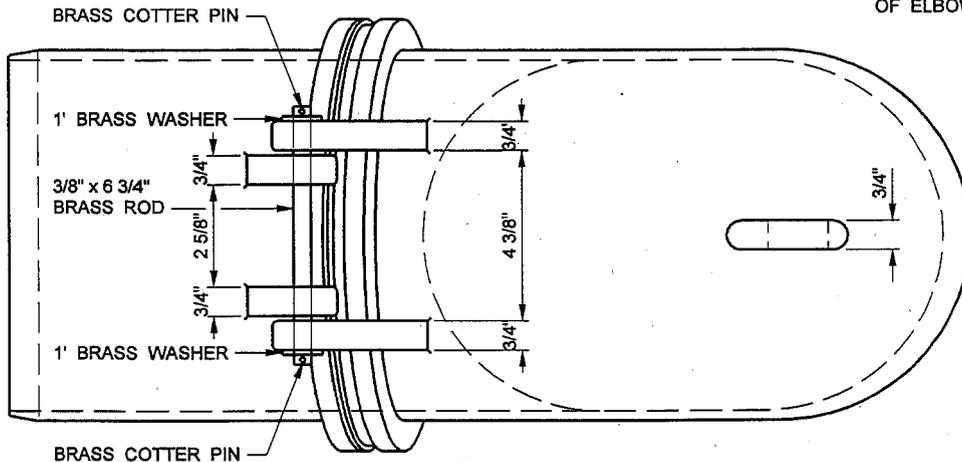
**DETAIL "B"**



**SECTIONAL VIEW**



**DETAIL "C"**



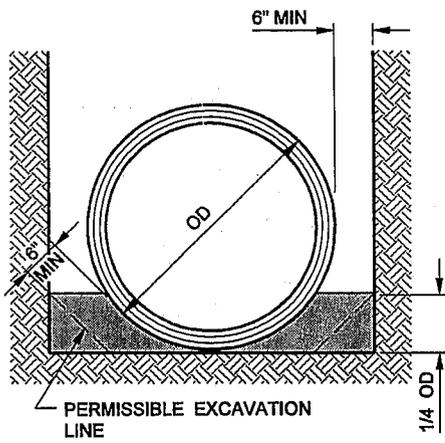
**PLAN VIEW**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

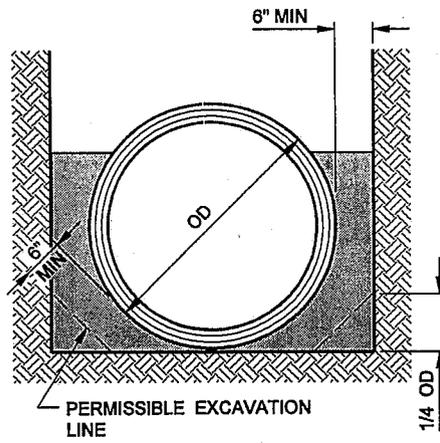
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD TRAP CASTING**

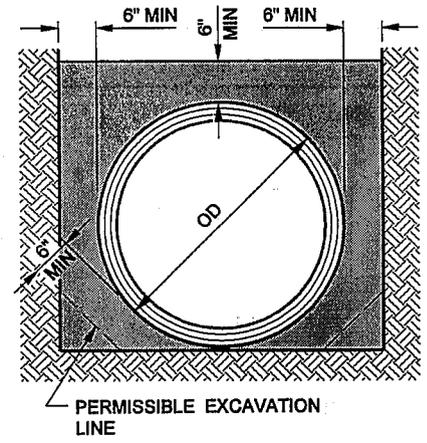
STANDARD DRAWING  
2006 EDITION  
**S - a - 2 1 1**  
SHEET 1 OF 1



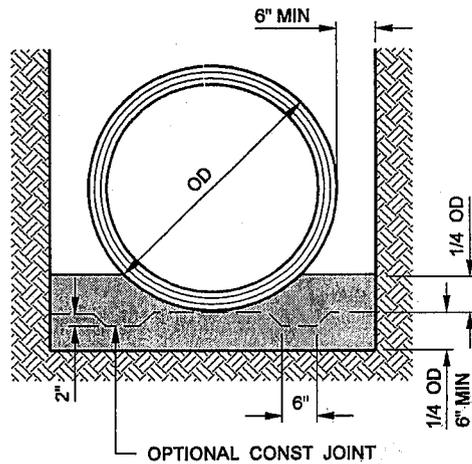
**CRADLE TYPE 1**



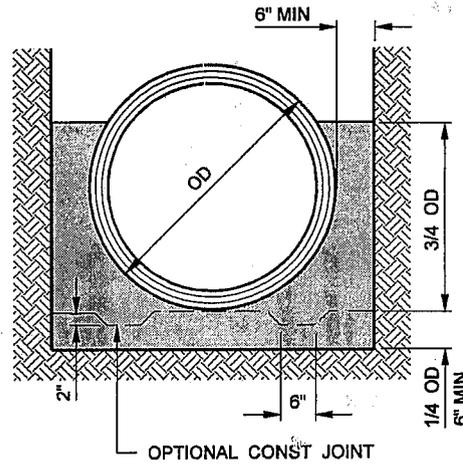
**CRADLE TYPE 2**



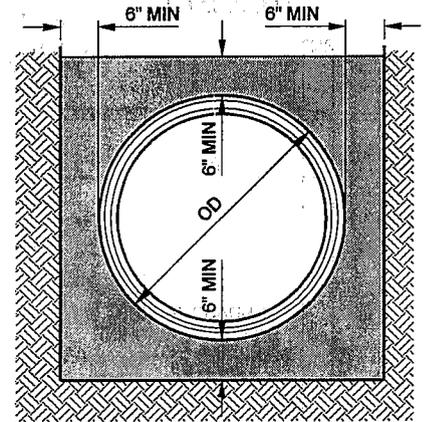
**ENCASEMENT TYPE 1**



**CRADLE TYPE 1A**



**CRADLE TYPE 2A**



**ENCASEMENT TYPE 1A**

**NOTES:**

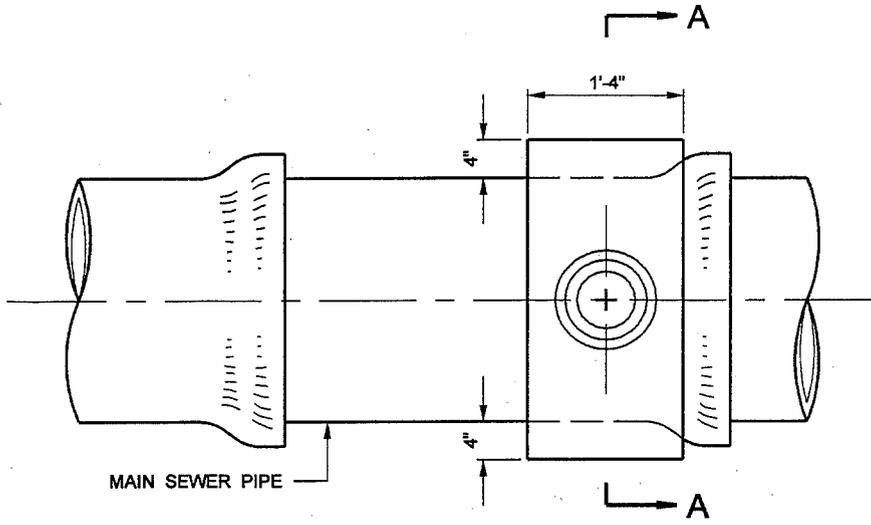
1. ALL CONCRETE FOR CRADLES TYPE 1 AND 2 AND ENCASEMENT TYPE 1 SHALL BE 420-C-2000. ALL CONCRETE FOR CRADLES TYPE 1A AND 2A AND ENCASEMENT TYPE 1A SHALL BE 660-B-4000. USE IS LIMITED TO BEDDING CONCRETE OVER WHICH BACKFILL WILL BE PLACED NOT LESS THAN 40 HOURS AFTER PLACEMENT. FOR BACKFILL AFTER 24 HOURS, ADD A NON-CHLORIDE ACCELERATING ADMIXTURE APPROVED BY THE ENGINEER AT DOSEAGES AS REQUIRED BY THE MANUFACTURER OF THE ADMIXTURE. FOR BACKFILL AFTER 18 HOURS AND REMOVAL OF SHEETING AFTER 18 HOURS, USE 660-C-4000 WITH A NON-CHLORIDE ACCELERATING ADMIXTURE APPROVED BY THE ENGINEER AT DOSAGES AS REQUIRED BY THE MANUFACTURER OF THE ADMIXTURE.
2. THE CONCRETE FOR CRADLES TYPE 1 AND 2 AND ENCASEMENT TYPE 1 SHALL NOT BE POURED AGAINST TRENCH SHEETING, FORMS, OR ON LOOSE MATERIAL IN THE TRENCH BOTTOM, BUT SHALL BE POURED AGAINST AND ON THE UNDISTURBED TRENCH WALLS AND BOTTOM.
3. THE CONCRETE FOR CRADLES TYPE 1A AND 2A AND ENCASEMENT TYPE 1A MAY BE POURED AGAINST TRENCH SHEETING, FORMS, OR AGAINST THE TRENCH WALLS, BUT SHALL NOT BE POURED ON LOOSE MATERIAL IN THE TRENCH BOTTOM.
4. UNLESS OTHERWISE PROVIDED IN THE SPECIFICATIONS OR AUTHORIZED BY THE ENGINEER, WHEN THE MAXIMUM ALLOWABLE TRENCH WIDTH HAS BEEN EXCEEDED, THE PIPE SHALL BE CRADLED WITH TYPE 1 OR TYPE 2 IF THE TRENCH IS IN UNDISTURBED SOIL OR TYPE 1A OR TYPE 2A IF THE TRENCH IS IN UNSTABLE SOIL. IF THE TRENCH WIDTH IS LESS THAN ONE AND ONE HALF TIMES THE MAXIMUM ALLOWED BY THE SPECIFICATIONS WITHOUT SPECIAL BEDDING, OR IF THE COVER ON THE PIPE IS LESS THAN TEN FEET, CRADLE TYPE 1 OR 1A SHALL BE USED. IF THE TRENCH WIDTH IS MORE THAN ONE AND ONE HALF TIMES THE MAXIMUM ALLOWED BY THE SPECIFICATIONS WITHOUT SPECIAL BEDDING AND THE COVER IS TEN FEET OR MORE, CRADLE TYPE 2 OR 2A SHALL BE USED.
5. UNLESS OTHERWISE AUTHORIZED BY THE ENGINEER, ALL CRADLES AND ENCASEMENTS SHALL BE PLACED SUCH THAT BOTH ENDS TERMINATE WITHIN 18 INCHES OF A FLEXIBLE JOINT.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

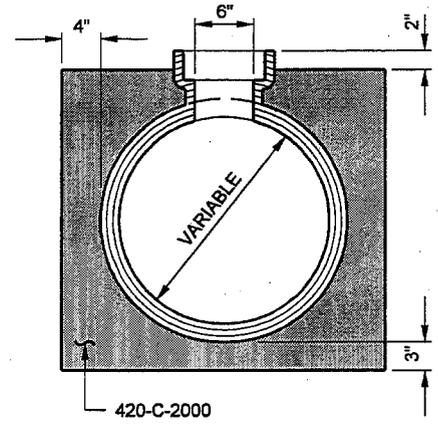
**STANDARD CONCRETE CRADLES  
AND ENCASEMENTS**

STANDARD DRAWING  
2006 EDITION  
**S - a - 212**  
SHEET 1 OF 1



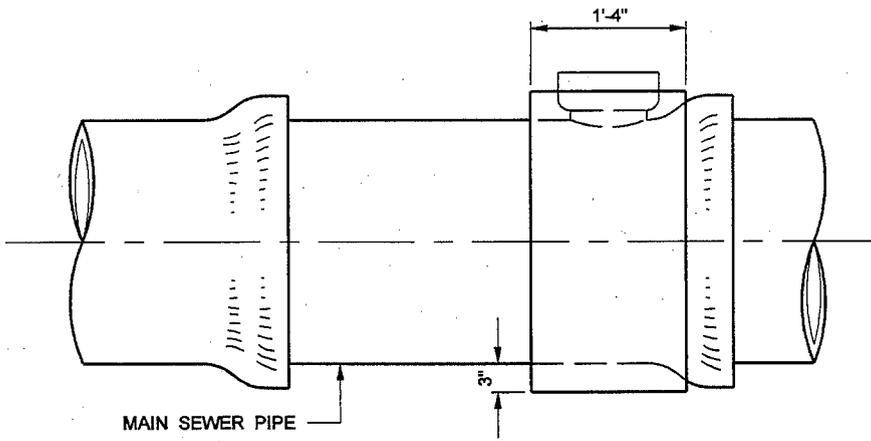
MAIN SEWER PIPE

PLAN



420-C-2000

SECTION A-A



MAIN SEWER PIPE

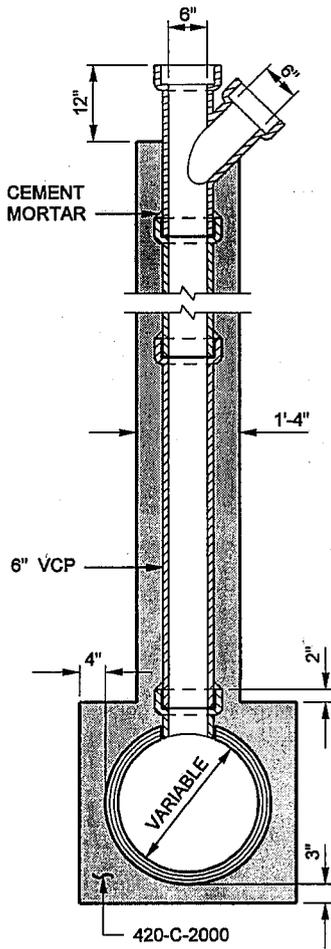
ELEVATION

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD "T" FOUNDATION**

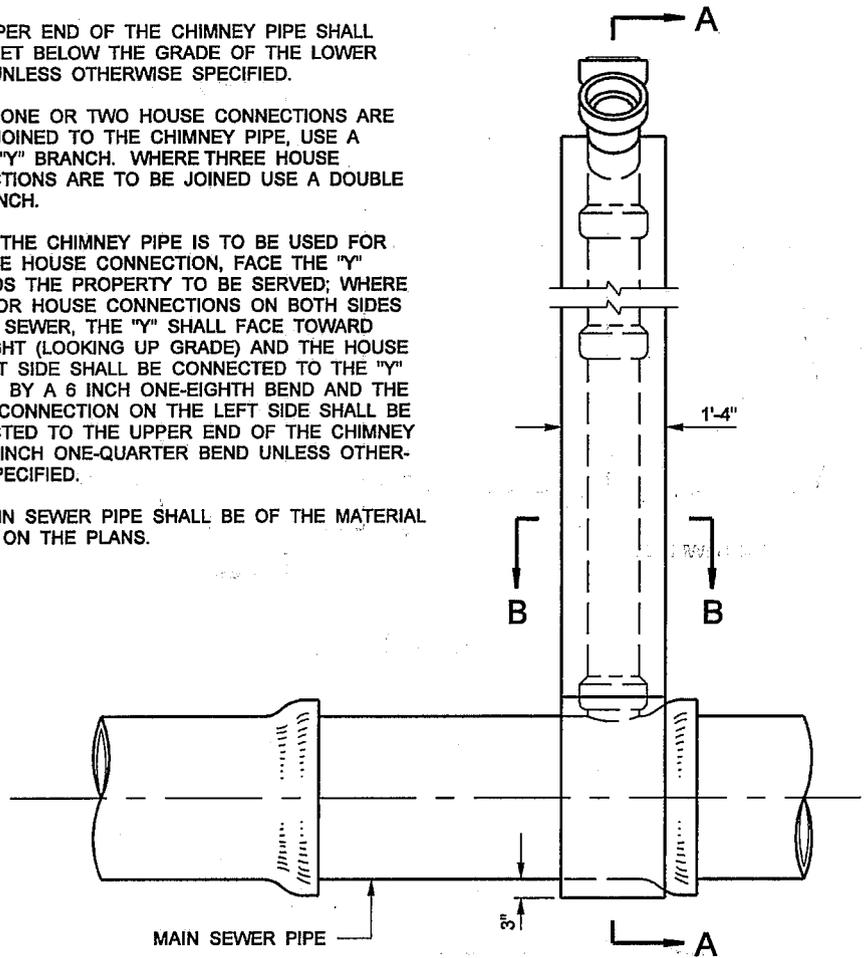
STANDARD DRAWING  
2006 EDITION  
**S - a - 213**  
SHEET 1 OF 1



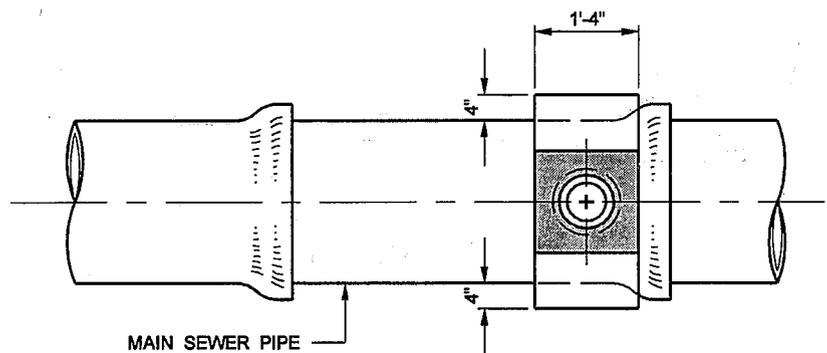
**SECTION A-A**

**NOTES:**

1. THE UPPER END OF THE CHIMNEY PIPE SHALL BE 8 FEET BELOW THE GRADE OF THE LOWER CURB, UNLESS OTHERWISE SPECIFIED.
2. WHERE ONE OR TWO HOUSE CONNECTIONS ARE TO BE JOINED TO THE CHIMNEY PIPE, USE A SINGLE "Y" BRANCH. WHERE THREE HOUSE CONNECTIONS ARE TO BE JOINED USE A DOUBLE "Y" BRANCH.
3. WHERE THE CHIMNEY PIPE IS TO BE USED FOR A SINGLE HOUSE CONNECTION, FACE THE "Y" TOWARDS THE PROPERTY TO BE SERVED; WHERE USED FOR HOUSE CONNECTIONS ON BOTH SIDES OF THE SEWER, THE "Y" SHALL FACE TOWARD THE RIGHT (LOOKING UP GRADE) AND THE HOUSE ON THAT SIDE SHALL BE CONNECTED TO THE "Y" BRANCH BY A 6 INCH ONE-EIGHTH BEND AND THE HOUSE CONNECTION ON THE LEFT SIDE SHALL BE CONNECTED TO THE UPPER END OF THE CHIMNEY BY A 6 INCH ONE-QUARTER BEND UNLESS OTHERWISE SPECIFIED.
4. THE MAIN SEWER PIPE SHALL BE OF THE MATERIAL SHOWN ON THE PLANS.



**ELEVATION**



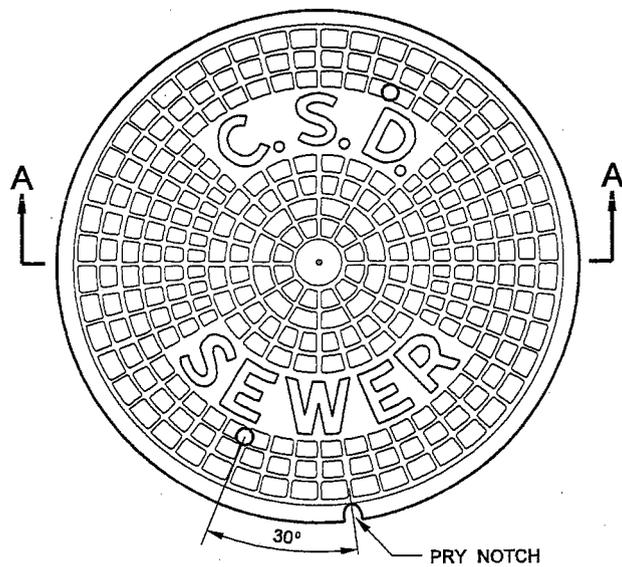
**PLAN-SECTION B-B**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

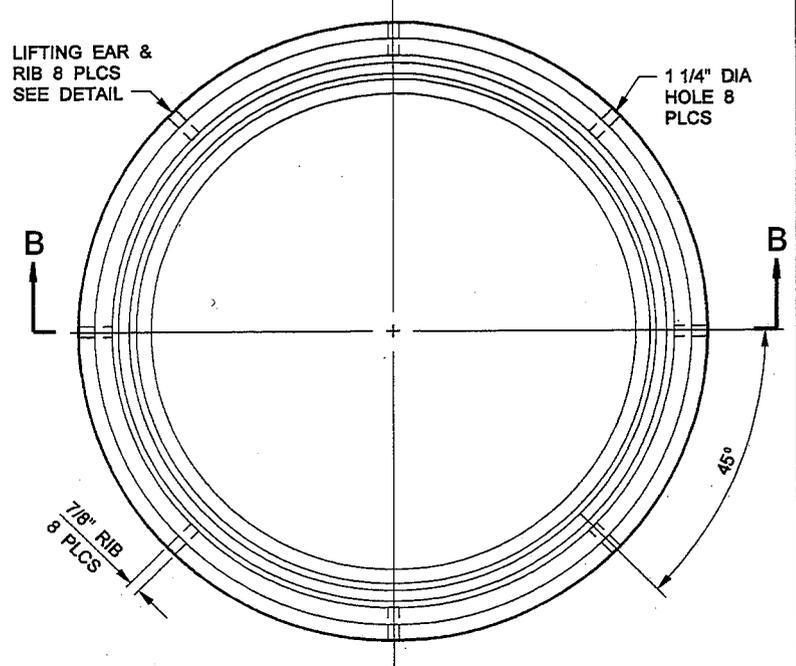
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD CHIMNEY PIPE**

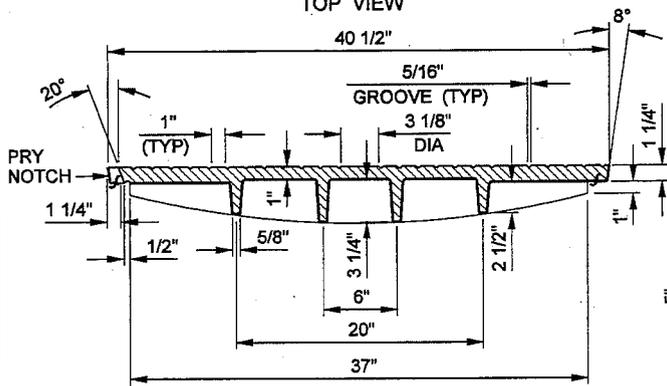
STANDARD DRAWING  
2006 EDITION  
**S - a - 214**  
SHEET 1 OF 1



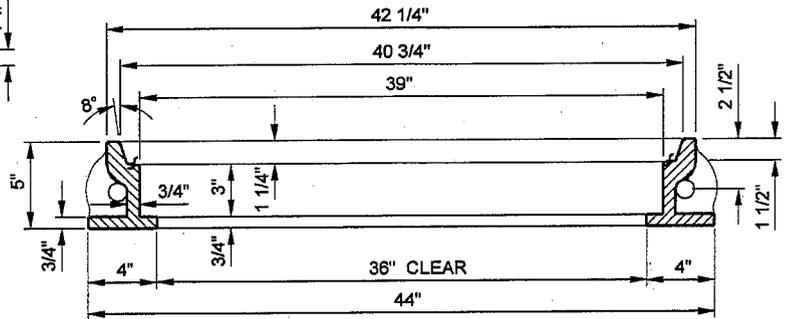
**PLAN OF COVER**  
TOP VIEW



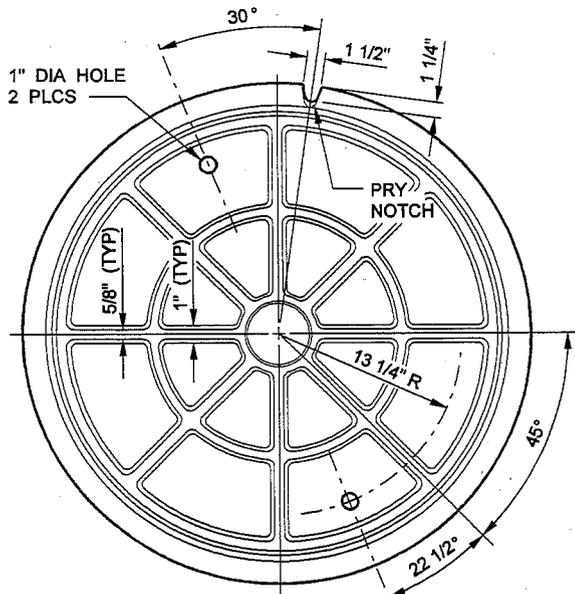
**PLAN OF FRAME**



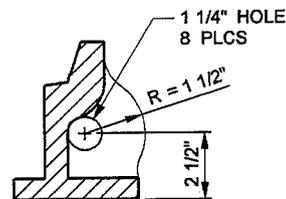
**SECTION A-A**



**SECTION B-B**



**PLAN OF COVER**  
BOTTOM VIEW



**DETAIL**  
**LIFTING EAR & RIB**

**NOTES:**

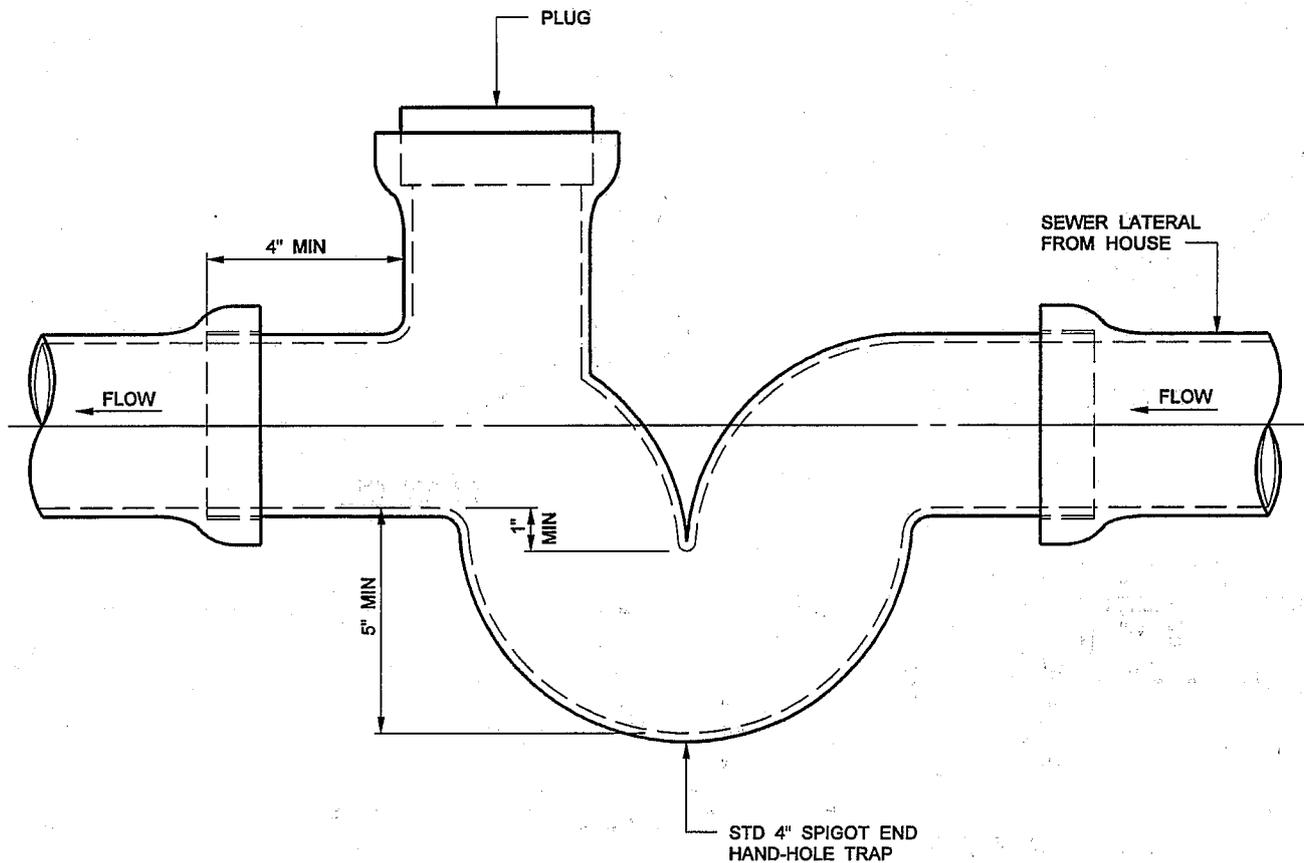
1. CAST IRON USED SHALL CONFORM WITH ASTM A-48 CLASS 35B.
2. FRAME AND COVER SHALL BE COATED WITH ASPHALTUM OR BITUMINOUS PAINT AFTER TESTING AND INSPECTION.
3. FRAME AND COVER SHALL BE TESTED FOR ACCURATE FIT PRIOR TO DELIVERY AND SHALL BE MARKED IN SETS.
4. ALL CASTINGS SHALL COMPLY WITH SECTION 206-3 OF THE STANDARD SPECIFICATIONS.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD 36" MANHOLE FRAME  
AND COVER**

STANDARD DRAWING  
2006 EDITION  
**S - a - 215**  
SHEET 1 OF 1



**NOTES:**

1. GAS TRAP SHALL BE INSERTED AT THE POINT OR POINTS OF CONNECTION TO THE HOUSE PLUMBING TWO (2) FEET OUTSIDE THE BUILDING AT PROPERTY OWNER'S EXPENSE.
2. SPIGOT END HAND-HOLE TRAPS OF CAST IRON SOIL PIPE MAY BE USED IN LIEU OF VITRIFIED CLAY PIPE FITTINGS.
3. GAS TRAP MADE OF OTHER MATERIALS MAY BE SUBMITTED FOR APPROVAL.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

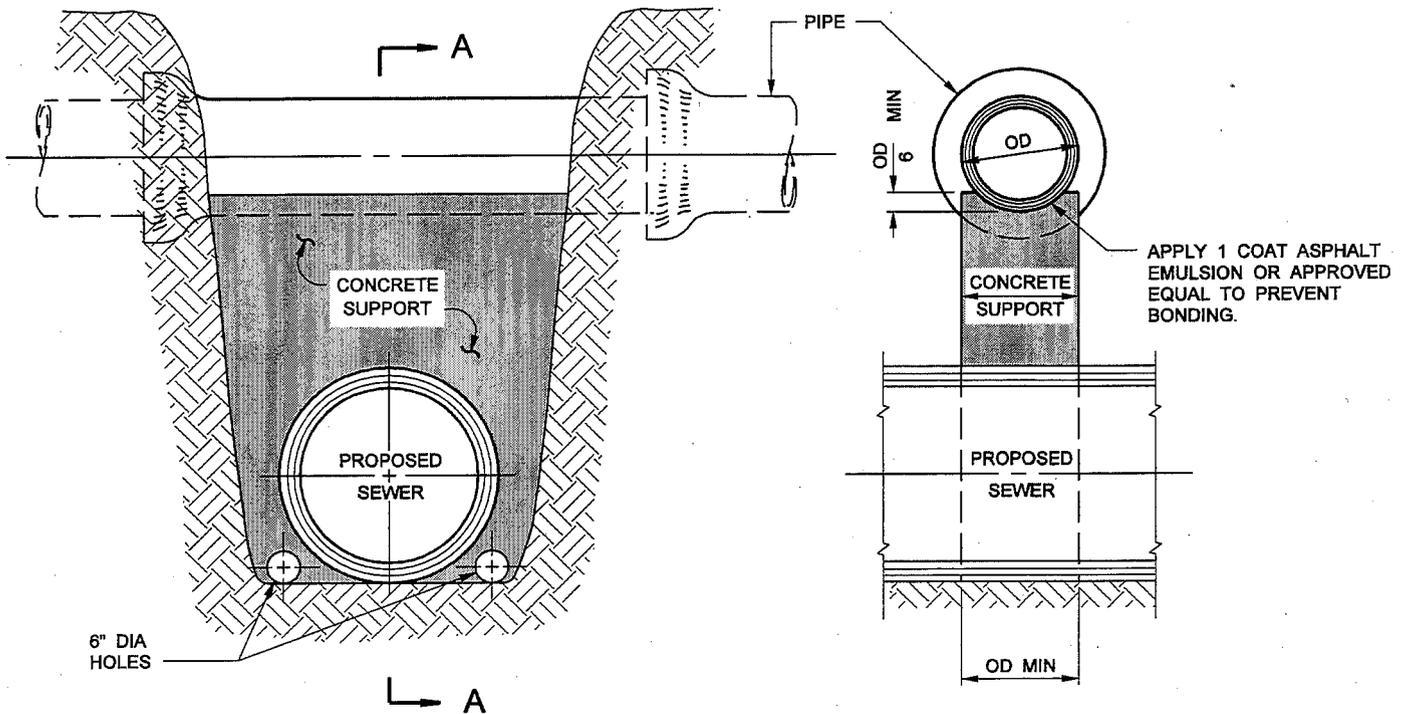
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD HOUSE CONNECTION GAS TRAP**

STANDARD DRAWING  
2006 EDITION

**S - a - 2 1 6**

SHEET 1 OF 1



**ELEVATION**

**SECTION A-A**

**NOTES:**

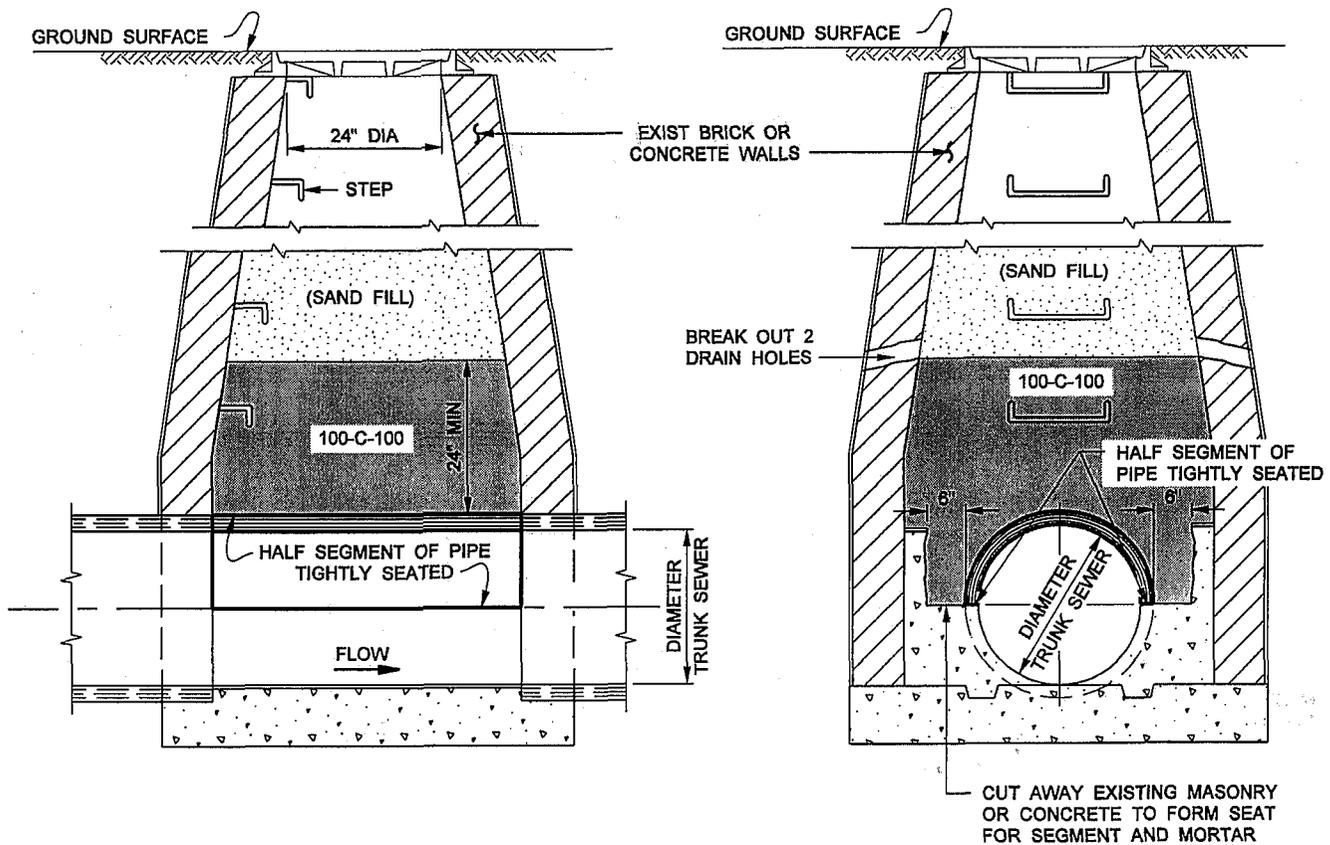
1. CONCRETE SUPPORT SHALL BE POURED AGAINST UNDISTURBED SOIL ON THE BOTTOM AND SHALL EXTEND THE FULL WIDTH OF EXCAVATION.
2. CONCRETE SHALL BE 420-C-2000. WHEN APPROVED BY THE ENGINEER, THE CONTRACTOR MAY SUBSTITUTE CONCRETE WITH 2-SACK CEMENT SAND SLURRY.
3. CONTRACTOR SHALL OBTAIN APPROVAL FROM THE ENGINEER OF HIS PROPOSED METHOD OF SUPPORTING THE EXISTING PIPE LINES DURING CONSTRUCTION.
4. CONTRACTOR SHALL PROVIDE CONCRETE PIPE SUPPORT UNDER ALL EXISTING CONCRETE, ASBESTOS CEMENT, CLAY, TELEPHONE AND POWER CONDUITS AND UNDER ALL OTHER CONDUITS WHERE REQUIRED ON THE PLANS OR REQUESTED BY OWNER.
5. CONCRETE PIPE SUPPORT TO BE PAID UNDER THE APPROPRIATE PIPE BID ITEM.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD CONCRETE PIPE SUPPORT**

STANDARD DRAWING  
2006 EDITION  
**S - a - 217**  
SHEET 1 OF 1



**LONGITUDINAL SECTION**

**CROSS SECTION**

**NOTES:**

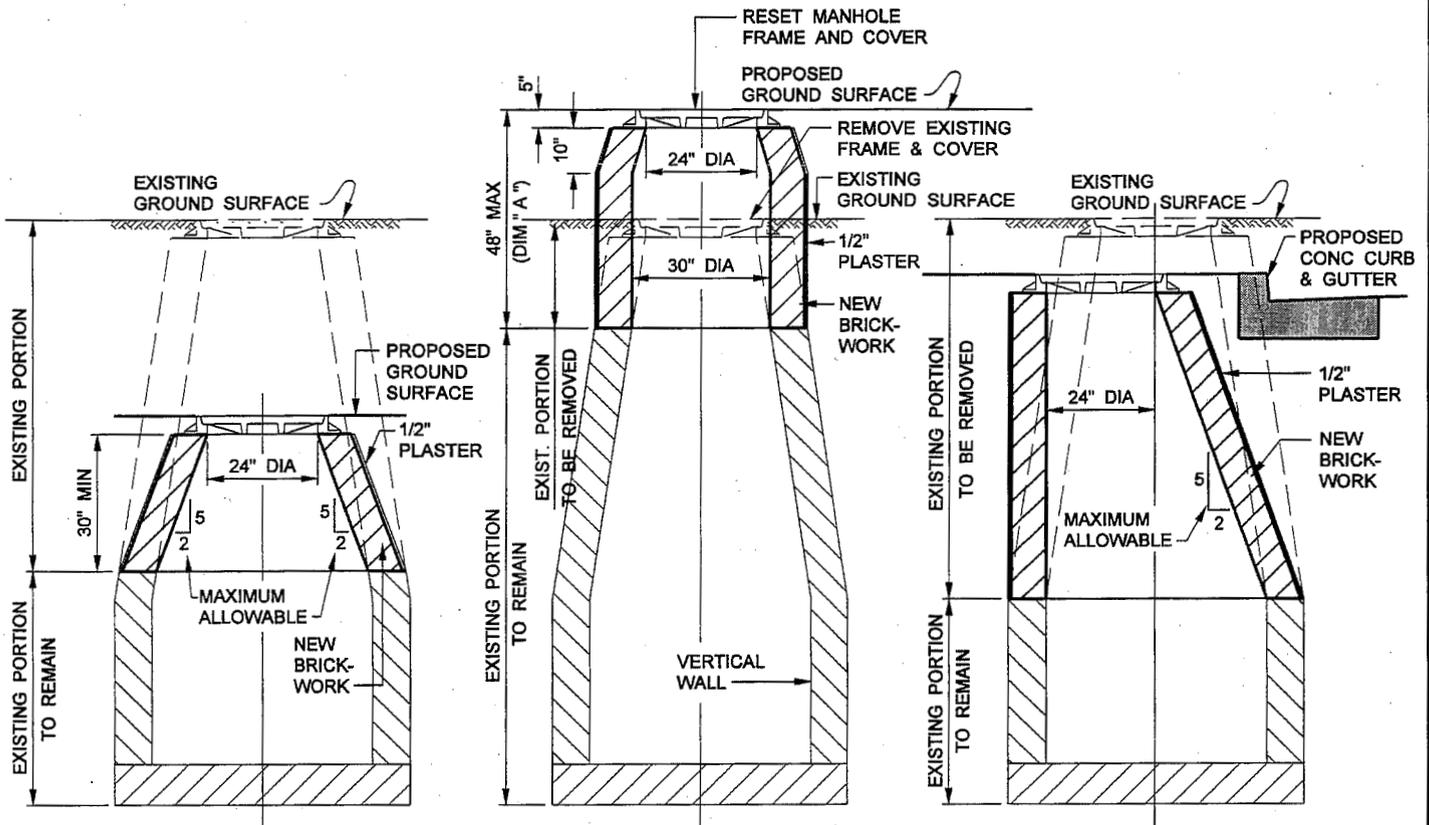
1. FORTY-EIGHT HOURS PRIOR TO COMMENCING THE ABANDONMENT OF THE MANHOLE, THE CONTRACTOR SHALL CONTACT THE DISTRICTS' SUPERINTENDENT OF MAINTENANCE AT (323) 774-7272.
2. NO WORK SHALL BE DONE ON MANHOLE EXCEPT IN THE PRESENCE OF COUNTY SANITATION DISTRICT REPRESENTATIVE.
3. MANHOLE FRAME AND COVER OF THE MANHOLE TO BE ABANDONED SHALL BE SALVAGED, CLEANED AND DELIVERED TO THE DISTRICTS' COMPTON FIELD OFFICE, 920 SOUTH ALAMEDA STREET, COMPTON, CALIFORNIA.
4. THE CONTRACTOR SHALL REMOVE A MINIMUM OF THREE FEET OF THE MANHOLE SHAFT BELOW STREET SUBGRADE.
5. IF THE LOWER PORTION OF THE EXISTING CHANNEL THROUGH THE MANHOLE IS NOT AS SHOWN, THE CHANNEL SHALL BE REFORMED AS DIRECTED BY THE COUNTY SANITATION DISTRICT REPRESENTATIVE.
6. HALF SEGMENT OF PIPE SHALL BE OF THE TYPE USED IN THE SEWER.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD ABANDONMENT OF EXISTING  
MANHOLES TYPE "A" OR "D"**

STANDARD DRAWING  
2006 EDITION  
**S - a - 2 1 8**  
SHEET 1 OF 1



**CASE I**

**CASE II**

**CASE III**

**NOTES:**

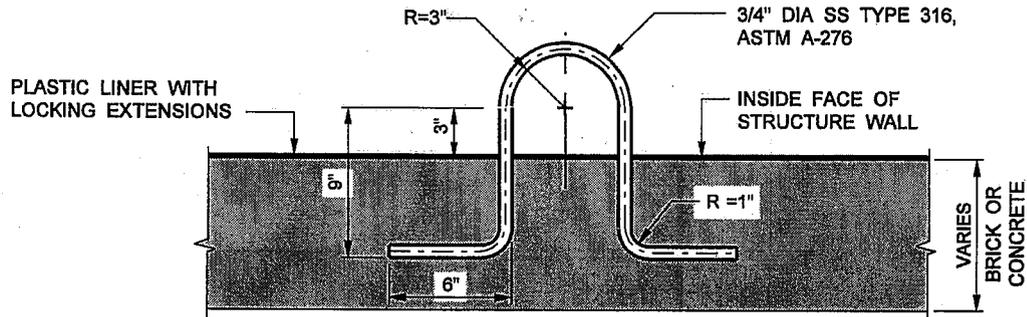
1. PRIOR TO THE REMOVAL OF THE FRAME OF ANY MANHOLE, THE CHANNEL OF THE MANHOLE SHALL BE COMPLETELY COVERED WITH PLANKING OR OTHER SUITABLE MATERIAL SO AS TO PREVENT DEBRIS FROM ENTERING THE CHANNEL. AFTER THE MANHOLE RECONSTRUCTION HAS BEEN COMPLETED ALL DEBRIS SHALL BE REMOVED FROM WITHIN THE MANHOLE AND THE COVER OVER THE CHANNEL SHALL BE REMOVED.
2. WHEN THE MANHOLE IS TO BE RECONSTRUCTED TO A STRAIGHT SIDED MANHOLE, THE BRICK WORK SHALL BE REMOVED TO THE HIGHEST POINT OF THE VERTICAL WALL. THE SLOPE OF THE CORBELED SIDE SHALL NOT EXCEED 2 INCHES IN 5 INCHES. THE MANHOLE STEPS SHALL BE PLACED ON THE VERTICAL SIDE. SEE CASE III.
3. WHEN THE MANHOLE IS TO BE RAISED AN AMOUNT SUCH THAT DIMENSION "A" (CASE II) IS LESS THAN 4', THE BRICKWORK SHALL BE REMOVED TO A POINT WHERE THE INSIDE DIAMETER IS A MINIMUM OF 30 INCHES. THE MANHOLE WALL SHALL THEN BE CONSTRUCTED VERTICALLY TO A POINT 15 INCHES BELOW THE TOP OF THE MANHOLE. SEE CASE II.
4. WHERE THE MANHOLE IS TO BE RAISED SUCH THAT DIMENSION "A" (CASE II) WOULD EXCEED 4', THE BRICKWORK SHALL BE REMOVED TO THE HIGHEST POINT OF THE VERTICAL WALL AND THE MANHOLE RECONSTRUCTED PER S-a-201 OR S-a-204.
5. WHEN THE DEPTH OF THE MANHOLE TO BE LOWERED IS SUCH THAT THE MAXIMUM ALLOWABLE SLOPES FOR THE BRICKWORK SHOWN FOR CASE I WOULD BE EXCEEDED. THE MANHOLE SHALL BE RECONSTRUCTED AS A TYPE "C" MANHOLE PER S-a-203.
6. MANHOLE STEPS, PER S-a-209, SHALL BE PLACED UNIFORMLY SO AS NOT TO BE MORE THAN 16 INCHES APART WITH THE TOP STEP BEING 16 INCHES BELOW THE MANHOLE FRAME.
7. PRIOR TO COMMENCING WORK OF RECONSTRUCTION, THE CONTRACTOR SHALL CONTACT DISTRICTS' SUPERINTENDENT OF MAINTENANCE AT (323) 774-7272.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

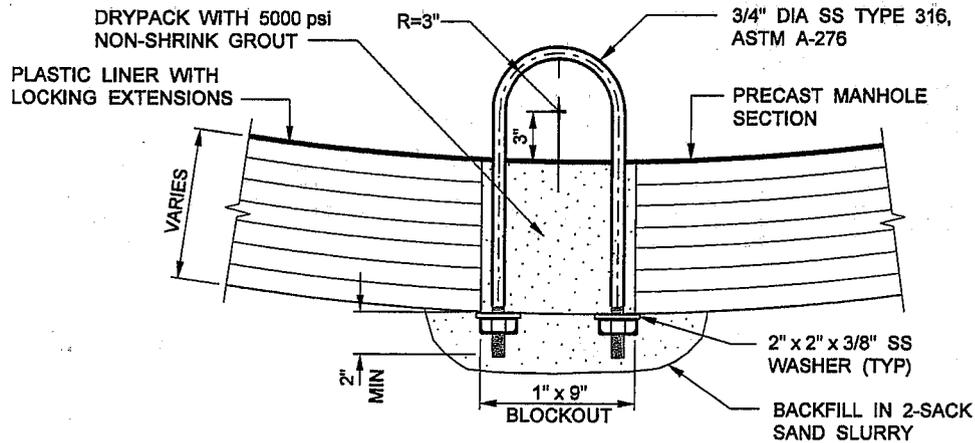
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD RECONSTRUCTION  
OF BRICK MANHOLES**

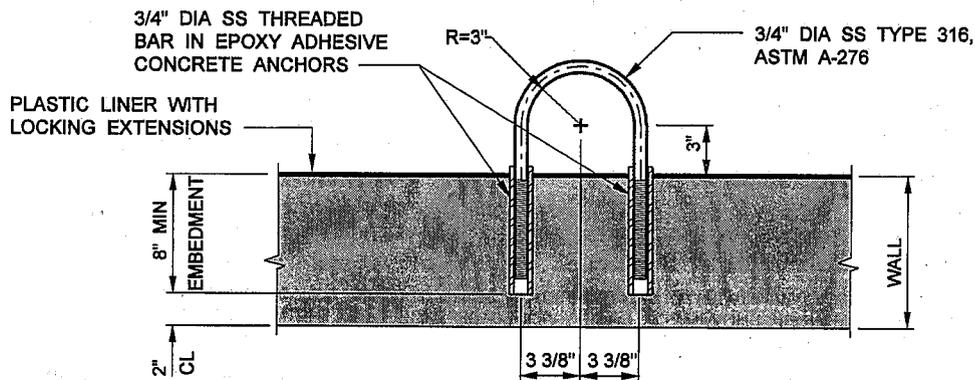
STANDARD DRAWING  
2006 EDITION  
**S - a - 219**  
SHEET 1 OF 1



**FOR CONCRETE STRUCTURE OR  
TYPE "A" MANHOLE WALL**



**FOR PRECAST MANHOLE SECTION OR  
CONCRETE WALL LESS THAN 8"**



**ALTERNATE PULL RING FOR  
CONCRETE STRUCTURE**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

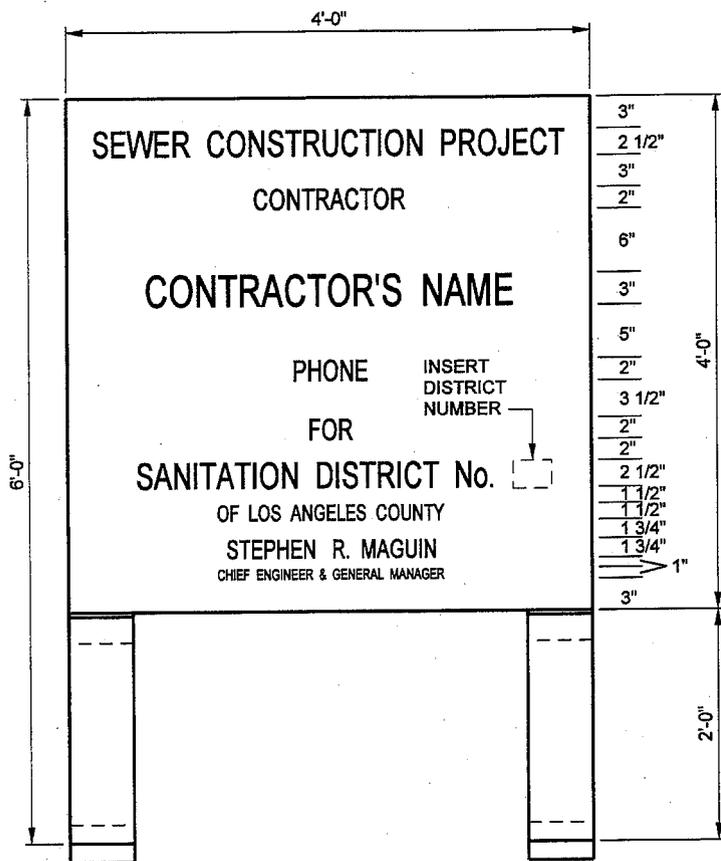
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD PULL RING**

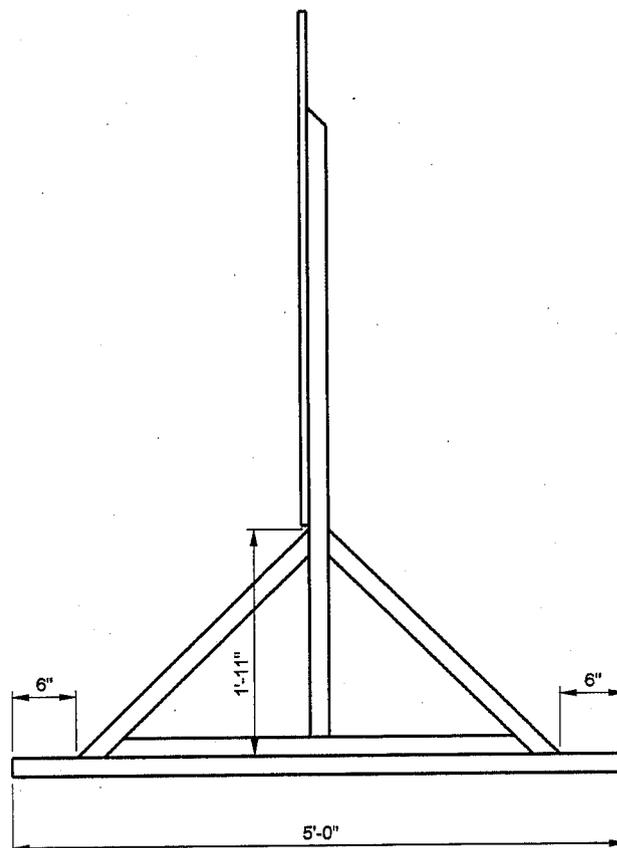
STANDARD DRAWING  
2006 EDITION

**S - a - 220**

SHEET 1 OF 1



FRONT VIEW



SIDE VIEW

NOTES:

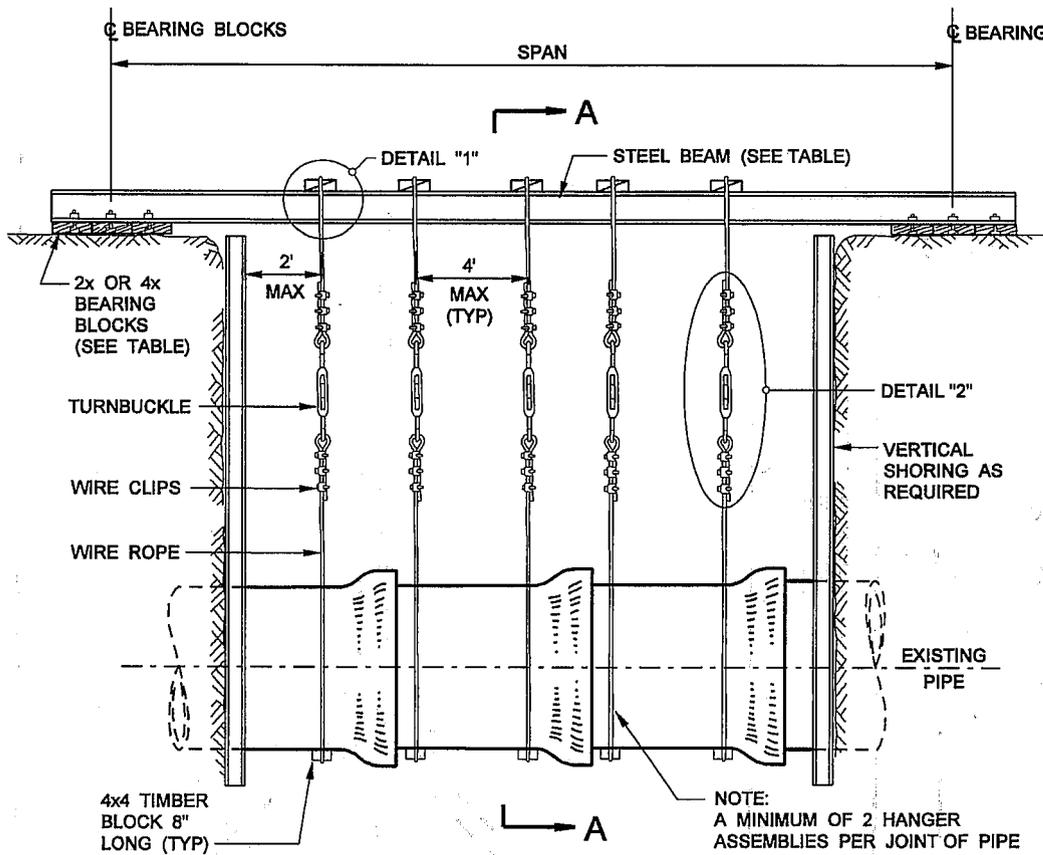
1. ALL FRAMING LUMBER SHALL BE 2" x 6" S4S D.F.
2. ENTIRE SIGN, INCLUDING FRAMING, SHALL BE PAINTED WITH TWO COATS OF EXTERIOR OIL BASE WHITE PAINT.
3. LETTERING SHALL BE DONE IN BLACK BY QUALIFIED SIGN PAINTER AND TO THE SATISFACTION OF THE ENGINEER.
4. SIGNS SHALL BE MAINTAINED IN A CONDITION SATISFACTORY TO THE ENGINEER.
5. SIGNS SHALL BE FURNISHED BY CONTRACTOR AND INSTALLED AND MOVED BY CONTRACTOR AS DIRECTED BY THE ENGINEER. NO CONSTRUCTION SHALL COMMENCE UNTIL SIGNS ARE IN PLACE. TWO REQUIRED.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

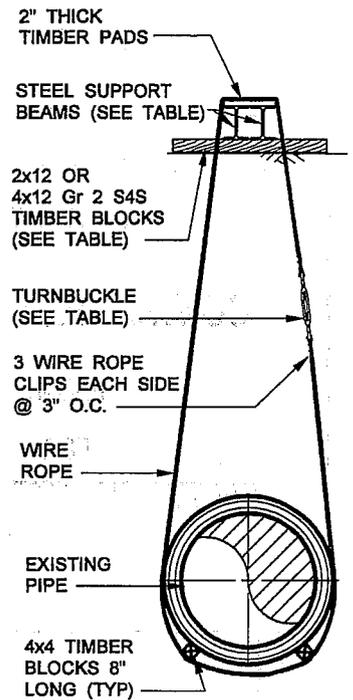
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD PROJECT SIGN**

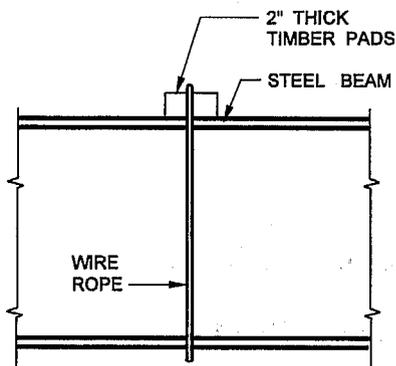
STANDARD DRAWING  
2006 EDITION  
**S - a - 2 2 1**  
SHEET 1 OF 1



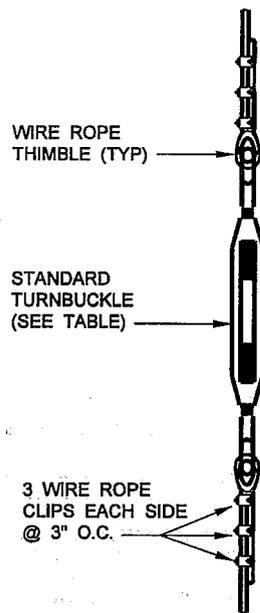
**ELEVATION**



**SECTION A-A**



**DETAIL "1"**



**DETAIL "2"**

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD TEMPORARY PIPE SUPPORT**

STANDARD DRAWING  
2006 EDITION  
S - a - 2 2 2  
SHEET 1 OF 2

**TABLE OF MEMBER SIZES (PART I)**

PIPE SIZE	STEEL BEAMS					WIRE ROPE	TURNBUCKLE
	SPAN						
	0' - 10'	11' - 15'	16' - 20'	21' - 30'	31' - 40'		
8" - 10"	w 6 x 9	w 6 x 9	w 6 x 9	w 8 x 18	w 10 x 22	3/8"	1/2"
12" - 15"	w 6 x 9	w 6 x 15	w 6 x 20	w 10 x 22	w 12 x 30	3/8"	1/2"
18" - 21"	w 6 x 9	w 8 x 18	w 8 x 24	w 10 x 33	w 12 x 53	3/8"	1/2"
24" - 27"	w 6 x 15	w 8 x 18	w 8 x 28	w 12 x 40	w 12 x 72	3/8"	1/2"
30"	w 6 x 15	w 8 x 18	w 8 x 31	w 12 x 53	2 - w 12 x 53	1/2"	5/8"
33"	w 8 x 18	w 8 x 24	w 10 x 33	w 12 x 65	2 - w 12 x 65	1/2"	5/8"
36"	w 8 x 18	w 10 x 22	w 10 x 33	w 12 x 72	2 - w 12 x 65	1/2"	5/8"
39"	w 8 x 18	w 10 x 22	w 10 x 39	w 12 x 72	2 - w 12 x 72	1/2"	5/8"
42"	w 8 x 18	w 10 x 22	w 10 x 49	w 12 x 79	2 - w 14 x 61	1/2"	5/8"
48"	w 8 x 18	w 12 x 30	w 12 x 53	---	---	1/2"	5/8"
54"	w 10 x 22	w 12 x 30	w 12 x 53	---	---	5/8"	3/4"
60"	w 10 x 22	w 12 x 40	w 12 x 65	---	---	5/8"	3/4"
66"	w 10 x 33	w 12 x 53	2 - w 12 x 53	---	---	5/8"	3/4"
72"	w 12 x 30	w 12 x 53	2 - w 12 x 65	---	---	5/8"	7/8"

**TABLE OF MEMBER SIZES (PART II)**

PIPE SIZE	BEARING BLOCKS				
	SPAN				
	0' - 10'	11' - 15'	16' - 20'	21' - 30'	31' - 40'
8" - 10"	1 - 2 x 12 x 2'	1 - 2 x 12 x 2'	2 - 2 x 12 x 2'	2 - 2 x 12 x 2'	2 - 2 x 12 x 2'
12" - 15"	1 - 2 x 12 x 2'	1 - 2 x 12 x 2'	2 - 2 x 12 x 2'	2 - 2 x 12 x 2'	2 - 4 x 12 x 3'
18" - 21"	1 - 2 x 12 x 2'	1 - 2 x 12 x 3'	2 - 2 x 12 x 3'	2 - 4 x 12 x 3'	2 - 4 x 12 x 4'
24" - 27"	1 - 2 x 12 x 3'	2 - 2 x 12 x 2'	2 - 2 x 12 x 3'	2 - 4 x 12 x 5'	3 - 4 x 12 x 4'
30"	1 - 2 x 12 x 3'	2 - 2 x 12 x 3'	2 - 4 x 12 x 4'	3 - 4 x 12 x 4'	3 - 4 x 12 x 5'
33"	2 - 2 x 12 x 2'	2 - 2 x 12 x 3'	2 - 4 x 12 x 4'	3 - 4 x 12 x 5'	3 - 4 x 12 x 6'
36"	2 - 2 x 12 x 2'	2 - 2 x 12 x 3'	2 - 4 x 12 x 4'	3 - 4 x 12 x 5'-6"	4 - 4 x 12 x 5'-6"
39"	2 - 2 x 12 x 3'	2 - 4 x 12 x 4'	2 - 4 x 12 x 5'	4 - 4 x 12 x 5'	4 - 4 x 12 x 6'
42"	2 - 2 x 12 x 3'	2 - 4 x 12 x 4'	2 - 4 x 12 x 5'	4 - 4 x 12 x 5'-6"	4 - 4 x 12 x 6'-6"
48"	2 - 4 x 12 x 4'	2 - 4 x 12 x 5'	3 - 4 x 12 x 5'	---	---
54"	2 - 4 x 12 x 4'	2 - 4 x 12 x 5'	3 - 4 x 12 x 5'	---	---
60"	2 - 4 x 12 x 4'	3 - 4 x 12 x 5'	3 - 4 x 12 x 5'	---	---
66"	2 - 4 x 12 x 5'	3 - 4 x 12 x 5'	3 - 4 x 12 x 6'	---	---
72"	2 - 4 x 12 x 5'	3 - 4 x 12 x 5'	4 - 4 x 12 x 5'	---	---

**NOTES:**

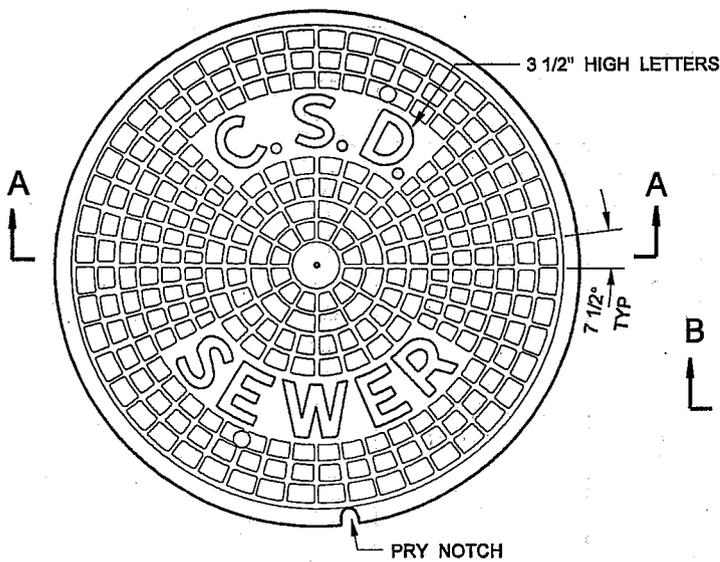
1. FORTY-EIGHT HOURS PRIOR TO COMMENCING CONSTRUCTION OF THE TEMPORARY SUPPORT, THE CONTRACTOR SHALL CONTACT THE DISTRICT SUPERINTENDENT OF MAINTENANCE AT (323) 774-7272.
2. APPROVAL SHALL BE OBTAINED FROM THE COUNTY SANITATION DISTRICT REPRESENTATIVE OF THE SPAN TO BE USED IN DETERMINING THE SIZE OF THE STEEL BEAM.
3. ALL WORK ON THE TEMPORARY SUPPORT SHALL BE DONE ONLY IN THE PRESENCE OF THE COUNTY SANITATION DISTRICT REPRESENTATIVE.
4. THE CONTRACTOR SHALL BE COMPLETELY RESPONSIBLE FOR THE ADEQUACY OF THE TEMPORARY SUPPORT AND FOR THE MANNER IN WHICH IT IS INSTALLED.
5. FOR PIPES AND MEMBER SIZES NOT SHOWN IN THE ABOVE TABLES, THE CONTRACTOR SHALL SUBMIT DETAILS OF THE PROPOSED SUPPORT AND CALCULATIONS PREPARED BY CIVIL/STRUCTURAL ENGINEER REGISTERED IN THE STATE OF CALIFORNIA TO THE COUNTY SANITATION DISTRICT REPRESENTATIVE FOR WRITTEN APPROVAL PRIOR TO COMMENCING CONSTRUCTION.
6. APPROVAL SHALL BE OBTAINED FROM THE COUNTY SANITATION DISTRICT REPRESENTATIVE PRIOR TO USING MEMBERS OR PARTS OF THE TEMPORARY SUPPORT DIFFERENT THAN DETAILED.
7. LARGER STEEL BEAMS WITH CORRESPONDINGLY LARGER SECTION MODULI MAY BE SUBSTITUTED.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

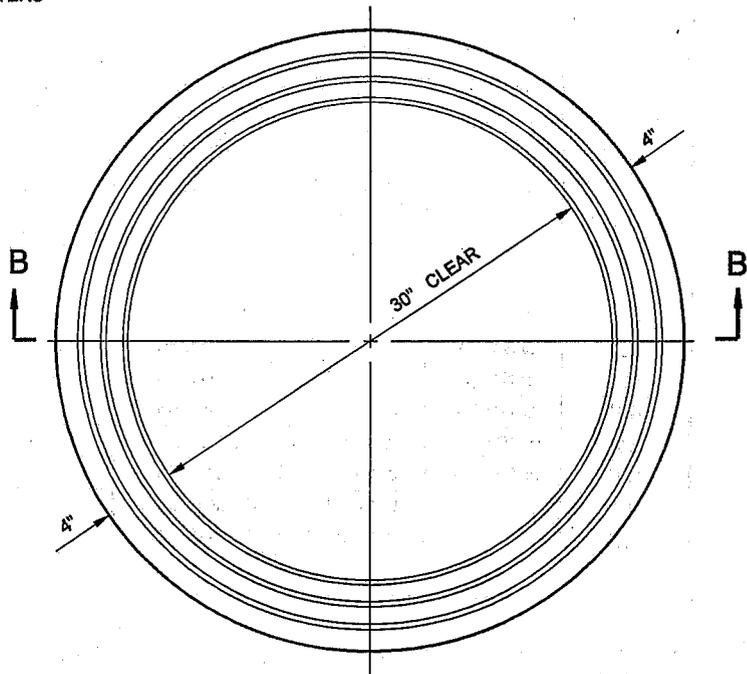
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD TEMPORARY PIPE SUPPORT**

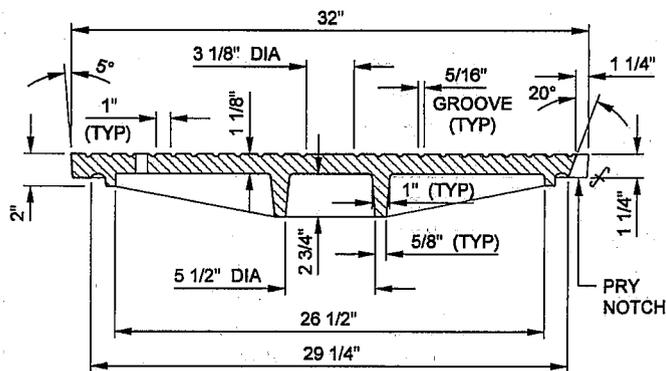
STANDARD DRAWING  
2006 EDITION  
**S - a - 2 2 2**  
SHEET 2 OF 2



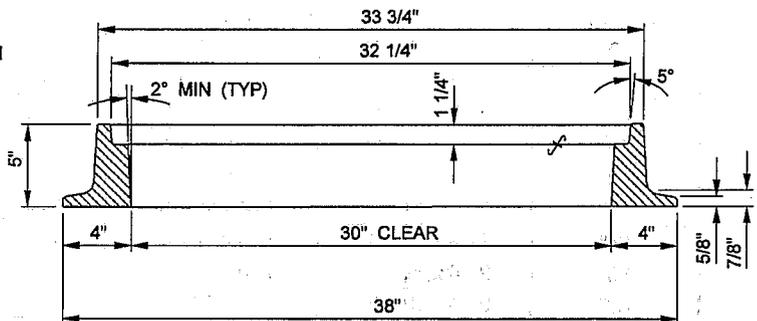
**PLAN OF COVER**  
TOP VIEW



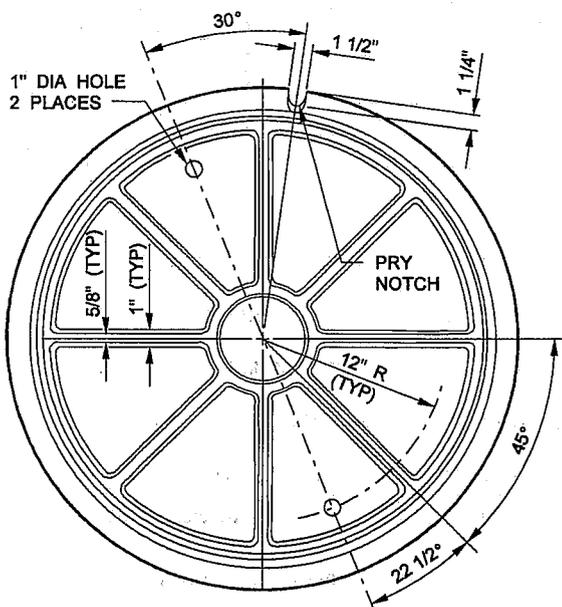
**PLAN OF FRAME**



**SECTION A-A**



**SECTION B-B**



**PLAN OF COVER**  
BOTTOM VIEW

**NOTES:**

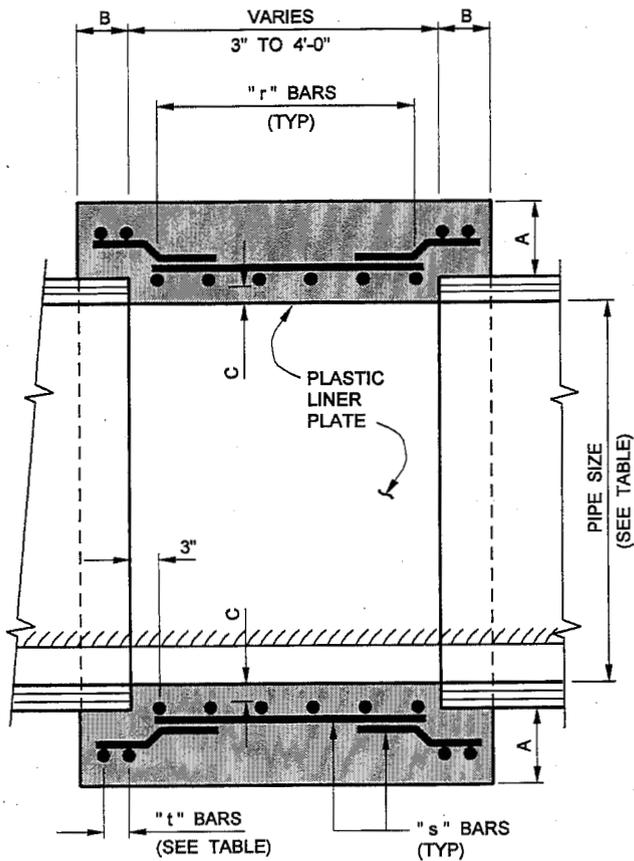
1. CAST IRON USED SHALL CONFORM WITH ASTM A-48 CLASS 35B.
2. FRAME AND COVER SHALL BE COATED WITH ASPHALTUM OR BITUMINOUS PAINT AFTER TESTING AND INSPECTION.
3. FRAME AND COVER SHALL BE TESTED FOR ACCURATE FIT PRIOR TO DELIVERY AND SHALL BE MARKED IN SETS.
4. ALL CASTINGS SHALL COMPLY WITH SECTION 206-3 OF THE STANDARD SPECIFICATIONS.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

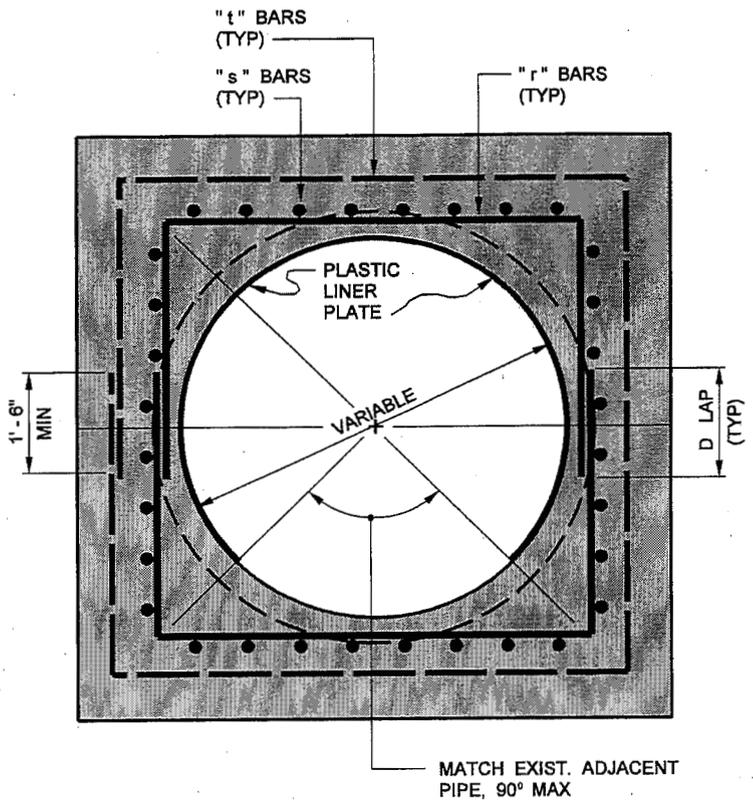
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD 30" MANHOLE FRAME  
AND COVER**

STANDARD DRAWING  
2008 EDITION  
**S - a - 2 2 3**  
SHEET 1 OF 1



**LONGITUDINAL SECTION**



**CROSS SECTION**

**TABLE OF REINFORCING BARS**

PIPE SIZE	DEPTH TO INVERT	DIMENSIONS				REINFORCING BARS		
		A	B	C	D	"r"	"s"	"t"
24" TO 33"	0' TO 15'	6"	8"	3"	16"	#4 @ 10"	#4 @ 12"	2 - #4
	16' TO 30'					#4 @ 10"	#4 @ 8"	2 - #4
36"	0' TO 15'	6"	8"	3"	16"	#4 @ 10"	#4 @ 12"	2 - #4
	16' TO 30'					#4 @ 10"	#4 @ 6"	2 - #4
39"	0' TO 15'	6"	8"	3"	16"	#4 @ 10"	#4 @ 12"	2 - #4
	16' TO 30'					#4 @ 10"	#4 @ 6"	2 - #4
42"	0' TO 15'	7"	8"	3"	16"	#4 @ 10"	#5 @ 12"	2 - #5
	16' TO 30'				20"	#5 @ 10"	#5 @ 12"	2 - #5
48"	0' TO 15'	7"	8"	4"	16"	#4 @ 10"	#5 @ 12"	2 - #5
	16' TO 30'				20"	#5 @ 8"	#5 @ 12"	2 - #5
54"	0' TO 15'	7"	8"	4"	16"	#4 @ 8"	#5 @ 12"	2 - #5
	16' TO 30'				20"	#5 @ 8"	#5 @ 12"	2 - #5
60"	0' TO 15'	8"	8"	4"	16"	#4 @ 6"	#5 @ 12"	2 - #5
	16' TO 30'				24"	#6 @ 8"	#5 @ 12"	2 - #5
66"	0' TO 15'	8"	10"	5"	20"	#5 @ 8"	#5 @ 12"	3 - #5
	16' TO 30'				28"	#7 @ 8"	#5 @ 12"	3 - #5
72"	0' TO 15'	8"	10"	5"	20"	#5 @ 8"	#5 @ 12"	3 - #5
	16' TO 30'				28"	#7 @ 6"	#5 @ 12"	3 - #5
84"	0' TO 15'	9"	12"	5"	20"	#5 @ 8"	#5 @ 12"	3 - #6
	15' TO 30'				28"	#7 @ 6"	#5 @ 12"	3 - #6
96"	0' TO 15'	9"	12"	6"	20"	#5 @ 6"	#5 @ 9"	3 - #6
	15' TO 30'				28"	#7 @ 6"	#5 @ 9"	3 - #6

**NOTES:**

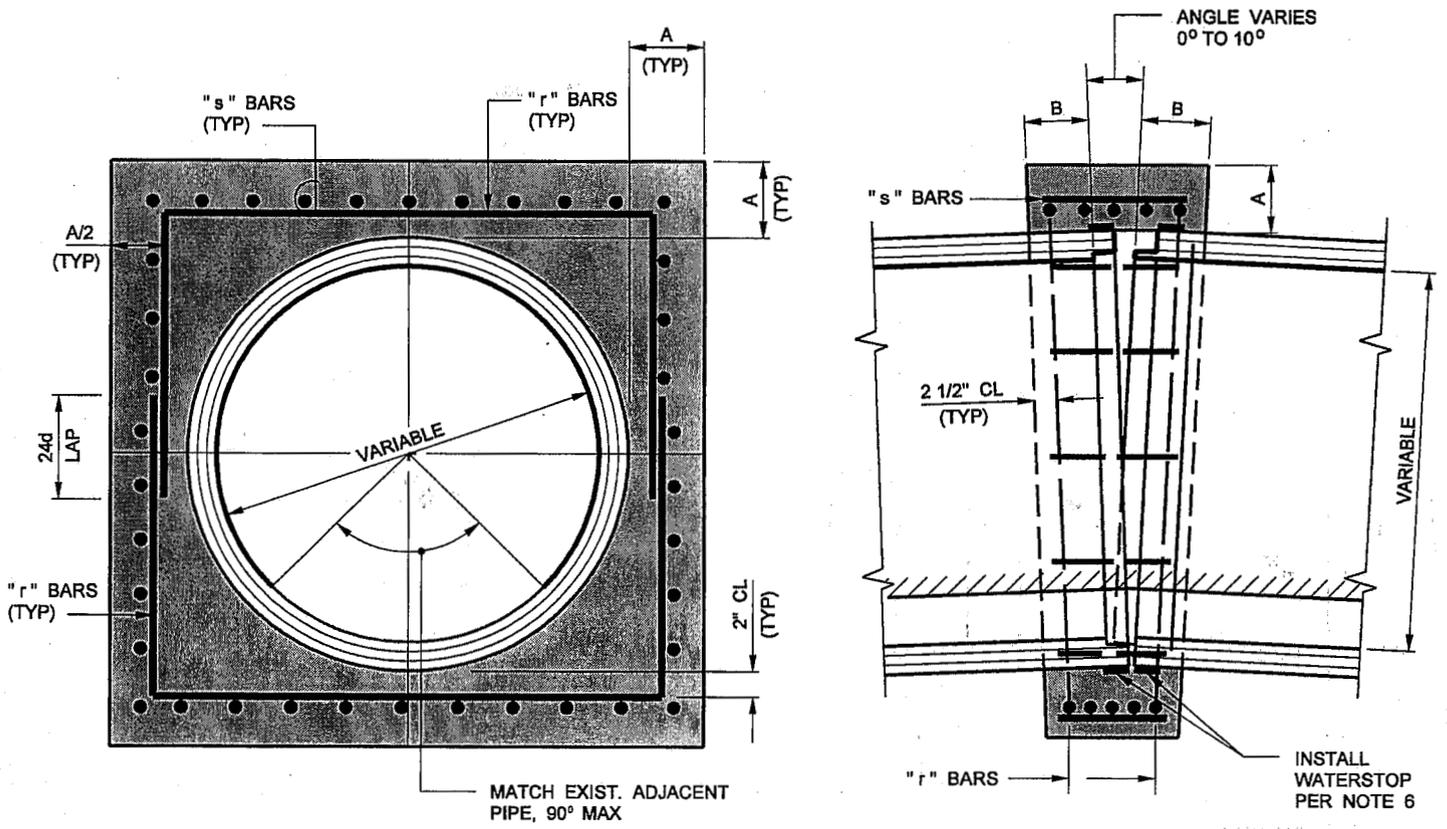
1. CONCRETE SHALL BE 660-B-4000.
2. ALL REINFORCING BARS SHALL BE ASTM A-706, CLASS 60.
3. THE CONCRETE SHALL BE CONSOLIDATED BY MEANS OF HIGH FREQUENCY INTERNAL VIBRATORS.
4. DETAIL APPLIES FOR PIPES WITH COVER FROM 3'-0" TO 30'-0" FOR TRENCH CONDITION AND FOR PIPES WITH COVER 3'-0" TO 10'-0" FOR EMBANKMENT CONDITION.
5. PIPE BARRELLING SHALL BE DONE AT LOCATIONS AND LENGTHS SHOWN ON THE DRAWINGS OR AUTHORIZED BY THE ENGINEER.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD PIPE BARREL**

STANDARD DRAWING  
2006 EDITION  
**S - a - 224**  
SHEET 1 OF 1



**CROSS SECTION**

**LONGITUDINAL SECTION**

TABLE OF REINFORCING BARS				
PIPE DIAMETER	DIMENSIONS		REINFORCING BARS	
	A	B	"r"	"s"
24" TO 36"	8"	8"	#4 @ 8	#4 @ 12
39" TO 57"	8"	10"	#6 @ 8	#5 @ 12
60" TO 78"	10"	12"	#7 @ 6	#5 @ 12
84" TO 96"	12"	16"	#7 @ 6	#5 @ 9"

**NOTES:**

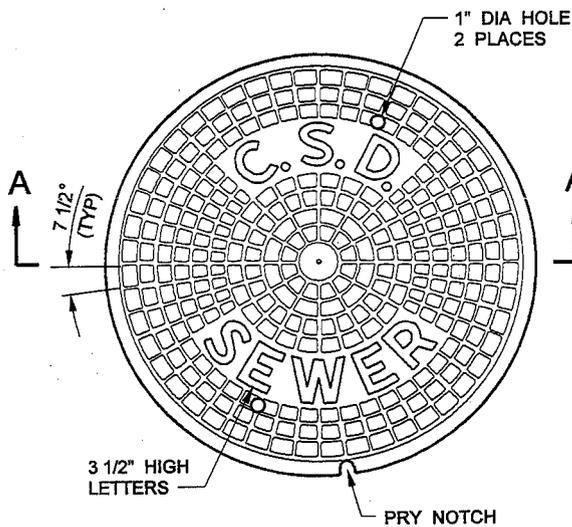
1. CONSTRUCT CONCRETE COLLAR WHERE REQUIRED ON THE DRAWINGS AND AT ALL PIPE JOINTS WHERE THERE IS A CHANGE IN THE TYPE OF JOINT OR A CHANGE IN THE THICKNESS OF THE WALLS OF ADJACENT PIPES.
2. UNLESS OTHERWISE SPECIFIED, CONCRETE SHALL BE 660-B-4000 AND ALL REINFORCING BARS SHALL BE DEFORMED BARS CONFORMING TO ASTM-A706 GRADE 60.
3. EXTERIOR SURFACES OF CONCRETE PIPE SHALL BE CLEANED BY SANDBLASTING PRIOR TO PLACING CONCRETE.
4. THE CONTRACTOR SHALL SUBMIT WORKING DRAWINGS THAT SHOW DETAILS FOR JOINING ANY PLASTIC LINERS IN ADJACENT PIECES OF PIPE.
5. FOR VITRIFIED CLAY PIPE HAVING NO ANGULAR DEFLECTION, THE CONTRACTOR MAY USE A REPAIR COUPLING AND OMIT THE REINFORCING STEEL FROM THE CONCRETE COLLAR. THE REPAIR COUPLING SHALL INCLUDE AN INTEGRAL SHEAR BAND. DETAILS OF THE REPAIR COUPLING SHALL BE SUBMITTED TO THE DISTRICTS FOR APPROVAL.
6. HYDROTITE CJ-2010-2/6 HYDROPHILIC WATERSTOP OR ADEKA MC 2010M OR EQUIVALENT. INSTALL ALL AROUND EACH PIPE.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

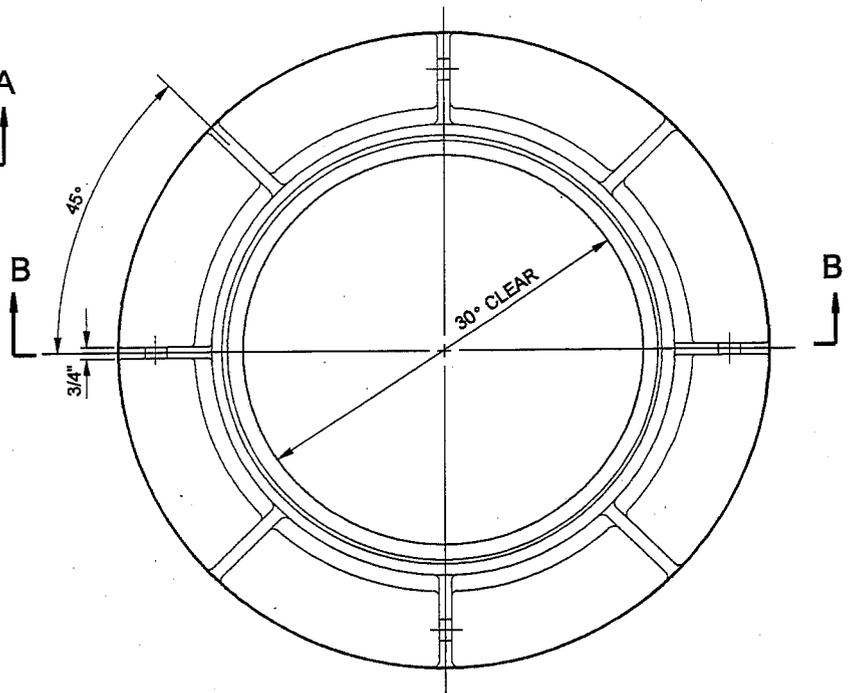
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD CONCRETE COLLAR**

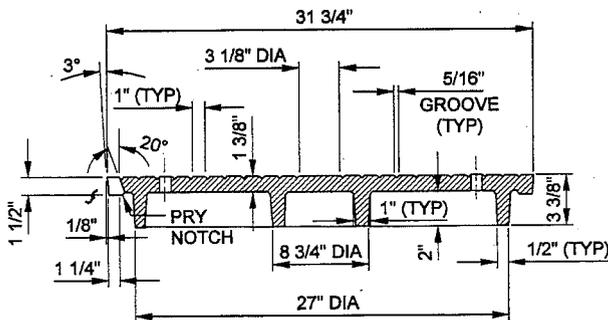
STANDARD DRAWING  
2006 EDITION  
**S - a - 225**  
SHEET 1 OF 1



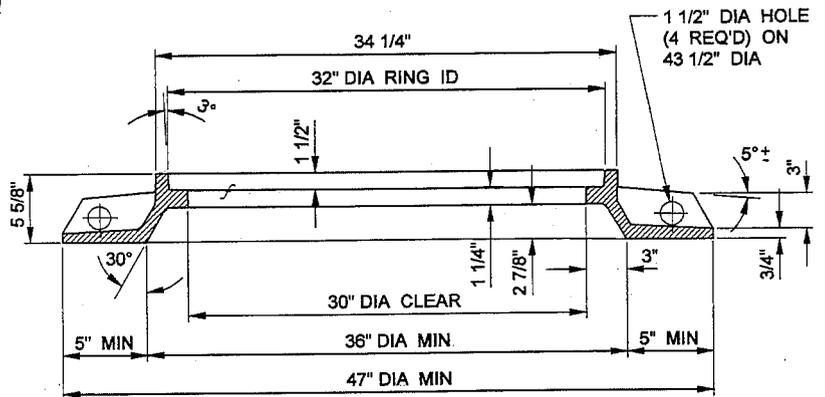
**PLAN OF COVER**  
TOP VIEW



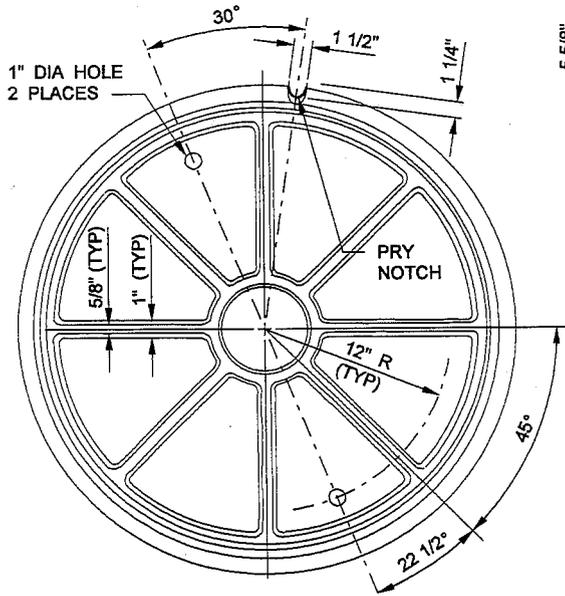
**PLAN OF FRAME**



**SECTION A-A**



**SECTION B-B**



**PLAN OF COVER**  
BOTTOM VIEW

**NOTES:**

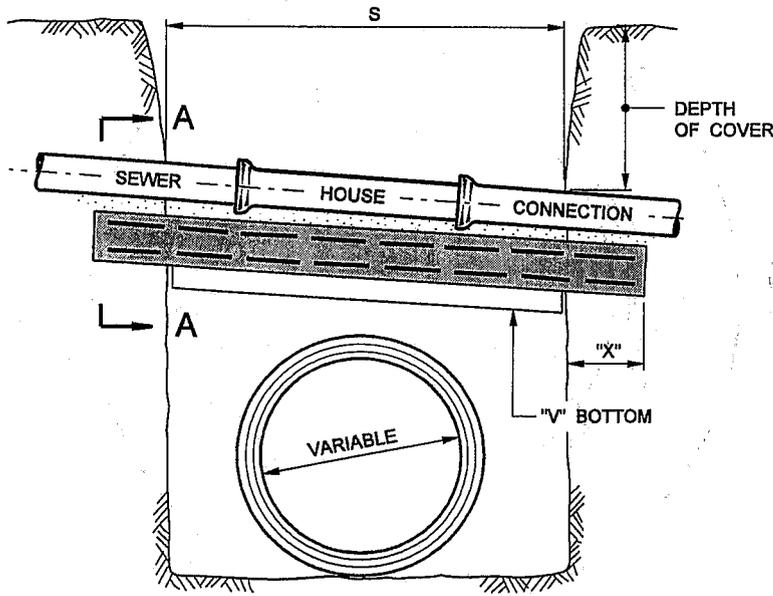
1. CAST IRON USED SHALL CONFORM WITH ASTM A-48 CLASS 35B.
2. FRAME AND COVER SHALL BE COATED WITH ASPHALTUM OR BITUMINOUS PAINT AFTER TESTING AND INSPECTION.
3. FRAME AND COVER SHALL BE TESTED FOR ACCURATE FIT PRIOR TO DELIVERY AND SHALL BE MARKED IN SETS.
4. ALL CASTINGS SHALL COMPLY WITH SECTION 206-3 OF THE STANDARD SPECIFICATIONS.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

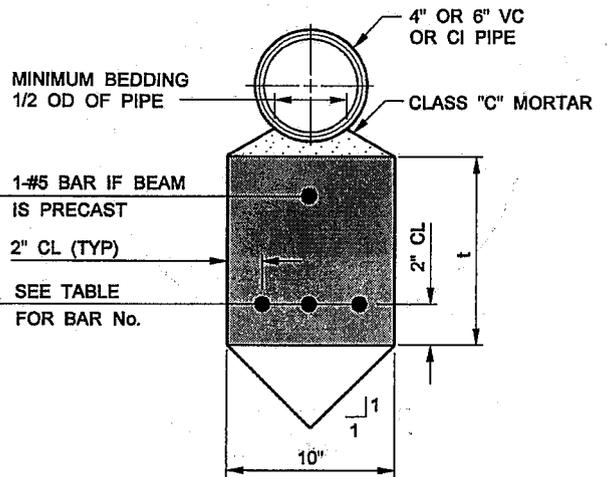
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD 36" MANHOLE FRAME  
WITH 30" COVER**

STANDARD DRAWING  
2006 EDITION  
**S - a - 2 2 6**  
SHEET 1 OF 1



**ELEVATION**



**SECTION A-A**

DIMENSIONS OF REINFORCED CONCRETE BEAM				
S (FEET)	DEPTH OF COVER			
	0 TO 8'-0"		8'-1" TO 16'-0"	
	t	BAR No.	t	BAR No.
4	8"	4	10"	5
5	9"	5	12"	5
6	10"	5	13"	6
7	11"	6	15"	6
8	12"	6	16"	6
9	13"	6	17"	7
10	14"	7	19"	7
11	15"	7	20"	7
12	16"	7	22"	7
13	17"	7	23"	8
14	18"	8	25"	8
15	19"	8	26"	8
16	20"	8	—	—
17	21"	8	—	—
18	22"	8	—	—

**NOTE:**

BEAM CONCRETE SHALL BE 060-B-4000. ALL REINFORCING BARS SHALL BE DEFORMED BARS CONFORMING TO ASTM-A706 GRADE 60. A "V" BOTTOMED BEAM AS DETAILED ABOVE SHALL BE POURED IN PLACE OR, IF APPROVED BY THE ENGINEER, A RECTANGULAR PRECAST BEAM SHALL BE PLACED ON BACKFILL WHICH HAS BEEN PREVIOUSLY CONSOLIDATED TO THE INVERT OF THE HOUSE CONNECTION AND REEXCAVATED TO ACCOMMODATE THE BEAM. IN EITHER CASE, THE BEAM SHALL BEAR ON UNDISTURBED OR CONSOLIDATED SOIL.

MINIMUM LENGTH OF BEARING OF ENDS OF REINFORCED CONCRETE BEAMS		
DEPTH OF COVER	S	MIN BEARING - "X"
0 TO 8'-0"	0 TO 12'-0"	18"
	12'-1" TO 18'-0"	24"
8'-1" TO 16'-0"	0 TO 7'-0"	18"
	7'-1" TO 11'-0"	24"
	11'-1" TO 15'-0"	30"

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

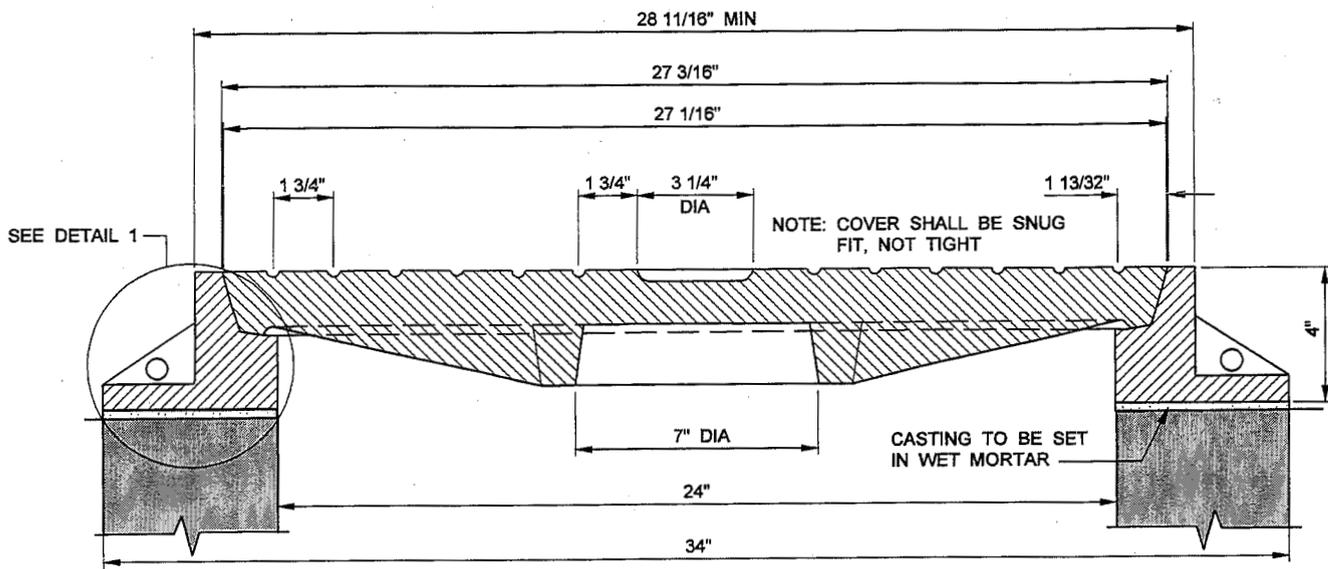
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD CONCRETE BEAM FOR  
HOUSE CONNECTIONS**

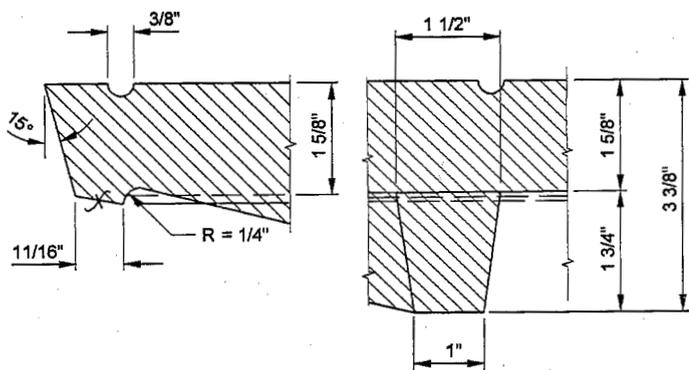
STANDARD DRAWING  
2006 EDITION

**S - a - 227**

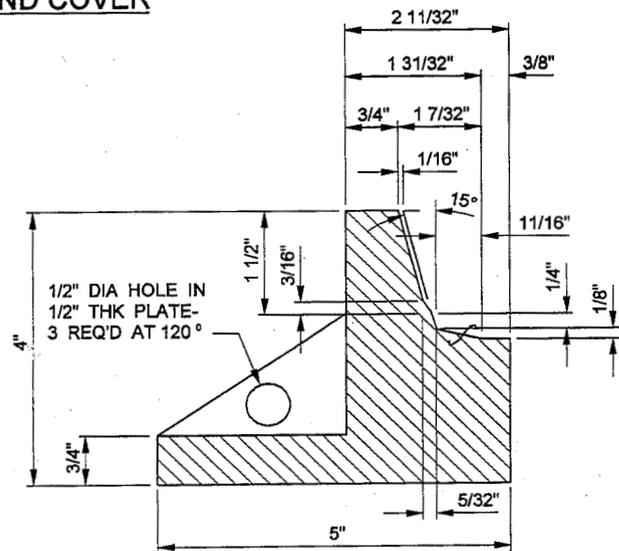
SHEET 1 OF 1



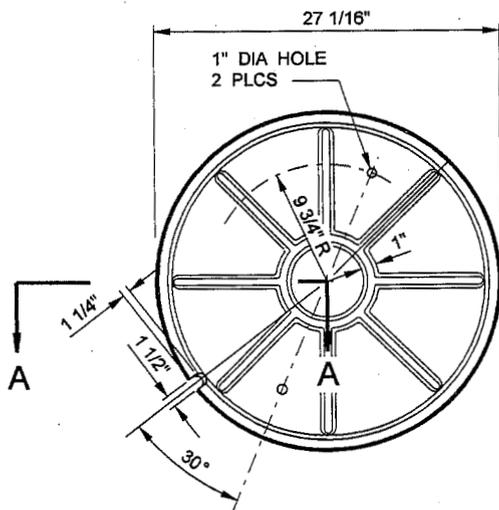
**SECTION  
MANHOLE FRAME AND COVER**



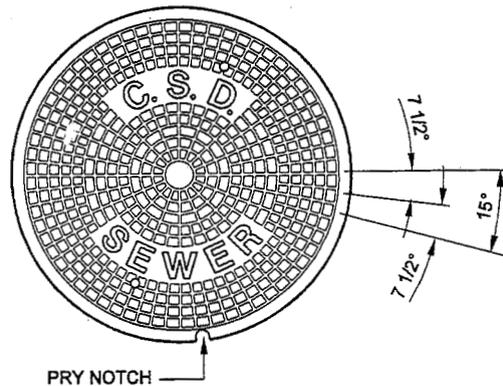
**SECTION A-A**



**DETAIL 1**



**PLAN OF COVER  
BOTTOM VIEW**



**PLAN OF COVER  
TOP VIEW**

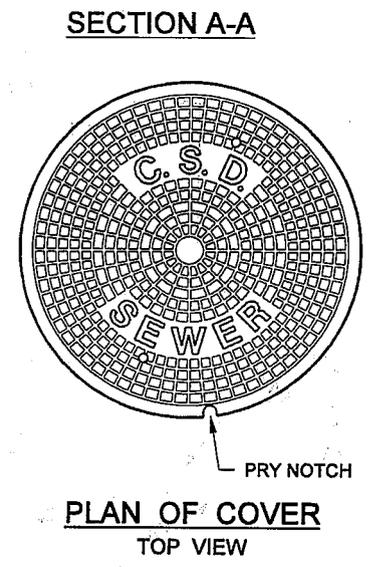
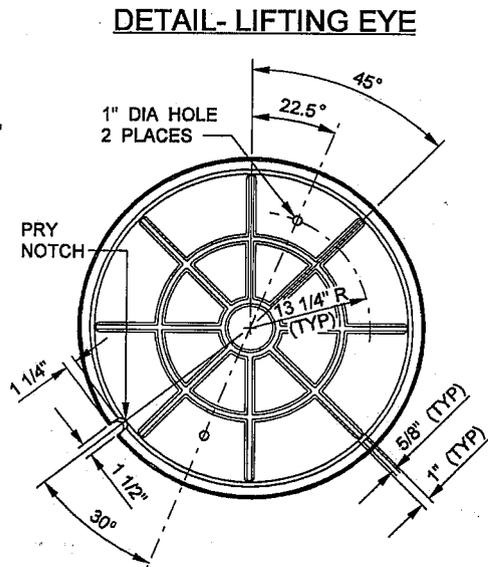
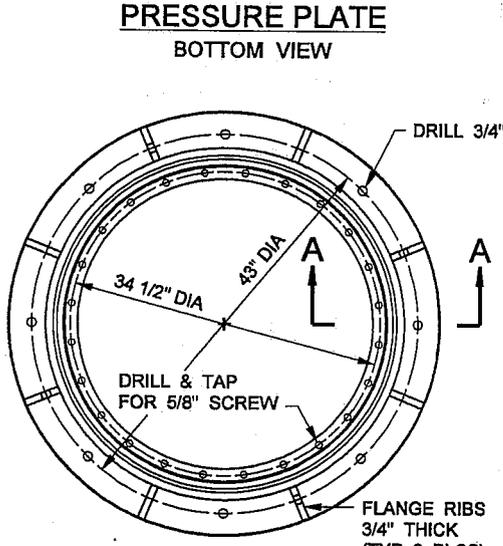
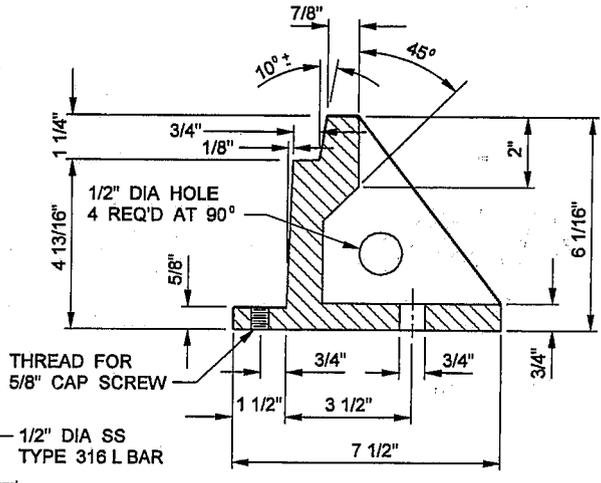
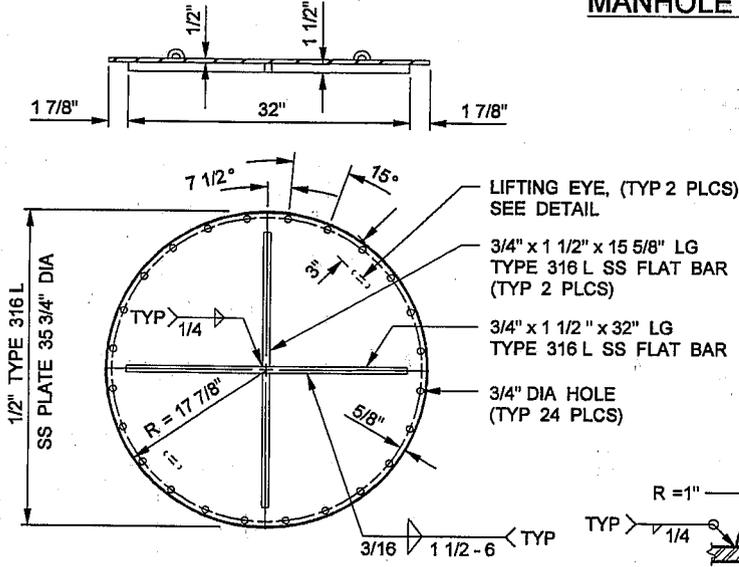
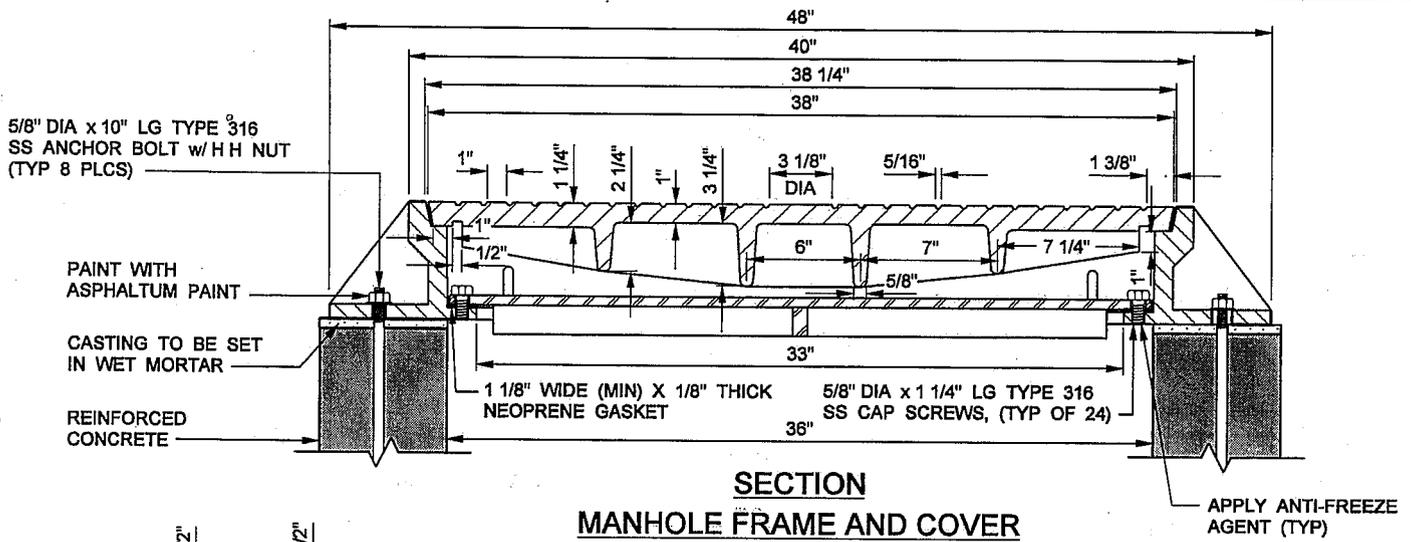
**NOTE:**  
FOR NOTES SEE S-a-207.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD 24" TRAFFIC MANHOLE  
FRAME AND COVER**

STANDARD DRAWING  
2006 EDITION  
**S-a-228**  
SHEET 1 OF 1



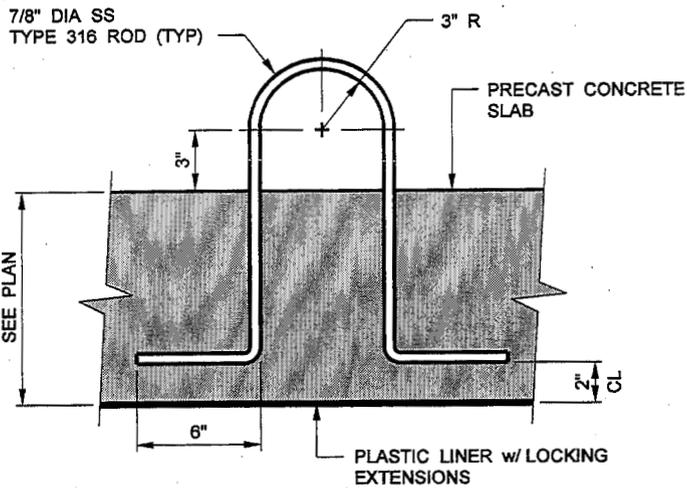
**NOTE:**  
FOR NOTES SEE S-a-207.

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

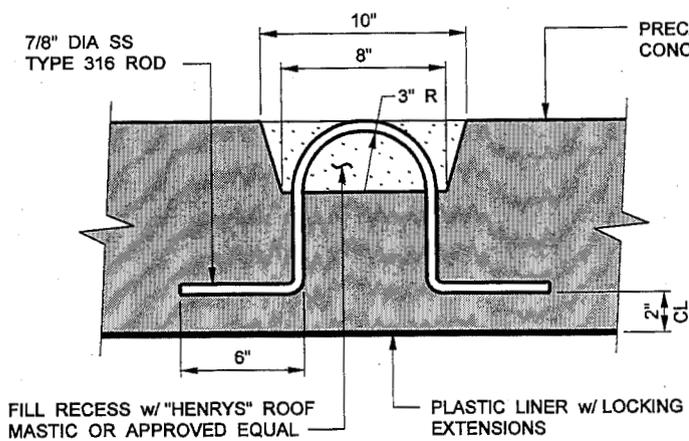
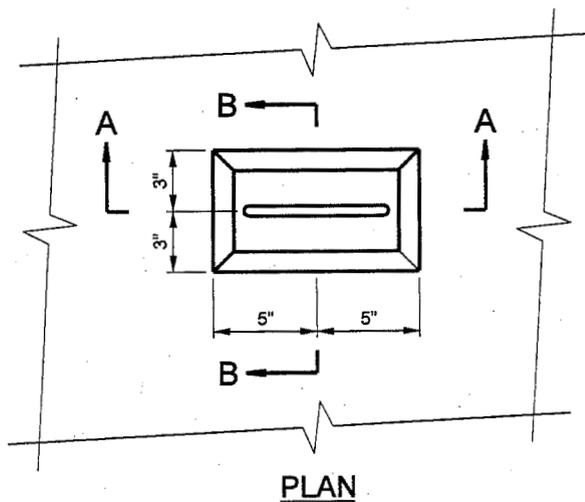
STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD 36" PRESSURE MANHOLE  
FRAME AND COVER**

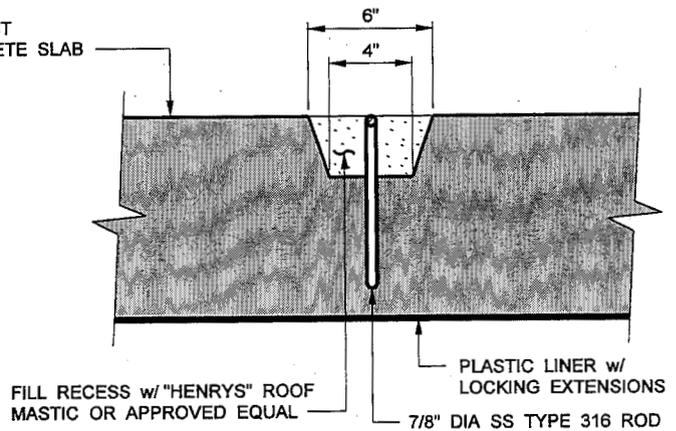
STANDARD DRAWING  
2006 EDITION  
**S-a-229**  
SHEET 1 OF 1



**TYPE I LIFTING EYE DETAIL**



**SECTION A-A**



**SECTION B-B**

**TYPE II LIFTING EYE DETAIL**  
(FOR COVER LESS THAN 12" THICK)

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY  
OFFICE OF CHIEF ENGINEER

STEPHEN R. MAGUIN  
CHIEF ENGINEER

**STANDARD LIFTING EYE**

STANDARD DRAWING  
2006 EDITION  
**S - a - 230**  
SHEET 1 OF 1



# **INFORMATION HANDOUT**

## **BATTERY BACKUP SYSTEM CONNECTION DIAGRAMS**

**CONTRACT No. 07-2159C1**

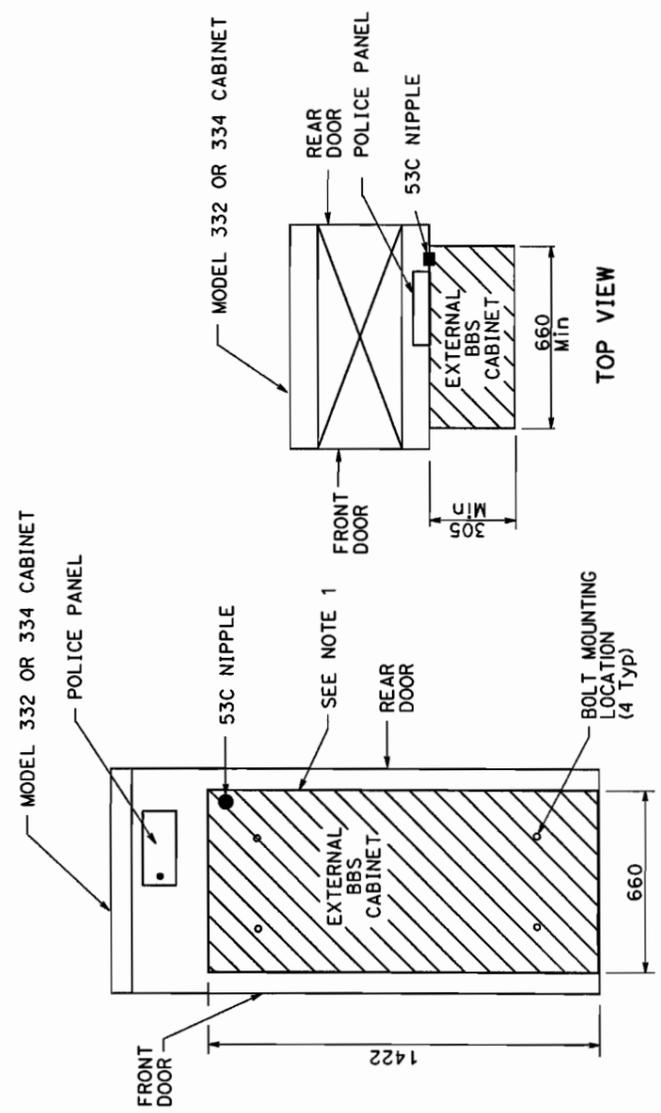
**Caltrans**  
**metric**

REGISTERED PROFESSIONAL ENGINEER  
 Theresa Gabriel  
 No. E15129  
 Exp. 6-30-10  
 STATE OF CALIFORNIA  
 ELECTRIC

REGISTERED PROFESSIONAL ENGINEER  
 Theresa Gabriel  
 No. E15129  
 Exp. 6-30-10  
 STATE OF CALIFORNIA  
 ELECTRIC

PLANS APPROVAL DATE: 12-20-07  
 REGISTERED PROFESSIONAL ENGINEER DATE: 12-20-07

KILOMETER POST TOTAL SHEET TOTAL  
 TOTAL PROJECT NO. SHEETS



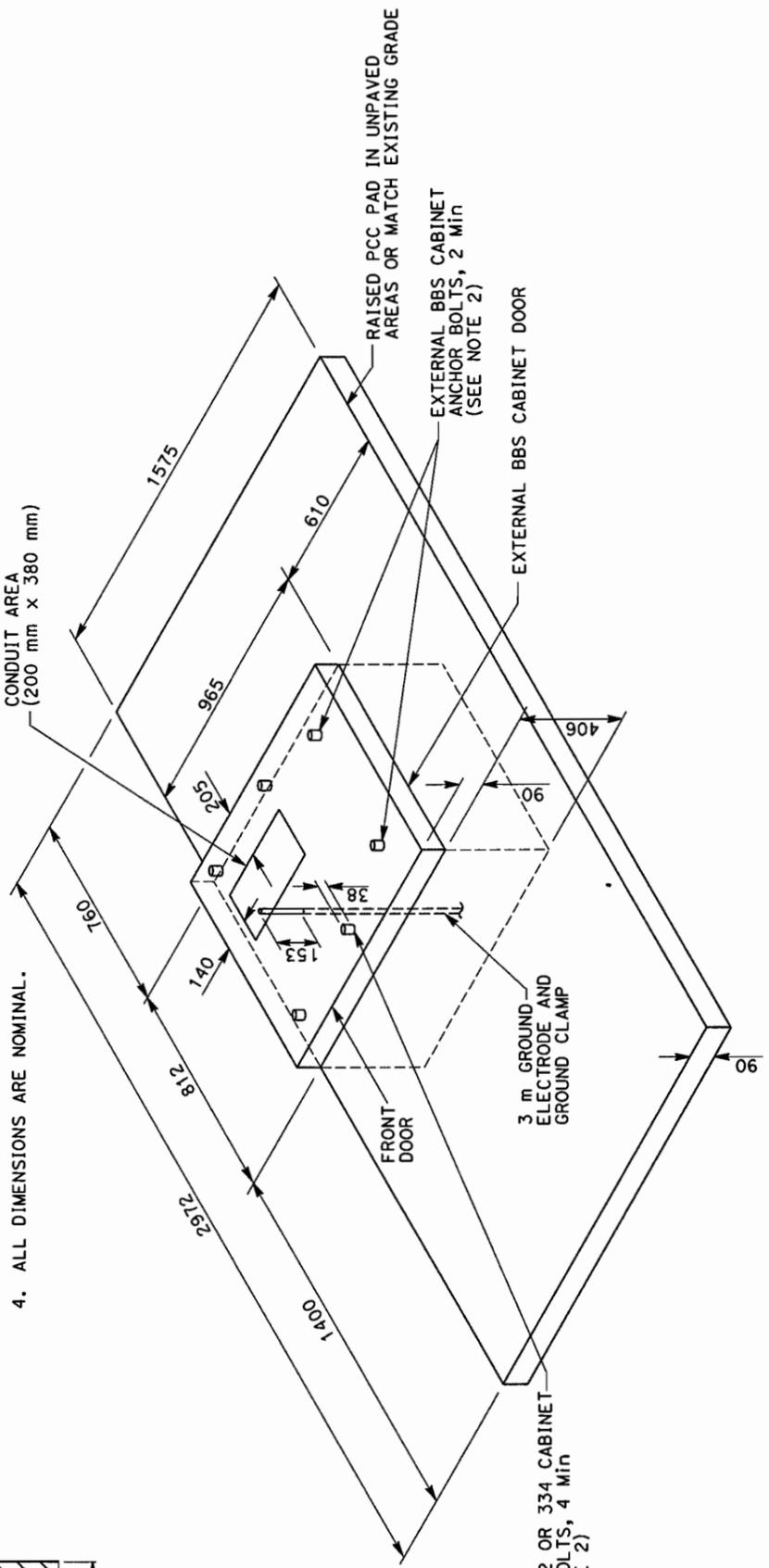
**EXTERNAL BBS CABINET MOUNTED TO THE MODEL 332 OR 334 CABINET**

SIDE VIEW

TOP VIEW

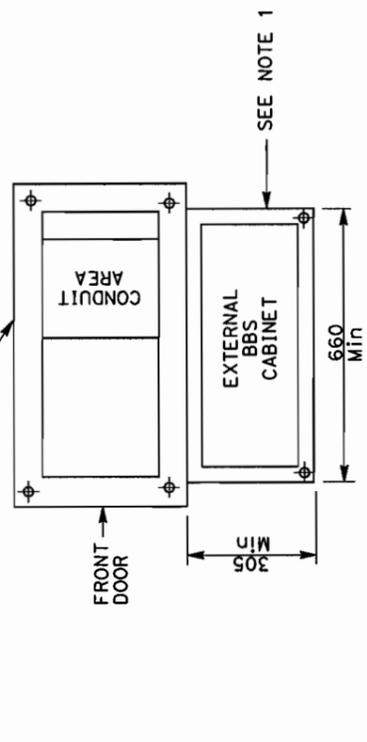
**NOTE: (THIS SHEET ONLY)**

1. THE EXTERNAL BBS CABINET SHALL BE MOUNTED TO THE MODEL 332 OR 334 CABINET WITH FOUR 18-8 STAINLESS STEEL HEX HEAD, FULLY-THREADED, 9.5 mm-16 X 25.4 mm BOLTS; TWO WASHERS PER BOLT, DESIGNED FOR 9.5 mm BOLTS AND ARE 18-8 STAINLESS STEEL, 25.4 mm OUTSIDE DIAMETER, ROUND, AND FLAT; AND ONE K-LOCK NUT PER BOLT, THAT IS 18-8 STAINLESS STEEL AND A HEX-NUT. THE ENGINEER WILL HAVE TO APPROVE THE BOLT MOUNTING LOCATION PRIOR TO INSTALLATION.
2. THE ANCHOR BOLTS SHALL BE 19 mm Dia X 380 mm WITH A 50 mm-90° BEND. THE CABINET MANUFACTURER'S SPECIFICATION SHALL DETERMINE THE LOCATION OF THE ANCHOR BOLTS IN THE FOUNDATION. THE ENGINEER WILL HAVE TO APPROVE ANCHOR BOLTS AND ITS LOCATION IN THE FOUNDATION PRIOR TO CONSTRUCTION.
3. THE CONTRACTOR SHALL VERIFY THE DIMENSIONS OF THE BBS CABINET PRIOR TO CONSTRUCTING THE FOUNDATION OF THE MODIFIED PORTION OF THE STD MODEL 332 AND 334 CABINET FOUNDATION. THE ENGINEER WILL HAVE TO APPROVE ANY NECESSARY DEVIATIONS PRIOR TO CONSTRUCTION.
4. ALL DIMENSIONS ARE NOMINAL.



**MODIFIED MODEL 332 AND 334 CABINET FOUNDATION DETAIL FOR BATTERY BACKUP SYSTEM (BBS)**

(FOR DIMENSIONS AND DETAILS NOT SHOWN AND ADDITIONAL NOTES, SEE SHEET ES-3C OF THE STANDARDS PLANS FOR MODEL 332 AND 334 CABINETS)



**BASE PLAN FOR BBS MOUNTED TO THE MODEL 332 OR 334 CABINET**

(FOR DIMENSIONS AND DETAILS NOT SHOWN, SEE SHEET A6-1 TO A6-4, CABINET HOUSING DETAILS OF THE TRANSPORTATION ELECTRICAL EQUIPMENT SPECIFICATION (TEES))

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN  
**ELECTRICAL SYSTEMS**  
**(BBS FOUNDATION DETAILS)**

NO SCALE

THIS PLAN IS ACCURATE FOR ELECTRICAL WORK ONLY.

RELATIVE BORDER SCALE IS IN MILLIMETERS

CU 00000

EA 000000

USERNAME => trpliance  
 DGN FILE => BBS Foundation metric.dgn

0 20 40 60 80

Dist COUNTY ROUTE KILOMETER POST TOTAL SHEET TOTAL  
 PROJECT PROJECT NO. SHEETS

12-20-07  
 REGISTERED ELECTRICAL ENGINEER DATE

Theresa A. Gaboriel  
 No. E15129  
 REG. PROFESSIONAL ENGINEER

PLANS APPROVAL DATE  
 THE STATE OF CALIFORNIA OR ITS OFFICERS  
 OR AGENTS SHALL NOT BE RESPONSIBLE FOR  
 THE ACCURACY OR COMPLETENESS OF ELECTRONIC  
 COPIES OF THIS PLAN SHEET.

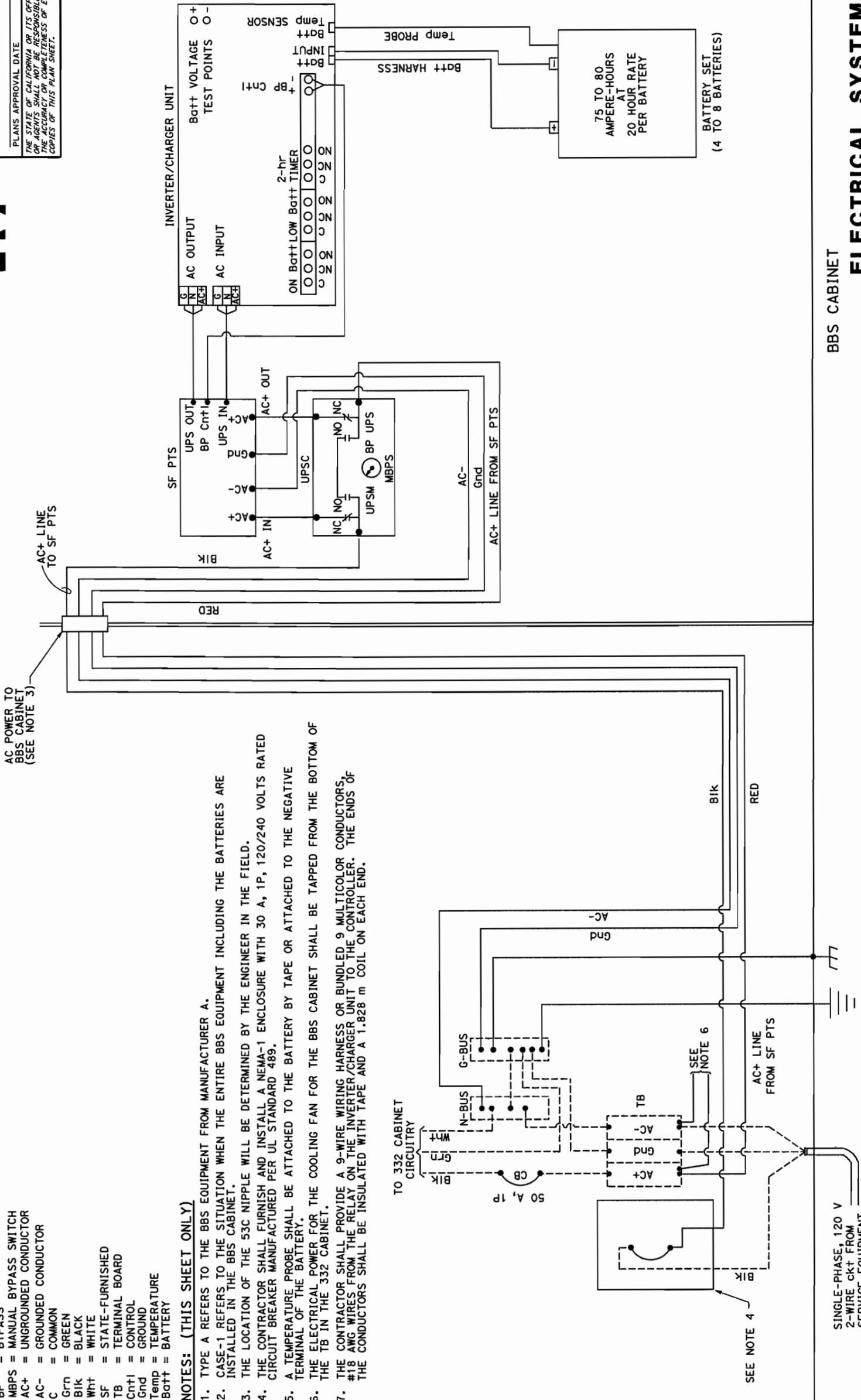


**LEGEND: (THIS SHEET ONLY)**

- PTS = POWER TRANSFER SWITCH
- UPS = UNINTERRUPTIBLE POWER SUPPLY
- UPSC = UNINTERRUPTIBLE POWER SUPPLY CONTROLLER
- UPSM = UPS MODE
- BP = BYPASS
- MBPS = MANUAL BYPASS SWITCH
- AC+ = UNGROUNDED CONDUCTOR
- AC- = GROUNDED CONDUCTOR
- C = COMMON
- Grn = GREEN
- Blk = BLACK
- Whit = WHITE
- SF = STATE-FURNISHED
- TB = TERMINAL BOARD
- Cnt+ = CONTROL
- Gnd = GROUND
- Temp = TEMPERATURE
- Batt+ = BATTERY

**NOTES: (THIS SHEET ONLY)**

1. TYPE A REFERS TO THE BBS EQUIPMENT FROM MANUFACTURER A.
2. CASE-1 REFERS TO THE SITUATION WHEN THE ENTIRE BBS EQUIPMENT INCLUDING THE BATTERIES ARE INSTALLED IN THE BBS CABINET.
3. THE LOCATION OF THE 53C NIPPLE WILL BE DETERMINED BY THE ENGINEER IN THE FIELD.
4. THE CONTRACTOR SHALL FURNISH AND INSTALL A NEMA-1 ENCLOSURE WITH 30 A, 1P, 120/240 VOLTS RATED CIRCUIT BREAKER MANUFACTURED PER UL STANDARD 489.
5. A TEMPERATURE PROBE SHALL BE ATTACHED TO THE BATTERY BY TAPE OR ATTACHED TO THE NEGATIVE TERMINAL OF THE BATTERY.
6. THE ELECTRICAL POWER FOR THE COOLING FAN FOR THE BBS CABINET SHALL BE TAPPED FROM THE BOTTOM OF THE TB IN THE 332 CABINET.
7. THE CONTRACTOR SHALL PROVIDE A 9-WIRE WIRING HARNESS OR BUNDLED 9 MULTICOLOR CONDUCTORS, #18 AWG WIRES FROM THE RELAY ON THE INVERTER/CHARGER UNIT TO THE CONTROLLER. THE ENDS OF THE CONDUCTORS SHALL BE INSULATED WITH TAPE AND A 1.828 m COIL ON EACH END.



**BBS CABINET**  
**ELECTRICAL SYSTEMS**  
**(BBS POWER CONNECTION DIAGRAM, TYPE A, CASE-1)**

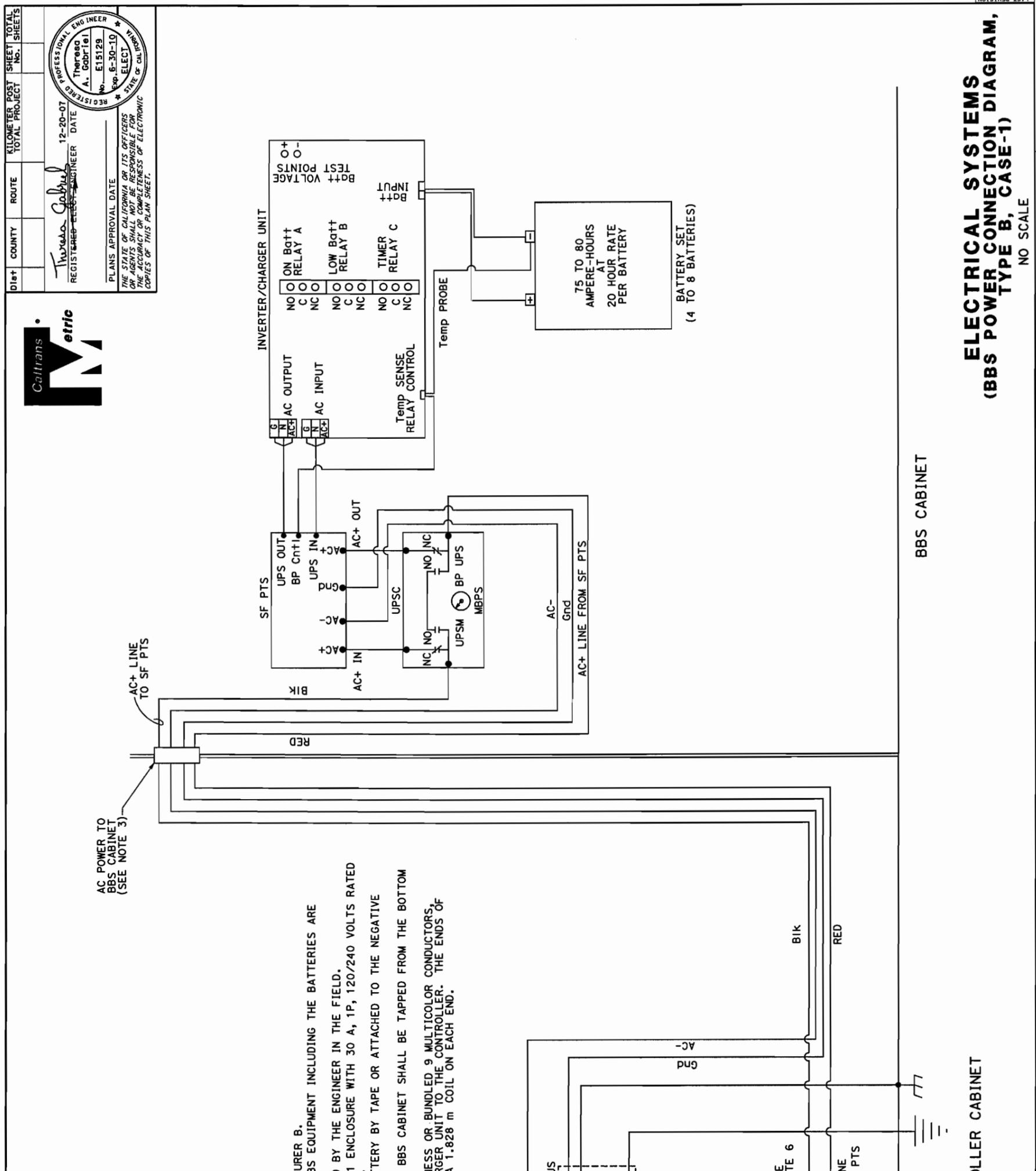
NO SCALE

**LEGEND: (THIS SHEET ONLY)**

PTS = POWER TRANSFER SWITCH  
 UPS = UNINTERRUPTIBLE POWER SUPPLY  
 UPSC = UNINTERRUPTIBLE POWER SUPPLY CONTROLLER  
 UPSM = UPS MODE  
 BP = BYPASS  
 MBPS = MANUAL BYPASS SWITCH  
 AC+ = UNGROUNDED CONDUCTOR  
 AC- = GROUNDED CONDUCTOR  
 C = COMMON  
 G/N = GREEN  
 B/K = BLACK  
 W/ht = WHITE  
 SF = STATE-FURNISHED  
 Batt+ = BATTERY  
 Temp = TEMPERATURE  
 TB = TERMINAL BOARD  
 Cnt1 = CONTROL  
 Gnd = GROUND

**NOTES: (THIS SHEET ONLY)**

- TYPE B REFERS TO THE BBS EQUIPMENT FROM MANUFACTURER B.
- CASE-1 REFERS TO THE SITUATION WHEN THE ENTIRE BBS EQUIPMENT INCLUDING THE BATTERIES ARE INSTALLED IN THE BBS CABINET.
- THE LOCATION OF THE 53C NIPPLE WILL BE DETERMINED BY THE ENGINEER IN THE FIELD.
- THE CONTRACTOR SHALL FURNISH AND INSTALL A NEMA-1 ENCLOSURE WITH 30 A, 1P, 120/240 VOLTS RATED CIRCUIT BREAKER MANUFACTURED PER UL STANDARD 489.
- A TEMPERATURE PROBE SHALL BE ATTACHED TO THE BATTERY BY TAPE OR ATTACHED TO THE NEGATIVE TERMINAL OF THE BATTERY.
- THE ELECTRICAL POWER FOR THE COOLING FAN FOR THE BBS CABINET SHALL BE TAPPED FROM THE BOTTOM OF THE TB IN THE 332 CABINET.
- THE CONTRACTOR SHALL PROVIDE A 9-WIRE WIRING HARNESS OR BUNDLED 9 MULTICOLOR CONDUCTORS, #18 AWG WIRES FROM THE RELAY ON THE INVERTER/CHARGER UNIT TO THE CONTROLLER. THE ENDS OF THE CONDUCTORS SHALL BE INSULATED WITH TAPE AND A 1.828 m COIL ON EACH END.



**Caltrans**  
**metric**

REGISTERED ELECTRICAL ENGINEER  
 12-20-07  
 No. E15129  
 Exp. 6-30-10  
 WITHOUT VOTING  
 STATE OF CALIFORNIA  
 PROFESSIONAL ENGINEER

PLANS APPROVAL DATE  
 THE STATE OF CALIFORNIA OR ITS OFFICERS  
 OR AGENCIES SHALL NOT BE RESPONSIBLE FOR  
 THE ACCURACY OR COMPLETENESS OF ELECTRONIC  
 COPIES OF THIS PLAN SHEET.

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET TOTALS
				NO. SHEETS