214-6.3 Non-Reflective Pavement Markers.

214-6.3.1 General. Non-reflective pavement markers shall be either ceramic or plastic as specified in the Special Provisions or shown on the Plans.

The bottom of each marker shall be free from gloss or glaze and shall have between 50 and 200 integrally formed protrusions or indentations approximately 50 mils (1.25 mm) high projecting from the surface in a uniform pattern. The tips of the protrusions shall not deviate more than 50 mils (1.25 mm) from a flat surface. Each protrusion shall have a face parallel to the bottom of the marker and shall project approximately 40 mils (1 mm). The area of each parallel face shall be between 0.01 and 0.065 square inches (6 and 42 mm^2) and the combined area of these faces shall be between 2.2 and 4 square inches (1420 and 2580 mm^2). 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 1/8 inch (3 mm) may have an additional taper not exceeding 30 degrees from perpendicular to the marker bottom and exceeding no more than 1/2 the total height of the protrusion.

The top surface of each marker shall be convex and the radius of curvature shall be between 3-1/2 inches (88 mm) and 6 inches (150 mm), except that the radius within 1/2 inch (12.5 mm) of the 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 that will affect the adhesion or appearance.

214-6.3.2 Ceramic Non-Reflective Pavement Markers. Ceramic non-reflective 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. Markers shall be produced from any suitable combination of intimately mixed clays, shales, talcs, flints, feldspars, or other inorganic materials which conform to the material requirements. The markers shall be thoroughly and evenly matured and free from defects which affect appearance or serviceability.

214-6.3.3 Plastic Non-Reflective Pavement Markers. Plastic non-reflective pavement markers shall be either polypropylene or ABS plastic as specified in the Special Provisions.

214-6.3.4 Requirements. Non-reflective pavement markers shall conform to the requirements shown in Table 214-6.3.4. Testing shall be performed in accordance with California Test 669.

TABLE 214-6.3.4

Test[1]	Test Description	Requirement
A	Bond Strength	700 psi (4826 kPa), min.
B	Glaze thickness	7 mils (178 µm), min.
C	Hardness	6 Mob, min.
D	Luminance factor, Type A white markers only, glazed surface.	75, min.
E	Yellowness index, Type A white markers only, glazed surface.	7, max.
F	Color-yellow, Type AY, yellow markers only, The chromaticity coordinates shall be within a color box defined in CTM 669.	Pass
G	Compressive strength	1500 lbs (680 kg) min.
H	Water absorption	2.0% max.
I	Artificial weathering, 500 hours exposure yellowness index	20, max.

1. Tests A, B, C, and H do not apply to plastic markers.

214-6.4 Retroreflective Pavement Markers.

214-6.4.1 General. Retroreflective pavement markers shall be of the prismatic, reflector-type consisting of a methyl methacrylate or suitably compounded shell with a mixture of an inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and contain 1 or 2 methyl methacrylate prismatic reflector faces of the number and color specified in the Special Provisions or shown on the Plans.

The infrared curves of the compounded methyl methacrylate or ABS shells shall match approved curves on file in the Caltrans Transportation Laboratory.

The retroreflective lens shall not contain any voids or air space and the back of the lens shall be metalized.

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 metalized lens surface.

The base shall be flat (the deviation from a flat surface shall not exceed 50 mils (1.25 mm), rough textured, and free from gloss or substances which may reduce its bond to the adhesive.

The color of the reflector faces, 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 clear, yellow, blue or red color as specified in the Special Provisions or shown on the Plans. Off-color reflection shall be a basis 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.

214-6.4.2 Requirements. Retroreflective pavement markers shall conform to the requirements shown in Table 214-6.4.2. Testing shall be performed in accordance with California Test 669.

TABLE 214-6.4.2

Test Description	Requirement		
Bond strength[2]	500 psi (3400 kPa), min.		
Compressive strength[3]	2000 lbs. (900 kg), min.		
Abrasion resistance, marker shall meet the respective specific intensity minimum requirements after abrasion.	Pass		
Water Soak Resistance	No delamination of the body or lens system of the marker nor loss of reflectance.		
	Specific Intensity		
Reflectance	Clear	Yellow	Red
0° Incidence Angle, min.	3.0	1.5	0.75
20° Incidence Angle, min.	1.2	0.60	0.30
After one year field evaluation	0.30	0.15	0.08

1. Failure of the marker body or filler material prior to reaching 500 psi (3400 kPa) shall constitute a failing bond strength.
2. Deformation of more than 125 mils (3200 µm) at a load of less than 2000 lbs. (3400 kPa) or delimitation of the shell and the filler material of more than 125 mils (3200 µm) regardless of the load required to break the marker shall be a basis for rejection of the markers.

Pavement markers to be placed in pavement recesses shall conform to the above requirements for retroreflective pavement markers except that the minimum compressive strength requirement shall be 1200 pounds (540 kg).

214-6.6 Storage. Pavement markers shall be stored indoors and shall be protected from any source of moisture both during shipment to, and at, the Work site. Pavement markers shall be stored at a temperature high enough to preclude moisture condensation. At the time of placement, both the pavement markers and their packaging shall be dry.

214-7 ADHESIVES FOR PAVEMENT MARKERS.

214-7.1 General. This specification covers high viscosity paste rapid-set and standard-set epoxy adhesives formulated primarily for use in bonding pavement markers to Portland cement concrete and asphalt concrete pavement, and hot-melt bituminous adhesives. The type of adhesive to be applied shall be as specified in the Special Provisions or shown on the Plans.

214-7.2 Epoxy Adhesives.

214-7.2.1 General. Epoxy adhesives shall be rapid-set or standard-set.

214-7.2.2 Rapid-Set Epoxy Adhesive. 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 pavement. Rapid-set epoxy adhesive shall conform to ASTM C881, Type IV, Viscosity Grade 3, Classes B and C, except that the gel time may be shorter than 30 minutes. Components shall conform to the requirements shown in Table 214-7.2.2.

TABLE 214-7.2.2

COMPONENT A

Ingredients	Parts by Weight
Epoxy Resin[1]	90.00
Orthocresol Glycidyl Ether[2]	10.00
Titanium Dioxide ASTM Designation D476	3.00
Talc[3]	50.00
Oleeophilic Fumed Silica[4]	4.50[9]

TABLE 214-7.2.2

COMPONENT B

Ingredients	Parts by Weight
High Functionality Polymercaptan Harder[5]	60.00
2,4,6-Tri (Dimethylaminomethyl) Phenol[6]	7.00
Polysulfide Polymer[7]	35.00
Furnace Black[8]	0.10
Talc[3]	52.00
Oleophilic Fumed Silica[4]	3.50[9]
Silicone Anti-Foam, Type DB 100, 100% Solids	0.005

1. Di Glycidyl ether of bisphenol A, viscosity 100-160 poise (10-16 Pa·s) at 25°C; weight per epoxide equivalent, 180-200. Gardner 19 maximum.
2. Viscosity at 25°C, 5-10 Centipoises (0.005 to 0.01 Pa·s). Weight per gallon (L), 9.00-9.10 (1.08-1.09 Kg). Weight per epoxy equivalent, 180-200.
3. Specify Gravity ..... 2.68 to 2.96
   Oil Absorption, ASTM D281 ..... 26 to 33
   pH ..... 8.9 to 9.6
   Hegman Rating ..... 3 to 5
   Particle Shape ..... Platey
   Maximum Particle Size, micrometers 55
   Percentage passing, No. 325 (45 µm) screen, min 99
   Dry Brightness, Min 93
4. High purity fumed silica treated with a silicone oil, with the following properties: Appearance, fluffy while powder; surface area, N_2 B.E.T. method 70 ± 15 m^2/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.
5. Liquid polymercaptan resin, viscosity 100-130 poise at 25°C, 0.973; specific gravity 1.14-1.16: mercaptan value, 3.6 meg/gram. Color, Gardner 1933, 1 maximum. Infrared curve shall match the curve on file in the Caltrans Transportation Laboratory.
6. Formula weight, 265; specific gravity at 250/25°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, 0.08% maximum.
7. Specific gravity, 1.24-`1.30 at 20°/20°C, viscosity, 0.7-1.2 Pa·s (700-1200 centipoises). 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-chloroetlyl) formal and 2 mole percent of trichloropropane.
8. 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; CCSi/gram, 0.80-0.90.
9. 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.

214-7.2.3 Standard-Set Epoxy Adhesive. 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 pavement. Standard-set epoxy adhesive shall conform to ASTM C881, Type IV, Viscosity Grade 3, Classes B or C, except that the gel time may be shorter than 30 minutes. Components shall conform to the requirements shown in Table 214-7.2.3.

TABLE 214-7.2.3

COMPONENT A

Ingredients	Parts by Weight
Epoxy Resin[1]	87.00
Orthocresol Glycidyl Ether[2]	13.00
Titanium Dioxide ASTM Designation D476	3.00
Oleeophilic Fumed Silica[3]	6.50[8]
Talc[4]	34.00

COMPONENT B

Ingredients	Parts by Weight
N-Ameinoethyl Piperazine[5]	23.20
Nonylphenol[6]	52.00
Furnace Black[7]	0.10
Oleophilic Fumed Silica[3]	6.50[8]
Silicone Anti-Foam, Type DB 100, 100% Solids	0.005

1. 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.
2. Aliphatic mono functional reactive ether, derived from an aliphatic alcohol. Viscosity at 1-15 Centipoises. Weight per epoxide equivalent 220-250. Specific gravity 0.88-0.95.
3. High purity fumed silica treated with a silicone oil, with the following properties: Appearance, fluffy while powder; surface area, N_2 B.E.T. method 70 ± 15 M^2/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.
4. Specify Gravity ..... 2.68 to 2.96
   Oil Absorption, ASTM D281 ..... 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. No. 325 (45 µm) screen, Min 99
   Dry Brightness, Min 93
5. 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.
6. Color (APHA) 50 maximum; hydroxyl number 245-255; distillation range, 25°C at 760 millimeters first drop 295 minimum, 5% 298 minimum, 95% 325 maximum; water, % (K.F.) 0.05 maximum.
7. 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; CCSi/gram, 0.80-0.90.
8. 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.

All tests shall be performed in accordance with California Test 425.

214-7.2.4 Mixing. Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments which cannot be readily re-dispersed with a paddle shall not be used. Prior to beginning mixing, Components A and B shall be at a temperature between 60°F (15°C) and 85°F (30°C), unless otherwise specified in the Special Provisions. 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, Components A and B shall be mixed together in the ratio specified by the manufacturer. Mixed adhesives shall have a uniform gray color without black or white streaks. No solvent shall be added. Mixed adhesives shall be used before thickening has begun.

214-7.2.5 Requirements of Combined Components. Components A and B, when combined, shall conform to the requirements shown in Table 214-7.2.5. Testing shall be performed in accordance with California Test 434.

TABLE 214-7.2.5

Property	Requirement
Gel time, minutes, maximum, at 77° F (25° C)	30
Bond Strength to Concrete, Time, minutes (maximum) to reach not less than 200 psi.	
at 77° F ± 2° F (25° C ± 1° C)	35
at 50° F ± 2° F (10° C ± 1° C)	45
Slant Shear Strength	
2 days at 77° F ± 2° F (25° C ± 1° C), psi	1,000
14 days at77° F ± 2° F (25° C ± 1° C), plus water soak, psi	1,500
Tensile Adhesion and Cohesion	
Ceramic marker bottom, psi	700 min
Ceramic marker bottom, including post cure, psi	700 min
Retroreflective pavement marker bottom, psi	500 min
Color of mixed epoxy	Gray
Glass transition temperature, Tg, samples conditioned at 77° F (25° C) for 24 hours, ASTM D4065.	86° F (30° C)

214-7.3 Hot-Melt Bituminous Adhesives.

214-7.3.1 General. This specification covers a bituminous-type, hot-melt adhesive used for the placement of pavement markers. The adhesive shall be capable of bonding ceramic and plastic pavement markers to PCC and asphalt concrete pavement when the roadway surface and pavement marker temperatures are in the range of 40°F to 160°F (5°C to 70°C). The composition must be such that its properties will not deteriorate when heated to and applied at temperatures up to 425°F (220°C) using either air or oil-jacketed melters.

214-7.3.2 Material Requirements. Filler material used in hot-melt bituminous adhesives shall be Type PC, Grade III, calcium carbonate conforming to ASTM D1199 and the requirements shown in Table 214-7.3.2 (A).

TABLE 214-7.3.2 (A)

Sieve Size	Percentage Passing
No. 100	100
No. 200	95
No. 325	75

Hot-melt bituminous adhesive material, when homogeneously mixed with filler material, shall conform to the requirements shown in Table 214-7.3.2 (B).

TABLE 214-7.3.2 (B)

Property	Min.	Max.	Test Method No.
Softening Point, °F (°C)	200 (93)	230 (110)	ASTM D36
Penetration, 100 g, 5 seconds, 77 °F (25° C)	10	20	ASTM D5
Flow, inch (mm)	---	0.2 (5)	ASTM D3407[1]
Heat Stability Flow, inch (mm)	---	0.2 (5)	See Note 2
Brookfield Thermosel Viscosity, Centipoise, No. 27 Spindle, 20 RPM, 400 °F (200°C)	3,000	6,000	ASTM D4402
Flash Point, C.O.C, °F (°C)	550 (290)		ASTM D92
Property	**Min.**	**Max.**	**Test Method No.**
Recommended Pouring Temp., °F (°C)	400 (200)	425 (220)	---
Shelf Life, Years	---	2	----
Filler Content, percent by weight (Insoluble in 1,1,1 Trichlorethane)	65	75	ASTM D2371

1. Flow shall be determined according to Section 6, Flow, of ASTM D3407 with the exception that the oven temperature shall be 158° ± 2°F (70°C ± 1°C) and sample preparation shall be according to Section 7.1 of ASTM D5.
2. 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.

SECTION 215 - NOT USED

SECTION 216 – PRECAST REINFORCED CONCRETE BOX

216-1 GENERAL. These specifications cover materials for single-cell precast reinforced concrete box (PRCB) sections intended for the conveyance of storm water.

The span, rise, and design earth cover shall be as shown on the Plans or specified in the Special Provisions.

Three sets of prints of the PRCB layout diagrams and 2 sets of Shop Drawings shall be submitted to the Engineer in accordance with 2-5.3, except one reproducible print of the layout diagrams will not be required. The layout diagrams will be used by the Engineer for reference only, and their use shall in no way relieve the Contractor for its responsibility for accuracy. The Engineer may waive the PRCB layout diagrams requirement.

216-2 MATERIALS.

216-2.1 Portland Cement Concrete (PCC). PCC for PRCB sections shall have a compressive strength of 5000 pounds per square inch (36 MPa) minimum and conform to 201-1.1.4 unless otherwise specified in the Special Provisions.

PCC shall conform to the following:

a) Portland cement shall conform to 201-1.2.1.

b) Aggregate shall conform to the reactivity requirements specified in 201-1.2.2.

c) The combined aggregate gradation shall include aggregate of 3/4 inch (19 mm) maximum diameter unless otherwise approved by the Engineer.

d) Water shall conform to 201-6.2.3.

e) Chemical admixtures shall conform to 201-1.2.4.

f) Cementitious material(s) shall be Portland cement or Portland cement and fly ash.

g) The water-cementitious material(s) ratio shall not exceed 0.53 by weight.

h) Proportioning shall conform to 201-1.3.

i) Mixing shall conform to 201-1.4.

216-2.2 Fly Ash. Fly ash shall be Class F conforming to 201-1.2.5 unless otherwise specified in the Special Provisions.

216-2.3 Reinforcement.

216-2.3.1 Deformed Welded Wire Reinforcement. The diameter of any deformed wire in finished deformed welded wire reinforcement shall conform to ASTM A496 or AASHTO M32 or M221. Deformed welded wire reinforcement shall conform to ASTM A497 or AASHTO M55 or M221.

216-2.3.2 Deformed Bars. Deformed bars shall be Grade 60, billet-steel bars conforming to 201-2.2.1.

216-2.4 Leveling Bed Material. Leveling bed material shall be sand, crushed aggregate or crushed miscellaneous base, native free-draining granular material having a sand equivalent of not less than 30, or the material specified in the Special Provisions.

216-3 FABRICATION.

216-3.1 General. PRCB sections shall be fabricated as shown on the Plans.

PRCB sections of greater strength than that specified may be furnished at the Contractor's option, and at its own expense. The interior surfaces of PRCB sections shall be smooth.

216-3.2 Joints. Joints for PRCB sections shall be fabricated with tongue and groove ends.

Outer cage transverse reinforcement shall be placed in the top and bottom slabs at the groove portion of the joint.

216-3.3 Reinforcement.

216-3.3.1 General. Reinforcement shall be deformed welded wire reinforcement conforming to 216-2.3.2 or deformed bars conforming to 216-2.3.3 unless otherwise specified in the Special Provisions. Other details shall be as shown on the Plans.

Before reinforcement is placed it shall be free of mortar, oil, dirt, excessive mill scale and scabby rust, and any other coating of any nature that would destroy or reduce its ability to bond.

216-3.3.2 Area of Steel Reinforcement. The area of steel reinforcement shall be as shown on the Plans or Standard Plans. Steel areas greater than those shown on the Plans shall not exceed 25 percent, unless the Engineer is provided with calculations verifying that the required ductile response is maintained. The calculations shall be prepared by a Registered Civil or Structural Engineer and submitted to the Engineer in accordance with 2-5.3.

If deformed steel bars are used, the steel area shall be increased to account for the difference in steel yield strength, steel spacing, concrete cover, and crack control between the welded wire reinforcement and steel bars.

216-3.3.3 Placement. Reinforcement placement shall conform to the details shown on the Plans. Reinforcement shall be firmly and securely held in position by wiring at intersections and splices and by using plastic or ferrous metal chairs, spacers, metal hangers supporting wires, or other devices of sufficient strength to resist crushing under applied loads. Wooden or aluminum supports shall not be used. Placement on layers of fresh concrete as the work progresses will not be permitted. Tack welding of reinforcing bars will not be permitted.

Welded wire fabric shall be rolled flat before placing concrete, unless otherwise shown on the Plans or Standard Plans.

216-3.3.4 Splicing. Splices in reinforcing bars shall be constructed using lap splices.

Splicing of reinforcing bars will not be permitted at locations shown on the Plans or Standard Plans as a "No-Splice Zone." At the option of the Contractor, reinforcing bars may be continuous at locations where splices are shown on the Plans. The locations of splices, except where shown on the Plans, shall be determined by the Contractor.

Unless otherwise shown on the Plans, splices in adjacent reinforcing bars at any particular section shall be staggered. The minimum distance between staggered lap splices or mechanical lap splices shall be the same as the length required for a lap splice in the largest bar.

216-3.4 Curing.

216-3.4.1 General. Curing shall be for a length of time sufficient for the PCC to develop the specified compressive strength in 28 Days or less. Any one of the following methods of curing or combinations thereof may be used:

a) Steam Curing. Steam curing shall conform to ASTM C1433/C1433M. PRCB sections shall be low pressure, steam-cured by a system capable of maintaining a moist atmosphere.

b) Water Curing. Water curing shall conform to ASTM C1433/C1433M. PRCB sections shall be kept moist continuously.

c) Membrane Curing. A sealing membrane conforming to ASTM C309 shall be applied and left intact until the specified PCC compressive strength is attained. The temperature of the PCC at the time of application of the membrane shall be within ± 100°F (± 60°C) of the atmospheric temperature. All surfaces shall be kept moist prior to the application of the membranes and shall be damp when the membrane is applied.

216-3.5 Forms. Forms shall have sufficient rigidity to be capable of maintaining section dimensions within the permissible tolerances. Form surfaces which will come into contact with PCC shall be constructed of smooth non-porous material.

216-3.6 Lifting Holes or Devices. Lifting holes or devices may be cast into, or attached to, PRCB sections. Shop drawings shall be submitted in accordance with 2-5.3.3 if so specified in the Special Provisions.

216-4 TESTING REQUIREMENTS.

216-4.1 Test Specimens. Test specimens shall conform to 201-1.1.5 as modified to allow the use of Section 11 of ASTM C497 or AASHTO T280. The Engineer shall be notified before testing is started.

216-4.2 Compression Testing of Cylinders.

216-4.2.1 General. Compression testing of cylinders shall conform to 201-1.1.5. A minimum of 3 test cylinders shall be prepared from each PCC mix used for each lot of PRCB sections. A production lot for PRCB shall be the lesser of one day's production, 400 feet (120 m) or 50 units.

216-4.2.2 Acceptance. When the average compressive strength of all cylinders tested is equal to or greater than the specified compressive strength of the PCC, and not more than 10 percent of the cylinders tested have a compressive strength less than the specified compressive strength, and no cylinder tested has a compressive strength less than 80 percent of the specified compressive strength, the lot will be accepted.

When the compressive strength of the cylinders tested does not conform to the aforementioned acceptance criteria, acceptance of the lot shall be determined in accordance with 216-4.3.

216-4.3 Compression Testing of Cores.

216-4.3.1 General. Cores shall be obtained and tested for compressive strength in accordance with 201-1.1.5.

216-4.3.2 Core Holes. Core holes shall be plugged and sealed using high-strength, non-shrink grout. The compressive strength of the repaired core holes shall meet or exceed the compressive strength requirements of the PRCB section.

216-5 PERMISSIBLE VARIATIONS.

216-5.1 Internal Dimensions. Internal dimensions shall not vary more than 1 percent from the dimensions shown on the Plans or Standard Plans. The haunch dimensions shall not vary more than 1/4 inch (6 mm) from the dimensions shown on the Plans.

216-5.2 Slab and Wall Thickness. Slab and wall thicknesses shall not be less than that shown on the Plans or Standard Plans by more than 5 percent or 3/16 inch (5 mm), whichever is greater. A thickness greater than that shown on the Plans will not be a cause for rejection.

216-5.3 Length of Opposite Surfaces. The length of opposite surfaces shall not vary more than 1/8 inch/foot of internal span. The maximum variation shall not exceed 5/8 inch (16 mm) for all sizes through an internal span of 7 feet (2100 mm), and 3/4 inch (19 mm) for an internal span greater than 7 feet (2100 mm), except where beveled ends for laying of curves are specified.

216-5.4 Length of Section. The under-run in length shall not be more than 1/8 inch/foot of length with a maximum of 1/2 inch (12.5 mm) in any PRCB section.

216-5.5 Position of Reinforcement. The maximum variation in the position of the reinforcement for slab and wall thicknesses of 5 inches (125 mm) or less shall be ± 3/8 inch (9.5 mm), and for thicknesses greater than 5 inches (125 mm) shall be ± 1/2 inch (12.5 mm).

The cover over the reinforcement shall not be less than 5/8 inch (15 mm), as measured to the internal surface or the external surface of the slab except as follows. The cover over the reinforcement for the external surface of the top slab for PRCB sections with less than 2 feet (600 mm) of cover shall not be less than 1-5/8 inches (41 mm). The aforementioned minimum cover limitations do not apply at the mating surfaces of a joint.

Hooks and bends shall conform to ACI 318.

216-6 MARKINGS. The following information shall be legibly marked on each PRCB section by indentation or waterproof paint:

a) PRCB section span,
b) rise,
c) table number,
d) maximum and minimum design earth cover,
e) specification designation,
f) interior invert cover,
g) date of manufacture, and
h) the word "top" lettered on the inside top surface.

216-7 CAUSES FOR REJECTION. Inspection of PRCB as may be deemed necessary by the Engineer will be made at the place of manufacture. Individual PRCB sections may be rejected due to any of the following unless repairs are made and approved by the Engineer:

a) Fractures or cracks with widths exceeding 0.10 inch (3 mm).
b) Mixing and molding defects, honeycombed or open texture that would adversely affect the function of the PRCB section,
c) Failure to meet the permissible variations specified in 216-5.
d) Exposure of any reinforcement arising from misplacement thereof.

216-8 BASIS OF ACCEPTANCE. The basis of acceptance shall be by one of the following as specified in the Special Provisions:

a) Compliance with these Specifications, inspection of the manufacturing, and inspection of the completed PRCB sections.

b) Acceptance of a Certificate of Compliance conforming to 4-1.5.

Such acceptance, however, shall be considered a tentative acceptance. Final acceptance will only be made when the Work is completed.

SECTION 217 – BEDDING AND BACKFILL MATERIALS

217-1 BEDDING MATERIAL.

217-1.1 General. Unless otherwise specified in the Special Provisions or shown on the Plans, bedding material, except for plastic pipe, shall be sand, gravel, crushed aggregate, or native free-draining granular material having a sand equivalent of not less than 30 or a coefficient of permeability greater than 1.5 inches/hour (35 mm per hour).

217-2 TRENCH BACKFILL.

217-2.1 General. Trench backfill material, whether native or imported, material shall be free from shale, sod, roots, rubbish, trash, lumber, organic material, ashes and other debris, unusual color, contamination, and sulfide odor.

When native material is unsuitable for use in backfill, it shall be disposed of off the Work site, and suitable material capable of being compacted to required relative densities shall be furnished by the Contractor at their expense.

217-2.2 Stones, Boulders and Broken Concrete. The maximum size of material to be placed as trench backfill shall be as shown in Table 217-2.2 unless otherwise specified in the Special Provisions or shown on the Plans. Rocks, boulders, and pieces of broken concrete or bituminous pavement shall be dispersed within, or mixed with, the backfill material such that voids or pockets of large pieces ("nesting") are not created.

TABLE 217-2.2

Zone	Zone Limits	Maximum Size (greatest dimension)	Backfill Requirements in Addition to 217-2.14
Street or Surface Zone	From ground surface to 12" (300 mm) below pavement subgrade or ground surface	2.5" (63 mm)	As required by the Plans or Special Provisions.
Street or Surface Zone Backfill of Tunnels beneath Concrete Flatwork		Sand	Sand equivalent of not less than 30.
Trench Zone	From 12" (300 mm) below pavement subgrade or ground surface to 12" (300 mm) above top of pipe or box	6" (150 mm)	Sand equivalent of not less than 20 unless otherwise required by the Plans or Special Provisions.
Deep Trench Zone (Trenches 3' (0.9 m) wide or wider)	From 60" (1.5 m) below finished surface to 12" (300 mm) above top of pipe or box	Rocks up to 12" (300 mm) excavated from trench may be placed as backfill	
Pipe Zone	From 12" (300 mm) above top of pipe or box to 6" (150 mm) below bottom of pipe or box exterior	2.5" (63 mm)	Sand equivalent of not less than 30 or a coefficient of permeability greater than 1-½ inches/hour (35 mm per hour).
Overexcavation	Backfill more than 6" (150 mm) below bottom of pipe or box exterior	6" (150 mm)	Sand equivalent of not less than 30 or a coefficient of permeability greater than 1-½ inches/hour (35 mm per hour). Trench backfill slurry (100-E-100) per 201-1 may also be used.

217-2.3 Imported Backfill. Whenever the Contractor elects to use, or the Contract Documents require the use of, imported material for backfill, a sample of the proposed material shall be delivered to the Engineer not less than 10 Days prior to its intended use. The sample shall have a minimum dry weight of 100 pounds (45 kg) and shall be clearly identified as to source, including street address and community of origin.

The Engineer will determine the material's suitability for use as trench backfill and the maximum dry density to be used in determining the relative compaction achieved during placement.

Should the imported material substantially differ from the approved sample, it shall not be used for backfill and shall be removed from the Work site.

217-2.4 Bedding Material for Plastic Pipe. For ABS-concrete-composite and PVC-concrete-composite pipe, bedding material shall conform to 217-1.1. For all other plastic pipe, the bedding material shall be crushed rock conforming to the requirements shown in Table 217-2.4 unless otherwise specified in the Special Provisions or shown on the Plans.

TABLE 217-2.4

Nominal Pipe Size inches (mm)	Maximum Rock Gradation
Up to and including 15 inches (375 mm)	1/2 inch (12.5 mm)
Over 15 inches (375 mm)	3/4 inch (19 mm)

Bedding for fittings shall be Portland cement concrete, Class 560-C-3250 (330-C-23) conforming to 201-1.1.2.

217-3 STRUCTURE BACKFILL. Material used for structure backfill shall have a sand equivalent of not less than 20 and conform to the gradation requirements shown in Table 217-3.

TABLE 217-3

Sieve Size	Percent Passing
4" (100 mm)	100
No. 4 (4.75 mm)	35 - 100
No. 30 (600 µm)	20 - 100

217-4 PERVIOUS BACKFILL. Pervious backfill material shall consist of gravel, crushed gravel, crushed rock, natural sands, manufactured sand, or combinations thereof and shall conform to the gradation requirements shown in Table 217-4.

TABLE 217-4

Sieve Size	Percent Passing
3/4" (19 mm)	100
3/8" (9.5 mm)	80 - 100
No. 100 (150 µm)	0 - 8
No. 200 (75 µm)	0 - 3

That portion of the material passing the No. 4 (4.75 mm) sieve shall have a sand equivalent of not less than 60.

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 on the Plans. 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 on the Plans.

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 1-1/2 inches (38 mm) in diameter or larger, buried logs, and all other objectionable material shall be removed 3 feet (1 m) 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 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 13.5 feet (4.1 m) above finished roadway grade or within 9 feet (2.7 m) 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.

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 1 inch (25 mm) 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 1-1/2 inches (38 mm). If a saw cut in concrete pavement falls within 3 feet (1 m) 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 1 inch (25 mm) in each 6 inches (150 mm).

c) **Concrete Curb, Walk, Gutters, Cross Gutters, Driveway, and Alley Intersections.** Concrete shall be removed to neatly sawed edges with saw cuts made to a minimum depth of 1-1/2 inches (38 mm). 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 30 inches (750 mm) in either length or width. If the saw cut in sidewalk or driveway would fall within 30 inches (750 mm) 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 12 inches (300 mm) 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 1-1/2 inches (38 mm) on a neat line at right angles to the curb face.

300-1.4 Payment. The lump sum Bid price, or the Contract Unit Price per acre, 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 Special Provisions, full compensation for any necessary clearing and grubbing required to perform the construction operations specified shall be included in the Bid price 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 unsuitable material will be paid for at the Contract Unit Price for unclassified excavation if the removal of such material is shown on the Plans or specified in the Special Provisions.

If the removal of unsuitable material is not shown on the Plans or specified in the Special Provisions, the removal and disposal of such material will be paid for at the Contract Unit Price for unclassified excavation. However, if the removal and disposal of such material involves a substantial change in the character of the work, an adjustment in payment will be made per 3-2.4.

300-2.2.2 Wet Material. If required excavated material is unsatisfactory for the specified use on the Work 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 3-2 or 3-3. 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 3-2 or 3-3.

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 6 inches (150 mm) measured at right angles to the slope. Where excavation is in rock, no point shall vary more than 2 feet (600 mm) 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 Special Provisions, 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 Special Provisions, 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 Special Provisions, or as directed by the Engineer. Topsoil excavated within the limits of the Work 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:

a) Excavating the roadway prism including public and private road approaches;

b) Connections and driveways;

c) Excavating unsuitable material when shown on the Plans or in the Special Provisions;

d) Excavating slides and slipouts not resulting from overshooting;

e) Excavating surplus material;

f) Excavating selected material and topsoil from within the limits of the Work and removing such materials from stockpiles when stockpiling is ordered;

g) 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 yard (m^3). 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 the Special Provisions 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 shown on the Plans or specified in the Specifications as structure excavation. Excavation and backfill for underground conduit construction, including box conduit, shall be in accordance with 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 the Special Provisions 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 1 foot (0.3 m) 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 Special Provisions 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 Working 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 2 feet (0.6 m) 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 6 inches (150 mm) 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 conform to 217-3. 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.

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 the Special Provisions, the following conditions shall apply:

a) Backfill material shall be placed and consolidated in layers not exceeding 4 feet (1.2 m) in thickness.

b) The jetting shall be performed without softening the embankment and in a manner that excess water will not be impounded.

c) Jetting methods shall be supplemented by the use of vibratory or other consolidation equipment when necessary to obtain 90 percent relative compaction.

d) The upper 3 feet (0.9 m) below finished subgrade shall be mechanically compacted in roadway areas.

300-3.5.2 Pervious Backfill. Pervious backfill shall conform to 217-4. 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.

All weep holes shall be backed with 2 cubic feet (0.06 m^3) of material conforming to the requirements for No. 3 concrete aggregate conforming to 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 12 inches (300 mm) above the bottom of the opening. An 8-inch (200 mm) square section of 1/4 inch (6 mm) galvanized or aluminum screen having a minimum wire diameter of 0.03 inch (0.8 mm) 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 1 foot (0.3 m) layer of earthy material approved by the Engineer.

300-3.6 Payment. Unless otherwise provided in the Special Provisions or 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 Bid 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 1 foot (0.3 m) 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 be fill generated from unclassified excavation on the Work site. Unclassified fill shall consist of all fill unless separately specified. Construction of unclassified fill shall include preparing the area on which unclassified fill is to be placed, and the depositing, conditioning, and compacting of fill material.

Rocks or other solid materials which are larger than 4 inches (100 mm) in greatest dimension shall not be placed in unclassified fill where piles are to be placed or driven.

Clods or hard lumps of earth of 6 inches (150 mm) in greatest dimension shall be broken up before compacting, except when the unclassified fill material contains large rocks, boulders, or hard lumps (such as hardpan or cemented gravel which cannot be broken readily) over 12 inches (300 mm) 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 approval by the Engineer.

Unclassified fill shall not be constructed when the material is frozen or a blanket of snow prevents proper compaction.

300-4.2 Preparation of Placement Areas. Areas over which unclassified fill is to be placed shall first be cleared and grubbed in accordance with 300-1. The areas shall then be scarified to a minimum depth of 6 inches (150 mm), moisture-conditioned in accordance with 300-4.6, and compacted in accordance with 300-4.7 to a relative compaction of at least 85 percent unless otherwise specified in the Special Provisions.

When unclassified fill is shown to be placed over existing surface improvements which are to remain in place, the preparation shall be as specified in the Special Provisions.

300-4.3 Other Fill Materials. Brick rubble, broken asphalt pavement, and broken concrete originating from the Work shall be disposed of off the Work site. Unless otherwise specified, no fill materials may be imported from outside the limits of the Work.

300-4.4 Benching. Benching is required when unclassified fill is to be placed on a slope of 1 vertical to 5 horizontal or steeper. When unclassified fill is being constructed against an existing slope, the slope face shall be horizontally benched to key the unclassified fill into the slope face. Benching shall be into firm soils free of loose or disturbed soils, such that, a minimum 3 feet (0.9 m) vertical face height is exposed into firm soils unless otherwise shown on the Plans. The horizontal surface of each bench shall be scarified to a depth of at least 6 inches (150 mm) prior to placing the first lift of unclassified fill.

300-4.5 Placement. Unclassified fill material shall be placed in horizontal layers of depths compatible with the material being placed and the type of equipment being used. Each layer shall be evenly spread and moisture-conditioned or aerated, as necessary. Unless otherwise specified, each layer spread for compaction shall not exceed 8 inches (200 mm) of compacted thickness.

Unless otherwise approved, each layer of unclassified fill material shall cover the length and width of the area to be filled before the next higher layer 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.

When unclassified fill material contains by volume over 25 percent of rock larger than 6 inches (150 mm) in greatest dimension, the unclassified fill below a plane 3 feet (0.9 m) 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 3 feet (0.9 m) in thickness. The interstices around the rock in each layer shall be filled with earth or other fine material and compacted.

300-4.6 Application of Water. At the time of compaction, the moisture content of unclassified fill material shall be such that the specified relative compaction will be obtained and the fill will be firm, hard, and unyielding.

Chemical additives may be used in water to be applied to fill material when approved by the Engineer.

300-4.7 Compaction. Unless otherwise specified, each layer of unclassified fill shall be compacted to a relative compaction of at least 90 percent.

Each layer of unclassified fill shall be compacted by sheepsfoot rollers, pneumatic-tired rollers, vibratory rollers, or other mechanical means approved by the Engineer. Unclassified fill layers shall be compacted to the specified relative compaction by hand-directed compaction equipment where it would be impractical because of inaccessibility to use larger compacting equipment.

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. Slopes constructed of unclassified fill shall be finished in conformance with the lines and grades shown on the Plans. Completed fill slopes shall not vary from the plane shown on the Plans by more than 6 inches (150 mm) measured at right angles to the slope, unless otherwise specified.

300-4.9 Measurement. The following earthwork operations will be measured as unclassified fill for the quantities of material involved:

a) Fill within the limits of the roadway prism including public and private road approaches.

b) Connections and driveways.

c) Slopes and embankments.

Unclassified fill placed outside the limits shown on the Plans, or to a grade flatter than the grade shown on the Plans will not be measured for payment.

300-4.10 Payment. Payment for unclassified fill will be made at the Contract Unit Price per cubic yard (m^3). The Contract Unit shall include preparation (other than clearing and grubbing) of placement areas, benching, unclassified fill material, placement, water, compaction, and grading to the lines, grades, and cross sections shown on the Plans.

Payment for clearing and grubbing shall conform to 300-1.4.

No separate or additional payment will be made for chemical additives.

No separate or additional payment will be made for bulking, subsidence, shrinkage, temporary erosion control measures unless otherwise specified in the Special Provisions.

No additional payment will be made for benching not approved by the Engineer or not shown on the Plans.

No additional payment will be made for disposal of excess unclassified fill material, except when determined by the Engineer to be unsuitable material in accordance with 300-2.2.

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 Work. 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 specified in the Special Provisions, 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 Special Provisions.

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 1/2 inch (12.5 mm) and 1-1/2 inches (38 mm) shall be removed to a depth of not less than 1 foot (0.3 m) below natural ground. Larger roots shall be removed down to the level at which the root diameter is 1-1/2 inches (38 mm) or less. Regardless of diameter, no roots need to be removed to a depth greater than 3 feet (1 m).

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 Special Provisions, 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 Work 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 6 inches (150 mm) 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 2 feet (0.6 m) 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 8 inches (200 mm) 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 Contract Unit Price for the compacted fill.

300-6.6 Payment. Clearing and grubbing shall be paid for on a lump sum or per acre (hectare) basis as provided in the Special Provisions.

Stripping, excavation, and compacted fill shall be measured and paid for on a cubic yard (m^3) basis as provided for in the Special Provisions.

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 Plans. 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 specified 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 Work 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 Work excavations will be permitted in the backfill or fill with the following limitations:

a) The maximum dimension of any piece used shall be 6 inches (150 mm).

b) Pieces larger than 4 inches (100 mm) shall not be placed within 12 inches (300 mm) of any structure.

c) Pieces larger than 3 inches (75 mm) shall not be placed within 12 inches (300 mm) of the subgrade for paving.

d) "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 3 inches (75 mm) below the specified grade will be allowed for:

a) The channel bottom.

b) The channel sideslopes in both cut and fill.

c) The levee and access road sideslopes in cut.

A vertical tolerance of zero below and 3 inches (75 mm) above the specified grade will be allowed on:

d) The top surface of levees and access roads in both cut and fill.

e) 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 yard (m^3) basis or as specified in the Special Provisions.

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 in the 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 12 inches (300 mm). 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 Days after placement. Fabrics left uncovered for more than 7 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 2 edges of the geotextile protruding at the top of the trench shall be overlapped 12 inches (300 mm) 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 yard (m^2) 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 18 inches (450 mm) or stitched when using nonwoven fabrics with a grab tensile strength of 90 pounds (400 N) or woven fabrics with a grab tensile strength of 200 pounds (890 N) or less. Borders and ends shall be overlapped 36 inches (900 mm) or stitched for nonwoven fabrics with a grab tensile strength greater than 90 pounds (400 N) or woven fabrics with a grab tensile strength greater than 200 pounds (890 N).

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 6 foot (1.8 m) centers at the midpoint of the overlaps unless a key trench is used. Pins at 6-foot (1.8 m) 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 12 inches (300 mm) 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 Days after placement. Fabric left uncovered for more than 7 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 24 inches (600 mm) or sewn if required by the Plans or Special Provisions. When indicated on the Plans or Special Provisions that soils have a CBR less than 5 or an R-value less than 20, a 36-inch (900 mm) overlap shall be used.

The fabric shall be secured with pins placed on 6-foot (1.8 m) 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 aggregate base material shall be placed on the fabric in such a manner and thickness that wheel rutting of aggregate over the fabric is limited to 1/2 inch (12.5 mm). Unless otherwise specified, the minimum thickness shall be 12 inches (300 mm). 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 STONEWORK 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 1 foot (0.3 m) 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 520-C-2500P (310-C-17P) 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

Class	500 lb (225 kg)	375 lb (170 kg)	Light (90 kg)	Facing (35 kg)
Minimum Penetration in inches (mm)	14 (350)	12 (300)	10 (250)	8 (200)

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 10 feet (3 m).

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 10-foot (3 m) 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 ton (tonne) of stone in place.

Concrete and concrete placement will be measured and paid for per cubic yard (m^3) in place.

SECTION 301 – SUBGRADE PREPARATION, TREATED MATERIALS, AND PLACEMENT OF BASE MATERIALS

301-1 SUBGRADE PREPARATION.

301-1.1 General. This subsection 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.

After rough grading has been completed, when scarifying and cultivating are required, the roadbed shall be loosened to a depth of at least 6 inches (150 mm). The loosened material shall then be worked to a finely divided condition and all rocks larger than 3 inches (75 mm) 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 6 inches (150 mm) 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 6 inches (150 mm) 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 6 inches (150 mm) 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 6 inches (150 mm) 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 1/4 inch (6 mm) from the specified grade and cross section. Subgrade for subbase or base material shall not vary more than 1/2 inch (12.5 mm) 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 Bid price 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 15 inches (375 mm) 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 15 inches (375 mm) or more, will be made at the Contract Unit Price per linear foot (m) for reconstructing each manhole.

If no payment provision for manhole adjustment or reconstruction is made, payment for such work will be as specified in 3-3.

301-2 UNTREATED BASE.

301-2.1 General. Untreated base material shall conform to 200-2.

301-2.2 Spreading. Untreated base 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.

Untreated base shall be deposited on the roadbed at a uniform quantity per linear foot (m), at a quantity which will provide the required compacted thickness within the tolerances specified herein without resorting to spotting, picking up, or otherwise shifting the base material. At the time untreated 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 6 inches (150 mm) or less, the base material, except "Pulverized Miscellaneous Base," may be spread and compacted in one layer. Where the required thickness is more than 6 inches (150 mm) the base material, except "Pulverized Miscellaneous Base," shall be spread and compacted in 2 or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 6 inches (150 mm). 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 10 inches (250 mm).

When the subgrade for untreated base consists of cohesionless sand and written permission is granted by the Engineer, a portion of the untreated 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 commence 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.

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 1/4 inch (6 mm) 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 recompacted 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 MATERIALS.

301-3.1 General. Portland cement treated materials shall include soil-cement, cement treated base, and cement-stabilized pulverized base. The specific mixture(s) to be produced and placed shall be as shown on the Plans.

301-3.2 Soil-Cement.

301-3.2.1 General. Soil-cement shall consist of a mixture of soil, Portland cement, and water mixed, placed, spread, compacted, finished, and cured such that the in-place mixture forms a dense, uniform mass conforming to the lines, grades, and cross sections shown on the Plans. The required 7-Day compressive strength shall be as shown on the Plans or as specified in the Special Provisions.

301-3.2.2 Materials. Materials shall conform to 201-8.2.

301-3.2.3 Mix Design(s). Mix design(s) shall conform to 201-8.3.

301-3.2.4 Subgrade Preparation for Central Plant and Off-Road Produced Mixtures. Subgrade preparation prior to placement of central plant or off-road produced mixtures shall conform to 301-1 except as follows:

The subgrade shall be scarified and graded to the lines, grades, and cross sections shown on the Plans. Unsuitable material shall be removed and replaced in accordance with 300-2.2. Soft or yielding subgrade shall be removed or stabilized as specified in the Special Provisions or as directed by the Engineer.

The subgrade, after preparation, shall be firm and able to support the loads imposed by soil-cement placement, spreading, grading, and compaction operations without yielding or settlement.

301-3.2.5 Mixing.

301-3.2.5.1 General. Mixing shall be performed at a central mixing plant, in-place, or off-road. The mixing method shall be as specified in the Special Provisions.

Soil-cement shall not be mixed or placed when the subgrade or material to be treated is muddy or frozen, or when the ambient temperature is 40°F (5°C) or less.

301-3.2.5.2 Central Plant Mixing. Mixing performed at a central mixing plant shall conform to 201-8.4.

301-3.2.5.3 In-Place Mixing.

a) **General.** In-place mixing shall include grading, spreading of Portland cement, and mixing of the soil to be treated, Portland cement, and water.

b) **Grading.** Prior to the spreading of Portland cement, the soil to be treated shall be graded to conform to the lines, grades, and cross sections shown on the Plans.

c) **Spreading.** Portland cement shall be uniformly spread on the graded soil. Spreading shall be performed with a spreader truck conforming to 301-3.4.4.3. The spread rate shall be that which results in the Portland cement content specified in the Special Provisions or in the approved mix design. The Portland cement content shall not vary more than 0.5 percent under nor more than 1.0 percent over the specified content. However, the moving average shall not be less than the specified content. The Engineer may increase the rate of application as in-place mixing operations progress.

d) **Mixing.** Mixing shall be performed with a reclaimer conforming to 301-3.4.4.2. The full-depth of the soil to be treated shall be mixed a minimum of 2 times. At least 1 of the 2 mixings shall be performed while introducing water into the soil-Portland cement mixture. The quantity of water added shall be adjusted as necessary to produce a moisture content between 1 percent below and 3 percent above the optimum moisture content.

301-3.2.5.4 Off-Road Mixing. If specified in the Special Provisions or approved by the Engineer, mixing may be performed off the roadway. Off-road mixing shall conform to 301-3.2.6.3.

301-3.2.6 Placement and Spreading of Central Mixing Plant and Off-Road Produced Mixtures. Prior to placement, the subgrade or receiving surface shall be moistened.

Soil-cement mixtures shall be placed in a manner that does not result in segregation. When 2 or more layers 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. Loose material shall be removed from the surface of each completed layer and the surface moistened immediately prior to placement of the next layer. No standing water will be permitted.

One or more self-propelled motor graders, or other mechanical spreading equipment approved by the Engineer, shall be used for spreading and trimming. Spreading shall be performed uniformly over the

full-width of the subgrade or underlying layer. Spreading equipment shall work in parallel as necessary to result in a uniform rate of full-width spreading.

Soil-cement mixtures shall be spread in a single layer 6 inches (150 mm) to 12 inches (300 mm) in thickness. If multiple layers are required, each layer shall be of equal thickness not less than 6 inches (150 mm) in thickness.

301-3.2.7 Compaction and Finishing. Soil-cement mixtures shall be compacted to a minimum of 95 percent of the maximum wet density determined in accordance with ASTM D558. In-place density shall be determined in accordance with ASTM D6938. In-place moisture content shall be determined in accordance with ASTM D4959.

Each layer shall be compacted after the completion of placement and spreading.

Compaction equipment shall be capable of achieving the specified compaction within the operational time limits specified. Areas inaccessible to rollers shall be compacted by other methods and equipment approved by the Engineer.

Initial rolling shall be performed with a vibratory pad-foot, or segmented pad-foot roller. After initial rolling, the soil-cement mixture shall be trimmed as necessary to conform to the lines, grades, and cross sections shown on the Plans. Excess soil-cement mixture shall be removed and disposed of. Final rolling shall be performed with a steel smooth drum, or vibratory smooth drum roller operated in the static mode. Finish rolling shall be performed with a pneumatic-tired roller and result in a smooth, dense surface without inducing hair-line cracking.

The total elapsed time between the addition of water to the mixed materials and Portland cement and the start of compaction shall not exceed 45 minutes. Not more than 1-1/2 hours shall elapse between the time water is added to the mixed materials and Portland cement, and the time of completion of initial rolling. Not more than 2-1/2 hours shall elapse between the time water is added to the mixed materials and Portland cement, and the time of completion of final rolling after trimming. Soil-cement mixtures that have not been compacted and finished shall not be left undisturbed for longer than 30 minutes. Not more than 60 minutes shall elapse between placement in adjacent lanes except at longitudinal and transverse construction joints.

301-3.2.8 Partial-Width Construction. Where traffic or other conditions make part-width construction necessary, as determined by the Engineer, and mixing is performed off-road, a windrow of soil shall be placed and compacted to form a choker to restrain the inner edge of the soil-cement mixture during compaction and finishing operations. The choker shall be constructed to the same elevation as that of the finished surface, and shall be completed in advance of the start of spreading. The toe of the choker shall be not less than 3 inches (75 mm) outside the finished longitudinal joint. Side forms or other methods capable of retaining the soil-cement mixture during compaction operations may be used if so approved by the Engineer.

Should only one spreader be used, not more than 60 minutes shall elapse between the times of placing the mixed material in adjacent lanes at any location without trimming the longitudinal joint.

After a partial-width section has been compacted and finished, the inner edge shall be vertically cut and trimmed to form a longitudinal joint. Choker material and trimmed soil-cement mixture shall be used only in the construction of adjacent shoulders or otherwise disposed of off the roadway, unless otherwise specified in the Special Provisions or approved by the Engineer.

301-3.2.9 Construction Joints. At the end of each Working Day, a transverse construction joint shall be constructed.

Construction joints shall have vertical faces and be constructed by cutting into soil-cement mixtures which have been compacted and finished. The face of cut joints shall be clean, free of deleterious material, and kept moist until the placement of the adjacent soil-cement mixture. Additional soil-cement mixtures shall not be placed against a construction joint until the joint has been approved by the Engineer.

Alternatively, if mixed-in-place, mixing passes shall overlap 3 inches into the adjacent soil-cement mixture.

301-3.2.10 Curing.

301-3.2.10.1 General. The surface of compacted and finished soil-cement mixtures (finished surface) shall be cured by the water curing method, bituminous seal method, or other method specified in the Special Provisions.

The finished surface shall be protected from drying, freezing, and traffic for a minimum of 7 Days unless otherwise specified.

301-3.2.10.2 Water Curing Method. The finished surface shall be kept wet continuously by the application of water. The application of water shall continue for a period of a minimum of 5 to a maximum of 7 Days from the date of completion of compaction and finishing unless otherwise specified.

301-3.2.10.3 Bituminous Seal Curing Method. The finished surface shall be uniformly sprayed with a bituminous curing seal. The bituminous curing seal shall form a continuous membrane over the finished surface after application. The bituminous curing seal material shall be either SS-1h or CSS-1h emulsified asphalt conforming to 203-3. The emulsified asphalt shall be diluted with water at a ratio of 50/50. The application rate shall be between 0.10 to 0.20 gallons per square yard (0.46 L/m^2 to 0.91 L/m^2). The exact rate will be determined by the Engineer.

Application shall begin within 24 hours after compaction and finishing is completed. The finished surface shall be kept moist until the bituminous curing seal is applied. At the time of application, the finished surface shall be dense, free of loose and extraneous material, and contain sufficient moisture to prevent excessive penetration of the bituminous curing seal.

No traffic or equipment shall either park or drive on the finished surface during the first 3 Days after applying the curing compound, unless otherwise permitted by the Engineer.

The Contractor shall, before the overlying pavement is placed on the finished surface, remove any other material which has been spread to protect the finished surface.

301-3.2.11 Acceptance.

301-3.2.11.1 Materials. Acceptance shall conform to 201-8.6.

301-3.2.11.2 Finishing. The thickness at any point shall not be more than 1/2 inch (12.5 mm) less than the thickness shown on the Plans.

The finished surface shall not vary more than 1/4 inch (6 mm) above or below the grades shown on the Plans and be free from porous areas.

Damaged areas shall be removed and replaced for the full-depth of the affected layers.

Feathering or thin layers may not be used to fill or repair depressed or shallow thickness areas.

301-3.2.12 Measurement. Portland cement will be measured by the ton (tonne). The basis of payment shall be the net weight of Portland cement used to produce soil-cement for the Work. The Contractor shall furnish the Engineer with certified weighmaster certificates.

Soil-cement will be measured by the cubic yard (m^3), or by the square yard (m^2) of finished surface for each thickness specified or shown on the Plans.

Excess in-place material requiring removal and disposal will be measured by the cubic yard (m^3).

301-3.2.13 Payment. Payment for preparation of the mix design, if prepared by the Contractor, will be made as specified in the Special Provisions or shown on the Bid.

Payment for Portland cement will be made at the Contract Unit Price per ton (tonne). The Contract Unit Price shall include furnishing and spreading. Payment for Portland cement will not be subject to the provisions of 3-2.2.2 and 3-2.2.3.

Payment for soil-cement will be made at the Contract Unit Price per cubic yard (m^3), or per square yard (m^2) of finished surface for each thickness specified. The Contract Unit Price shall include mixing, placement, spreading, trimming, compaction, finishing, and curing.

Payment for removal and disposal of excess in-place material prior to treatment will be made at the Contract Unit Price per cubic yard (m^3) for unclassified excavation.

No separate or additional payment will be made for removal and disposal of excess soil-cement.

301-3.3 Cement Treated Base (CTB).

301-3.3.1 General. CTB shall consist of a mixture of untreated base material, Portland cement, and water mixed, placed, spread, compacted, finished, and cured such that the in-place mixture forms a dense, uniform mass conforming to the lines, grades, and cross sections shown on the Plans. The required 7-Day compressive strength shall be as shown on the Plans or specified in the Special Provisions.

301-3.3.2 Materials. Materials shall conform to 201-9.2.

301-3.3.3 Mix Designs. Mix designs shall conform to 201-9.3.

301-3.3.4 Equipment for In-Place and Off-Road Produced Mixtures. Equipment for in-place and off-road produced mixtures shall conform to 301-3.4.4.

301-3.3.5 Subgrade Preparation for Central Plant and Off-Road Produced Mixtures. Subgrade preparation for central plant and off-road produced mixtures shall conform to 301-3.2.4.

301-3.3.6 Mixing. Mixing shall conform to 301-3.2.5.

301-3.3.7 Placement and Spreading of Central Plant and Off-Road Produced Mixtures. Placement and spreading of central plant and off-road produced mixtures shall conform to 301-3.2.6.

301-3.3.8 Compaction and Finishing. Compaction and finishing shall conform to 301-3.2.7, except cement treated base mixtures shall be compacted to a minimum of 92 percent of the maximum wet density determined in accordance with ASTM D1557. In-place moisture content shall be determined in accordance with ASTM D4959.

301-3.3.9 Partial-Width Construction. Partial-width construction shall conform to 301-3.2.8.

301-3.3.10 Construction Joints. Construction joints shall conform to 301-3.2.9.

301-3.3.11 Curing. Curing shall conform to 301-3.2.10.

301-3.3.12 Acceptance.

301-3.3.12.1 Materials. Acceptance shall conform to 201-9.6.

301-3.3.12.2 Finishing. The thickness at any point shall not be more than 1/2 inch (13 mm) less than the thickness shown on the Plans.

The finished surface shall not vary more than 1/4 inch (6 mm) above or below the grades shown on the Plans and be free from porous areas.

Damaged areas shall be removed and replaced for the full-depth of the affected layers.

Feathering or thin layers shall not be used to fill or repair depressed or shallow thickness areas.

301-3.3.13 Measurement. Portland cement will be measured by the ton (tonne). The basis of payment shall be the net weight of Portland cement used to produce CTB for the Work. The Contractor shall furnish the Engineer with certified weighmaster certificates.

CTB will be measured by the cubic yard (m^3), or by the square yard (m^2) of finished surface for each thickness specified.

Excess in-place material requiring removal and disposal will be measured by the cubic yard (m^3).

301-3.3.14 Payment. Payment for preparation of the mix design, if prepared by the Contractor, will be made as specified in the Special Provisions or shown on the Bid.

Payment for Portland cement will be made at the Contract Unit Price per ton (tonne). The Contract Unit Price shall include furnishing and spreading. Payment for Portland cement will not be subject to the provisions of 3-2.2.2 and 3-2.2.3.

Payment for CTB will be made at the Contract Unit Price per cubic yard (m^3), or per square yard (m^2) of finished surface for each thickness specified. The Contract Unit Price shall include mixing, placement, spreading, trimming, compaction, finishing, and curing.

Payment for removal and disposal of excess in-place material prior to treatment will be made at the Contract Unit Price per cubic yard (m^3) for unclassified excavation.

No separate or additional payment will be made for removal and disposal of excess CTB.

301-3.4 Cement Stabilized Pulverized Base (CSPB).

301-3.4.1 General. CSPB shall consist of pulverized asphalt concrete pavement, base material, subgrade soil, Portland cement, and water uniformly mixed, compacted, finished and cured in such a manner that the in-place mixture forms a dense, uniform mass conforming to the lines, grades, and cross sections shown on the Plans.

301-3.4.2 Materials.

301-3.4.2.1 Portland Cement. Portland cement shall be Type II/V conforming to 201-1.2.1. Supplementary cementitious materials shall not be substituted for any portion of the required Portland cement content.

301-3.4.2.2 Water. Water shall conform to 201-1.2.3.

301-3.4.2.3 Pulverized Base Material. Pulverized base material shall consist of existing or remaining asphalt concrete pavement, base material, and subgrade soil pulverized and mixed by a reclaimer conforming to 301-3.4.4.2.

The resultant pulverized base material shall conform to the following requirements when tested in accordance with ASTM C136:

a) 100 percent shall pass the 3-inch (75 mm) sieve.

b) 95-100 percent shall pass the 2-inch (50 mm) sieve.

c) Not less than 90 percent shall pass the 1-1/2 inch (37.5 mm) sieve.

d) 35 to 60 percent shall pass the No. 4 (4.75 mm) sieve.

e) The material shall be uniformly graded.

301-3.4.2.4 Emulsified Asphalt for Fog Seal. Emulsified asphalt for fog seal applications shall be SS-1h or CSS-1h conforming to 203-3 diluted up to 50 percent with water.

301-3.4.3 Mix Design. The mix design shall be prepared using the proposed proportions of pulverized asphalt concrete pavement, base material, and subgrade soil to be stabilized, and Portland cement.

The materials shall be tested and the mix design(s) developed in accordance with ASTM D1633, Method A, except:

a) Test specimens shall be compacted in accordance with ASTM D1557, Method A or B.

b) Test specimens shall be cured by sealing each specimen with 2 layers of plastic at least 4 mils thick. The plastic must be tight around the specimen. All seams shall be sealed with duct tape. Sealed specimens shall be placed in an oven for 7 Days at 100°F ± 5°F (38°C ± 3°C). At the end of the cure period, specimens shall be removed from the oven and air-cooled. Duct tape and plastic wrap shall be removed before capping. Specimens shall not be soaked before testing.

The mix design shall show:

c) the rate, as a percentage of the dry unit weight of the pulverized base material, of application of Portland cement to the pulverized base material which results in a 7-Day compressive strength of a minimum of 400 pounds per square inch (2.8 MPa) unless otherwise specified in the Special Provisions,

d) the proportions and gradation of the material to be stabilized,

e) optimum water content during mixing, curing and compaction, and

f) the moisture-density relationship

Unless otherwise specified in the Special Provisions, the Agency will prepare the mix design.

301-3.4.4 Equipment.

301-3.4.4.1 General. Equipment shall be approved by the Engineer prior to use.

301-3.4.4.2 Reclaimer. Pulverizing and mixing shall be performed, and cement stabilized pulverized base produced, only by the utilization and operation of a reclaimer specifically designed and constructed for, and capable of, pulverizing and mixing of in-place materials to the depth shown on the Plans. Such machine shall hereinafter be referred to as a "reclaimer."

The reclaimer shall be equipped with a controllable water additive and distribution system capable of attaching to and being fed from a water truck, and regulating and uniformly introducing and mixing water into the mixture; a visible depth indicator showing the mixing depth; and an odometer or foot meter displaying travel speed.

301-3.4.4.3 Spreader Trucks. Portland cement shall be spread by trucks equipped with a body specifically designed and constructed for the spreading of dry lime or Portland cement, hereinafter referred to as "spreader trucks." Spreader trucks shall be equipped with a non-pressurized mechanical vane-feed spreader, on-board scales, and an automatic spread rate control system with cab-mounted controls capable of regulating the rate of application of Portland cement. Spreader trucks shall be capable of maintaining a constant spread rate at variable travel speeds.

Dump trucks, tailgate spreaders, and manual spread rate controls will not be allowed.

301-3.4.4.4 Rollers. Rollers shall be pad foot, segmented wheel, pneumatic-tired, or steel drum, and of sufficient weight to compact the full-depth of the CSPB mixture.

301-3.4.5 Sequence of Work. Unless otherwise specified in the Special Provisions, the sequence of work for production of CSPB shall be as follows:

a) Pulverize the existing or remaining asphalt concrete pavement and mix with the underlying base material and subgrade soil to the depth shown on the Plans. The resultant material shall hereinafter be referred to as "pulverized base material."

b) Grade the pulverized base material to the lines, grades, and cross sections shown on the Plans. Remove and dispose of the excess material.

c) Uniformly spread and mix Portland cement into the pulverized base material to the depth shown on the Plans.

d) Compact the pulverized base material-Portland cement mixture.

e) Grade the pulverized base material-Portland cement mixture to the lines, grades, and depths shown on the Plans.

f) Initial cure the in-place mixture for 48 hours.

g) Micro-crack the in-place mixture.

h) Final cure the in-place mixture as required

301-3.4.6 Pulverizing. The existing or remaining asphalt concrete pavement, base material, and subgrade soil shall be pulverized to the depth shown on the Plans. The number of passes required shall be that which results in pulverized base material conforming to 301-3.4.2.3.

301-3.4.7 Initial Grading. Following the completion of pulverizing, pulverized base material shall be graded to the lines, grades and cross sections shown on the Plans.

Temporary access ramps shall be constructed at each driveway following the completion of initial grading or at the end of each Working Day, whichever comes first.

Excess pulverized base material shall be removed and disposed of off the Work site.

301-3.4.8 Spreading. Portland cement shall be uniformly spread on the pulverized base material at the rate specified in the approved mix design unless otherwise approved by the Engineer. The rate shall not be less than 0.5 percent under nor greater than 1.0 percent over the specified rate. However, the moving average shall not be less than the specified rate. The Engineer may direct the Contractor to increase the rate as necessary.

Spreading shall be performed in a series of passes parallel to the centerline of the roadway.

Portland cement shall not be spread more than 2 hours prior to mixing.

After spreading, no traffic shall pass over the roadway until the mixing operation is completed.

301-3.4.9 Mixing. Mixing shall be performed in a series of passes parallel to the centerline of the roadway such that transverse and longitudinal construction joints are minimized. The full- depth of the pulverized base material shall be mixed with Portland cement a minimum of 2 times. At least 1 of the 2 mixings shall be done while introducing water into the pulverized base material through the metering device on the reclaimer. Water shall be added to the pulverized base material during mixing to provide a moisture content not less than 1 percentage point below nor more than 3 percentage points above the optimum moisture content of the pulverized base material-Portland cement mixture as determined in accordance with 301-3.4.3.

Any remaining untreated pulverized base material around or attached to manholes, valves, vaults, survey monuments or other structures; adjacent or attached to curbs and gutters; or in areas inaccessible

by the reclaimer shall be removed to the depth mixed, and replaced with the pulverized base material-Portland cement mixture.

301-3.4.10 Compaction and Final Grading. Compaction and final grading shall be performed in such a manner as to produce a smooth, dense surface free of compaction planes, cracks, ridges or loose materials.

CSPB material shall be compacted to not less than 92 percent of the maximum wet density determined in accordance with ASTM D1557. In-place density shall be determined in accordance with ASTM D6938. In-place moisture content shall be determined in accordance with ASTM D4959. Unless otherwise specified, the Contractor shall perform a minimum of 1 compaction test per 750 square yards (627 m^2) of CSPB. Test data shall be recorded on forms approved by the Engineer. Test results shall be furnished to the Engineer at the end of each Working Day.

Initial compaction shall be performed using static or vibratory pad foot, or segmented wheel rollers. Final compaction shall immediately follow initial compaction. Final compaction shall be performed using steel drum or pneumatic-tired rollers. The use of vibratory rollers in vibratory mode will not be permitted during final compaction.

Areas inaccessible to rollers shall be compacted to the required density by other equipment approved by the Engineer.

Compaction shall be completed within 2-1/2 hours after the initial application of water during the mixing operations.

CSPB material shall be graded to the lines, grades, and cross sections shown on the Plans. The finished surface of the CSPB material shall be hereinafter referred to as the "grading plane." At any point along the grading plane, the elevation shall not vary more than 1/4 inch above or below the required elevation.

If, after compaction, any point along the grading plane is above the specified grade tolerance, excess material shall be trimmed, removed, and disposed of as necessary. No loose material shall be left on the grading plane. Trimming of excess material shall not be conducted unless rolling can be completed within 2 hours after trimming.

New or trimmed material shall not be added to any point or area along the grading plane below the specified tolerance or to raise the elevation of compacted material.

Points or areas along the grading plane below the specified tolerance, irregularities, or weak spots that develop shall be corrected immediately by scarifying the area affected, adding or removing material as required, re-compacting, and re-graded.

Once the grading plane is within tolerance, it shall be completely rolled using steel drum or pneumatic-tired rollers.

301-3.4.11 Construction Joints. At the end of each Working Day, a vertical-faced construction joint shall be constructed in the CSPB normal to the centerline of the roadway. The joint shall be constructed for the full-depth of the CSPB and be moisture-cured continuously until placement of adjacent CSPB begins. Adjacent CSPB shall not be placed until the construction joint has been approved by the Engineer.

301-3.4.12 Initial Curing. CSPB shall be moisture-cured continuously for 48 hours after final grading. Water shall be applied as necessary to keep the surface damp. During curing, only traffic necessary for access to residences and businesses shall be allowed to drive on the CSPB.

301-3.4.13 Micro-Cracking.

301-3.4.13.1 General. Micro-cracking is the process of generating minute, subsurface cracks in the CSPB. The Contractor shall perform micro-cracking on the CSPB within 30 to 72 hours of the completion of compaction.

301-3.4.13.2 Method. Micro-cracking shall be performed by operating a 10 to 12-ton steel wheel vibratory roller, traveling at a speed of approximately 2 mph, and vibrating at maximum amplitude, over the CSPB for a minimum of 3 passes unless otherwise specified or directed by the Engineer. The CSPB surface shall be completely covered, exclusive of the outside 1 foot.

301-3.4.14 Final Curing. After the completion of initial curing and micro-cracking, CSPB shall be continuously moisture-cured for an additional 48-72 hours, or until placement of the overlying asphalt concrete base course, whichever occurs first.

301-3.4.15 Fog Seal. If specified, a fog seal shall be applied over the CSPB after final curing. The fog seal material shall be applied at a rate of 0.10 to 0.20 gallon per square yard (0.46 L/m^2 to 0.91 L/m^2) unless otherwise specified. The final application rate shall be approved by the Engineer.

The fog seal material shall be allowed to break or otherwise become stable before placement of the overlying asphalt concrete base course. Traffic shall not be allowed to drive upon fog seal material at any time.

301-3.4.16 Measurement. Portland cement will be measured by the ton (tonne). The basis of payment shall be the net weight of Portland cement used to produce CSPB for the Work. The Contractor shall furnish the Engineer with certified weighmaster certificates showing the weight of each load delivered to the Work site and the weight remaining on the Work site after completion.

CSPB will be measured by the square yard (m^2) of finished surface for each thickness specified or shown on the Plans.

Excess pulverized base material, excess CSPB, and unsuitable material will be measured by the cubic yard (m^3).

301-3.4.17 Payment. Payment for Portland cement will be made at the Contract Unit Price per ton (tonne). The Contract Unit Price shall include furnishing and spreading. Payment for Portland cement will not be subject to the provisions of 3-2.2.2 and 3-2.2.3.

Payment for CSPB will be made at the Contract Unit Price per square yard (m^2) for each thickness specified or shown on the Plans. The Contract Unit Price shall include pulverizing, initial grading, mixing, compaction, final grading, curing, micro-cracking, and fog seal (if required).

Payment for preparation of the mix design, if prepared by the Contractor, will be made as specified in the Special Provisions or shown on the Bid.

Payment for removal and disposal of excess pulverized base material and excess cement stabilized pulverized base material will be made at the Contract Unit Price per cubic yard (m^3) for unclassified excavation.

301-4 LEAN CONCRETE BASE (LCB).

301-4.1 General. This subsection specifies the methods to be used to place LCB conforming to 200-4.

301-4.2 Subgrade. Immediately prior to placement, the subgrade shall conform to 301-1. The subgrade shall be free of loose or extraneous material and shall be sufficiently dampened to ensure that no water is absorbed from the LCB.

301-4.3 Placement. Placement shall conform to 302-6.3.

Unless otherwise shown on the Plans or specified in the Special Provisions, LCB shall be placed in widths of not less than 12 feet (4 m) separated by construction joints. LCB placed monolithically in

widths greater than 26 feet (8 m) shall be placed with a longitudinal weakened plane joint offset not more than 3 feet (1 m) from the centerline of the width being constructed. Longitudinal weakened plane joints shall conform to 302-6.5.4.

When PCC pavement is to be placed over LCB, longitudinal construction joints and longitudinal weakened plane joints in the LCB shall not be within 1 foot (300 mm) of longitudinal weakened plane joints nor longitudinal construction joints in the PCC pavement.

Areas of the subgrade that are lower than the grade established on the Plans shall be filled with LCB.

LCB shall not be mixed nor placed while the atmospheric temperature is below 35° F (2° C), and shall not be placed on frozen ground.

301-4.4 Spreading, Compacting and Shaping. Spreading, compacting, and shaping shall conform to 301-3.3.

In advance of curing operations, LCB to be surfaced with asphalt concrete pavement shall be textured with a drag strip of burlap, a broom, or a spring steel tine device capable of producing scoring in the finished surface. The scoring shall be parallel with or transverse to the centerline.

LCB to be surfaced with PCC pavement shall not be textured and shall be finished to a smooth surface, free of mortar ridges and other projections, before curing compound is applied.

The finished surface of LCB shall be free from porous areas and not vary at any point more than 5/8 inch (16 mm) above or below the grade shown on the Plans.

301-4.5 Curing. LCB shall be cured with a pigmented curing compound conforming to 201-4. Curing compound shall be applied to areas to be surfaced with PCC pavement in 2 separate applications. Each application shall be applied at a rate of approximately 1 gallon per 150 square feet (1 L/4 m^2).

Curing compound shall be applied before the atmospheric temperature falls below 40° F (40 C).

Areas to be covered with PCC pavement that are not covered by the fourth day after the curing compound is applied shall be given a subsequent application (or applications, if necessary) so that each application occurs no more than 4 Days in advance of placing the overlying PCC pavement. LCB surfaces shall be cleaned of all foreign material prior to the application of curing compound.

Curing compound shall be applied at a rate of approximately 1 gallon per 200 square feet (1 L/5 m^2) for each subsequent application.

Damage to the curing compound or the LCB shall be promptly repaired by the Contractor at the Contractor's expense, as directed by the Engineer.

301-4.6 Acceptance.

301-4.6.1 Material. LCB will be tested for acceptance in accordance with 201-1.1.5.

301-4.6.2 Placement. Hardened LCB with a surface lower than 5/8 inch (16 mm) below the grade shown on the Plans shall be removed and replaced with LCB, or if permitted by the Engineer, low areas shall be filled with paving material as follows:

a) When the surface pavement is PCC, low areas shall be filled with PCC at the time and in the same operation the PCC pavement is placed.

b) When the surface pavement is asphalt concrete, the low areas shall be filled with asphalt concrete at the time and in the same operation that asphalt concrete pavement is placed.

Hardened LCB with a surface higher than 5/8 inch (16 mm) above the grade shown on the Plans shall be removed and replaced with LCB, or if permitted by the Engineer, high areas may be ground until the surface conforms to the tolerances specified in 301-4.4. Grinding shall be performed with diamond blade or carborundum blade grinding equipment. Ground areas to be surfaced with PCC pavement shall

be cleaned of all foreign material and grinding residue as soon as all free water has left the surface. Curing compound conforming to 301-4.5 shall be applied at a rate of approximately 1 gallon per 150 square feet (1 L/4 m^2).

301-4.7 Measurement. LCB will be measured by the cubic yard (m^3). The volume will be calculated on the basis of the dimensions shown on the Plans adjusted by the amount of any change approved by the Engineer. LCB used to fill depressed areas of subgrade will not be measured for payment.

301-4.8 Payment. Payment for LCB will be made at the Contract Unit Price per cubic yard (m^3).

No separate payment will be made for bringing the surface of the LCB within tolerance. Payment will be considered as included in the Contract Unit Price per cubic yard (m^3).

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 C51.

When sampled by the Engineer at the point of delivery, the lime shall meet the following quality requirements:

TABLE 301-5.2

Sieve Sizes	Percent Passing	
	Hydrated Lime	Quicklime
No. 4 (4.75 mm)	100	100
No. 30 (600 µm)	95 - 100	
No. 100 (150 µm)		0 - 20
No. 200 (75 µm)	75 - 100	
Test Method	ASTM C110[1]	ASTM C136[2]
Chemical	**Percent of Chemical (Min.)**	
$Ca(OH)_2$	85	119
CaO		80
Test Method	California Test 414 or ASTM C25	

1. The sample shall be washed for 15 ± 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 Work 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 2 inches (50 mm) in diameter. Removing and disposing of rocks larger than 2 inches (50 mm), when in excess of 5 percent of the total material to be treated, will be considered as Extra Work.

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 35°F (2°C) 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 phenolphthalien-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 1 inch (25 mm) 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 lines, grades, and cross sections shown on the plans.

The thickness of a compacted layer shall not exceed 8 inches (200 mm). Where the thickness is more than 8 inches (200 mm), 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 1/4 inch (6 mm) 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 1/2 inch (12.5 mm) 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 0.10 and 0.20 gallon per square yard (0.45 L/m^2 and 0.90 L/m^2), 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 Work site. 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 Work site 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 yard or cubic yard (m^2 or m^3) in place as shown on the Plans or as directed by the Engineer. The Contract Unit Price per square yard or cubic yard (m^2 or m^3) shall include payment for breaking-up, mixing, spreading, compacting, trimming, and curing treated soil. Lime will be paid for by the ton (tonne) when spread at the rate prescribed on the Plans or directed by the Engineer. Payment for lime will include furnishing and spreading lime.

SECTION 302 - ROADWAY SURFACING

302-1 COLD MILLING OF EXISTING PAVEMENT

302-1.1 General. The Contractor shall cold mill existing pavement as shown on the Plans and as specified in the Special Provisions. The type of pavement and depth to be cold milled shall be as shown on the Plans or as 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 will 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 3/8 inch (9.5 mm) 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 5 feet (1500 mm) in length or to the next joint.

The Contractor shall remove existing asphalt concrete overlay from gutters adjacent to any area specified to be cold milled, as directed by the Engineer.

302-1.2 Milling Machines. 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 60 inches (1500 mm) 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.

302-1.3.2 Milling Machines. 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. The resultant milled surface shall not deviate from the grade shown on the Plans, using the straightedge specified in 302-5.6.2, by more than 1/4 inch (6 mm) at any point.

302-1.4.2 Milling Machines. Milling machines used for profile milling operations shall conform to 302-1.2. The Contractor shall also use a minimum 20-foot (6 m) paving ski with spring loaded feet attached to the bottom at not more than 18-inch (450 mm) 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 3/16 inch (5 mm) 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.

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 1/2 inch (12.5 mm) 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.

302-1.5.2 Milling Machines. Milling machines used for full depth milling of pavement shall conform to 302-1.2 and be capable of milling a minimum depth of 10 inches (250 mm) 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 of the Plans.

302-1.7 Work Site Maintenance. Work site maintenance shall conform to 7-8. A motorized street sweeper shall follow within 50 feet (15 m) 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 12 inches (300 mm) 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 700-5.8 and 701-17.6.

302-1.10 Pavement Transitions. Structures and vertical joints within the cold-milled areas that are transverse to through traffic shall be ramped as shown on the Plans or specified in the Special Provisions. 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 foot (m) along the edge of the transverse joint lines, adjacent curb, gutter, or cross gutter, or by the square foot (m^2) 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.

302-2 CHIP SEAL.

302-2.1 General. A chip seal shall consist of an application of polymer modified emulsified asphalt or modified paving asphalt and screenings to an existing roadway surface. A double chip seal shall include a second application of polymer modified emulsified asphalt or modified paving asphalt and screenings of a smaller size. A chip seal consisting of an application of asphalt rubber binder and screenings shall conform to 302-10.

Chip seals shall be specified by the type (size of screenings) and grade of emulsified asphalt or modified paving asphalt, i.e. "Medium Fine - PMCRS-2h."

The type (size of screenings) and grade of emulsified asphalt or modified paving asphalt to be applied, and the type of screenings to be spread, shall be as specified in the Special Provisions or shown on the Plans.

302-2.2 Materials.

302-2.2.1 Emulsified Asphalt. Unless otherwise specified in the Special Provisions or shown on the Plans, emulsified asphalt for chip seal applications shall be PMCRS-2h conforming to Section 37-2.02F of the Caltrans Standard Specifications.

Emulsified asphalt for fog seal applications shall consist of 50 percent CQS-1h conforming to 203-3 and 50 percent water conforming to 203-3.2.

302-2.2.2 Modified Paving Asphalt. Modified paving asphalt shall be defined as performance grade paving asphalt containing polymer and/or ground tire rubber modifiers. Modified paving asphalt shall conform to the requirements in the Special Provisions.

302-2.2.3 Screenings. Screenings shall conform to 200-1.2.2.

302-2.2.4 Sand. Sand for sand cover shall conform to 200-1.5.3.

302-2.3 Equipment.

302-2.3.1. General. Equipment shall be approved by the Engineer prior to use on the Work.

302-2.3.2 Distributor Trucks. Distributor trucks shall be self-propelled and of the pressure-type with insulated tanks. Distributor trucks shall be capable of uniform application in controlled amounts ranging from 0.02 gallon to 1 gallon per square yard (0.10 to 4.5 L/m^2) of surface.

Distributor trucks shall be equipped with:

a) a cab-mounted computerized control system capable of adjusting the application rate, spray bar circulation, spray bar width, and turning on/off in 1 foot (0.3 m) increments of the spray bar;

b) a cab-mounted display with selectable digital readouts of application rate, truck speed (feet per minute) (meters per minute), distance traveled, spray bar width, and total area sprayed;

c) a cab-mounted automatic valve control system;

d) a ground travel speed and distance traveled measuring system;

e) heating unit and pump or pumps capable of spraying within 0.02 gallons per square yard (0.10 L/m^2) of the specified application rate;

f) a full-circulation spray bar (including extensions), a minimum of 12 feet (3.7 m) wide, capable of uniform application across the full-width of a traffic lane without streaks or other distortions, adjustable to permit positioning at various heights above the surface to be treated, and equipped with individual quick-disconnect valves for each nozzle;

g) tachometer;

h) pressure gauges;

i) volume measuring device and gauges;

j) temperature gauges, including one on the side of the tank visible to the Engineer when standing on ground level; and

k) a single or multiple nozzle hand spray wand with a minimum of 25 feet (7.6 m) of hose.

302-2.3.3 Haul Trucks. Trucks for hauling screenings shall be of the tailgate discharge ("end dump") type and be equipped with:

a) a device capable of locking onto the rear hitch of the chip spreader;

b) a dump bed that, when fully raised, will not push down on the chip spreader; and

c) a dump body lip of sufficient length that screenings will not spill onto the roadway surface during dumping into the rear hopper of the chip spreader.

302-2.3.4 Chip Spreaders. Chip spreaders shall be specifically designed and constructed for spreading screenings. Chip spreaders shall be:

a) self-propelled;

b) equipped with a locking device for attaching to haul trucks, separate rear receiving and front spreading hoppers, a conveyor system capable of transporting material deposited in the rear hopper to the front hopper, an adjustable-width spreading hopper, and a computerized spread rate control system capable of adjusting the spread rate up or down in 1 pound increments; and

c) capable of towing haul trucks during discharge and spreading screenings over an entire traffic lane width in one pass.

302-2.3.5 Pneumatic Tire Rollers. Pneumatic tire rollers (rollers) shall be self-propelled, reversible, and the oscillating-type having a width of not less than 4 feet (1.2 m).

Roller tires shall be of equal size, diameter, type, and ply, and be spaced such that the gaps between adjacent front tires will be covered by adjacent rear tires. Rollers shall carry a minimum of 3,000 pounds (1360 kg) of load on each tire. Each tire shall be inflated to 100 pounds per square inch (689 kPa) and maintained so that the air pressure will not vary more than 5 pounds per square inch (34 kPa).

Rollers shall be equipped with pads and a water application system capable of preventing asphalt from adhering to the pneumatic tires. A biodegradable parting agent approved by the Engineer may be used in addition to the pads and water application system.

302-2.3.6 Sweepers. Sweepers shall be self-loading, motorized street sweepers or self-propelled power brooms equipped with an adjustable, power-driven, rotating circular broom. Sweepers shall be capable of removing loose screenings without dislodging those seated in the residual asphalt.

302-2.4 Roadway Surface Preparation. Prior to application and spreading, the roadway surface shall be prepared as follows.

Manhole covers, utility vaults and the surfaces of other utility facilities, survey monuments and benchmarks, shall be covered using a material approved by the Engineer. The cover material and application procedure shall not result adherence of the chip seal nor in stripping of the chip seal from the adjacent roadway pavement.

Thermoplastic striping and pavement markings, raised pavement markers, and raised pavement marker adhesive shall be removed.

Cleaning shall be performed by sweeping, flushing, or other method which results in the removal of all loose particles of extraneous material.

302-2.5 Temporary Traffic Control. In addition to the requirements of 601, temporary traffic control shall conform to the following requirements:

a) Roadways to be chip sealed may be closed to through traffic if so specified in the Special Provisions or approved by the Engineer.

b) At locations where traffic is being routed over an open roadway upon which a chip seal is to be applied, the chip seal shall not be applied to more than 1/2 the width of the traveled way at a

time, and the remaining width shall be kept free of obstructions and open for use by traffic until the chip seal is finished.

c) Pilot cars utilized by the Contractor to convoy or otherwise control traffic shall maintain radio contact with other pilot cars, flaggers, and personnel in the Work area. The maximum speed of the pilot cars convoying or controlling traffic through the temporary traffic control zone shall be 15 miles per hour on 2-lane, 2-way roadways and 25 miles per hour on multi-lane divided and undivided roadways. Pilot cars shall only use open traffic lanes.

d) On 2-lane, 2-way roadways, C6 "LOOSE GRAVEL" signs and W6 (35) speed advisory signs shall be furnished and placed adjacent to both sides of the traveled way where screenings are being spread on a traffic lane. The first C6 sign in each direction shall be placed where traffic first encounters loose screenings, regardless of which lane the screenings are being spread on. The W6 (35) signs need not be placed in those areas with posted speed limits of less than 40 MPH. The signs shall be placed at maximum 2,000-foot (610 m) intervals along each side of the traveled way and at public roads or streets entering the seal coat area as directed by the Engineer.

e) On multilane roadways where screenings are being spread on a traffic lane, C6 "LOOSE GRAVEL" signs and W6 (35) speed advisory signs shall be furnished and placed adjacent to the outside edge of the traveled way nearest to the lane being worked on. The first C6 sign shall be placed where the screenings begin with respect to the direction of travel on that lane. The W6 (35) signs need not be placed in those areas with posted speed limits of less than 40 MPH. The signs shall be placed at maximum 2,000-foot (610 m) intervals along the edge of traveled way and at public roads or streets entering the scrub seal coat area as directed by the Engineer.

f) The C6 and W6 signs shall be maintained in place at each location until final sweeping at that location has been completed. The signs may be set on temporary portable supports with the W6 below the C6 or on barricades with the W6 sign alternating with the C6 sign.

g) During flush coat operations, the traffic lanes upon which the flush coat is being applied shall be closed.

h) Traffic lanes shall not be opened until the flush coat has been applied.

302-2.6 Application and Spreading.

302-2.6.1 General. Application and spreading shall only be performed when the pavement is clean and dry, wind conditions are such that uniform coverage will result, and rain is not imminent.

302-2.6.2 Polymer Modified Emulsified Asphalt. Polymer modified emulsified asphalt shall only be applied when the ambient temperature is between 60°F and 105°F (16°C and 41°C), and the roadway pavement surface temperature is a minimum of 55°F (13°C).

The liquid temperature at the time of application shall be between 130°F and 180°F (54°C and 82°C).

The application rate shall be within the range shown in Table 302-2.6.2 for the type of chip seal. The initial rate of application, if pre-determined, shall be as specified in the Special Provisions or shown on the Plans. The exact rate will be determined by the Engineer.

TABLE 302-2.6.2

Chip Seal Types	Application Rate gal/yd^2 (L/m^2)
Fine	0.15 to 0.30 (0.68 to 1.36)
Medium Fine	0.25 to 0.35 (1.13 to 1.58)
Medium	0.25 to 0.40 (1.13 to 1.81)
Coarse	0.30 to 0.40 (1.36 to 1.81)
Double	
1st Application	0.20 to 0.35 (0.91 to 1.58)
2nd Application	0.20 to 0.30 (0.91 to 1.36)

Distribution shall not vary from the specified rate by more than 15 percent transversely nor more than 10 percent longitudinally, as determined in accordance with California Test 339.

Application a) may be performed with a wand in areas inaccessible to the distributor truck if so approved by the Engineer, b) shall not be to a greater distance than can be immediately covered by screenings, unless otherwise approved by the Engineer, and c) shall be discontinued sufficiently early each Working Day to permit the termination of temporary traffic control prior to darkness.

302-2.6.3 Modified Paving Asphalt. Modified paving asphalt shall only be applied when the atmospheric temperature is 65°F (18°F) or above and the existing pavement surface temperature is 80°F (27°C) or above.

The liquid temperature at the time of application shall be between 330°F and 375°F (166°C and 191°C).

The application rate shall be within the range shown in Table 302-2.6.3 for the type of chip seal. The initial rate of application, if pre-determined, shall be as specified in the Special Provisions or shown on the Plans. The exact rate will be determined by the Engineer.

TABLE 302-2.6.3

Chip Seal Types	Application Rate gal/yd^2 (L/m^2)
Fine	0.28 to 0.34 (0.68 to 1.36)
Medium Fine	0.32 to 0.38 (1.13 to 1.58)
Medium	0.36 to 0.46 (1.13 to 1.81)
Coarse	0.38 to 0.48 (1.36 to 1.81)
Double	
1st Application	0.36 to 0.42 (0.91 to 1.58)
2nd Application	0.26 to 0.34 (0.91 to 1.36)

Distribution shall not vary from the specified rate by more than 15 percent transversely nor more than 10 percent longitudinally, as determined in accordance with California Test 339.

Application:

a) shall not be to a greater distance than can be immediately covered by screenings, and

b) shall be discontinued sufficiently early each Working Day to permit the termination of temporary traffic control prior to darkness.

302-2.6.4 Screenings.

302-2.6.4.1 General. The chip spreader shall be operated at a speed that will not result in the screenings rolling over after striking the asphalt covered roadway surface. The speed of the distributor truck shall be governed by the speed of the chip spreader.

302-2.6.4.2 Spreading on Polymer Modified Emulsified Asphalt. Screenings shall be spread before setting or "breaking" of the polymer modified emulsified asphalt occurs.

Screenings may be stockpiled; however, screenings contaminated during storage or reloading operations will be rejected.

Screenings shall be surface damp at the time of application. Screenings shall be dampened in the haul truck prior to dumping into the chip spreader when so directed by the Engineer.

The spread rate shall be within the range shown in Table 302-2.6.4.2 for the type of chip seal. The initial rate, if pre-determined, shall be as shown on the Plans or specified in the Special Provisions. The exact rate will be determined by the Engineer.

TABLE 302-2.6.4.2

Chip Seal Types	Spread Rate lbs/yd^2 (kg/m^2)
Fine	12 to 20 (6.5 to 10.9)
Medium Fine	16 to 25 (8.7 to 13.6)
Medium	20 to 30 (10.9 to 16.3)
Coarse	23 to 35 (12.5 to 19.0)
Double	
1st Application	23 to 30 (12.5 to 16.3)
2nd Application	12 to 20 (6.5 to 10.9)

Screenings shall be spread at a rate within 10 percent of the rate determined by the Engineer.

302-2.6.4.3 Spreading on Modified Paving Asphalt. Pre-coated, pre-heated screenings shall be spread immediately after application of modified paving asphalt. Stockpiling will not be permitted.

The spread rate shall be within the range shown in Table 302-2.6.4.3 for the type of chip seal. The initial rate, if pre-determined, shall be as shown on the Plans or specified in the Special Provisions. The exact rate will be determined by the Engineer.

TABLE 302-2.6.4.3

Chip Seal Types	Spread Rate lbs/yd^2 (kg/m^2)
Fine	16 to 24 (6.5 to 10.9)
Medium Fine	16 to 24 (8.7 to 13.6)
Medium	18 to 26 (10.9 to 16.3)
Coarse	18 to 26 (12.5 to 19.0)
Double	
1st Application	20 to 26 (12.5 to 16.3)
2nd Application	16 to 22 (6.5 to 10.9)

Screenings shall be spread at a rate within 10 percent of the rate determined by the Engineer.

302-2.6.5 Joints. Joints shall be smooth, straight, and uniform. Edges shall be swept free of loose screenings prior to the adjacent application of asphalt.

Application shall start and stop on building paper or other similar material approved by the Engineer wherever a transverse join to existing roadway pavement or an adjacent application occurs. The material shall cover the full-width of the application. The material length shall be that which is necessary to ensure the distributor truck spray nozzles are fully-operational when the existing pavement to be chip sealed is reached, and which prevents application on previously placed screenings or beyond the limits shown on the Plans. The joint material shall then be removed and disposed of by the Contractor.

Longitudinal joints between adjacent applications shall a) coincide with traffic lane lines, b) be swept of loose screenings prior to the adjacent application, and c) be overlapped between applications for a maximum width of 4 inches (100 mm). The resultant joints shall be free of ridges and depressions and have an appearance and texture consistent with the adjacent chip sealed surface.

302-2.7 Finishing.

302-2.7.1 General. Finishing shall consist of, in order of sequence:

a) initial and final rolling;

b) sweeping; and

c) application of a flush coat.

After the screenings have been spread, piles and ridges shall be removed. Additional screenings shall be spread in whatever quantity as may be necessary to completely and uniformly cover the residual asphalt, after which the chip seal shall be rolled. After initial sweeping, sand shall be applied to areas where free residual asphalt is evident.

302-2.7.2 Rolling. A minimum of 3 pneumatic tire rollers shall be furnished and operated during rolling operations.

A pass shall be defined as 1 roller movement parallel to the chip seal application in either direction. Coverage shall be defined as the number of passes needed for a roller to cover the full application width. Overlapping passes shall be considered part of the coverage being performed and not a part of a subsequent coverage. Subsequent coverage shall not be started until the previous coverage has been completed.

Rolling shall be performed in the following sequence:

a) Initial rolling consisting of 1 coverage.

b) Final rolling consisting of 3 coverages.

Initial rolling shall begin immediately after the screenings have been spread.

Final rolling shall begin immediately after completion of the initial rolling. If approved by the Engineer, final rolling for screenings on modified paving asphalt may be performed with one steel wheel roller weighing between 8 tons (7.3 tonnes) minimum and 10 tons (9.1 tonnes) maximum. The steel wheel roller shall be operated in the static mode only.

302-2.7.3 Sweeping. The Contractor shall notify the Engineer of the time it intends to wait after the screenings have been spread before beginning sweeping operations. A minimum of 3 sweepers shall be furnished and operated in addition to those required to conform to 302-2.8.

Sweeping shall not cause screenings which have seated in the residual asphalt to become loose. Sweeping shall result in the removal of loose screenings from the roadway, adjacent gutters, curb ramps, sidewalks, driveways, and intersecting roadways.

Excess screenings generated by sweeping operations shall be removed and disposed of by the Contractor except as follows:

a) Excess screenings may remain on unimproved, graded shoulders unless otherwise specified or approved by the Engineer.

b) Excess screenings may be salvaged and stockpiled for spreading if so specified or approved by the Engineer.

302-2.7.4 Finished Surface. The finished surface, prior to application of the flush coat, shall be uniform in appearance and free from ridges, depressions or other irregularities.

302-2.8 Flush Coat.

302-2.8.1 General. Flush coat shall consist of the application of an emulsified asphalt fog seal and sand cover to the surface of the chip seal. Flush coat application shall begin immediately after initial sweeping and removal of excess screenings and prior to opening the lane to uncontrolled (not controlled with pilot cars) traffic.

Flush coat shall not be applied when the atmospheric temperature is below 40°F (4°C).

302-2.8.2 Fog Seal. Emulsified asphalt shall be applied by a distributor truck conforming to 302-2.3.2. The diluted application rate shall be within the range of 0.06 to 0.18 gallons per square yard (0.28 to 0.81 L/m^2). The exact application rate will be determined by the Engineer. The actual rate shall not vary more than 5 percent from the specified rate.

After the application of a fog seal coat, emulsified asphalt that becomes tacky shall be sprinkled with water in the amount ordered and as directed by the Engineer.

302-2.8.3 Sand Cover. Sand shall be spread by a chip spreader conforming to 302-2.3.4 at a uniform rate over the full width of a traffic lane in a single application.

Sand cover shall be applied immediately following application of the fog seal. Sand shall be spread at a rate of 2 to 4 pounds per square yard (0.91 to 1.8kg/m^2). The exact rate will be determined by the Engineer. The actual rate shall not vary more than 5 percent from the specified rate.

302-2.9 Maintenance. The Contractor shall maintain the chip seal surface for 4 Days beginning on the date of application and spreading. Maintenance shall include maintaining the chip seal surface free of loose screenings by sweeping, applying additional screenings and/or sand cover as may be necessary to absorb free residual asphalt or cover bare areas, and other work as directed by the Engineer. Sweeping shall not result in screenings set in the residual asphalt becoming loose.

The exact duration of sweeping operations will be determined by the Engineer. As a minimum, sweeping, in addition to that required in 302-2.7, is required as follows:

a) On 2-lane, 2-way roadways, from 2 to 4 hours after public traffic controlled with pilot cars has been routed over the seal coat.

b) On multilane roadways, from 2 to 4 hours after screenings have been applied.

c) In addition to previous sweeping, immediately prior to opening any lane to public traffic not controlled with pilot cars.

d) As a first order of work on the morning following the spreading of screenings, on any lane that has been open to public traffic not controlled with pilot cars.

e) For double seal coats, prior to the second application.

f) At the end of the 4-Day maintenance period.

The following shall apply to seal coat operations on 2-lane, 2-way roadways under one-way traffic control:

g) Upon the completion of final rolling, public traffic routed over the seal coat must be controlled with pilot cars from 2 to 4 hours. The exact period of time will be determined by the Engineer.

h) The flush coat shall be applied on both lanes such that traffic control is discontinued 1 hour before darkness. At the end of the work shift, the end of the seal coat on each lane shall match.

The following shall apply to seal coat operations on multi-lane roadways:

i) The initial sweeping shall begin 2 to 4 hours after the screenings have been applied. When the initial sweeping is not completed during the work shift in which the screenings were applied, the initial sweeping shall be completed as the first order of work at the beginning of the next work shift.

j) After the completion of initial sweeping, public traffic controlled by pilot cars shall be routed over the seal coat surface.

k) A maximum of 1 lane in each direction shall be open to public traffic when controlled by pilot cars.

l) Public traffic shall be controlled with pilot cars for a minimum of 2 hours or until the adjacent traffic lanes have been seal-coated and swept, whichever comes last.

302-2.10 Measurement. Chip seals will be measured by the square yard for each combination of size of screenings and grade of polymer modified emulsified asphalt or modified paving asphalt, or by the ton for each size of screenings and each grade of polymer modified emulsified asphalt or modified paving asphalt. The basis of measurement shall be as specified in the Bid.

The Contractor shall submit licensed weighmaster certificates for materials delivered to the Work site by the end of the first Working Day following the date of delivery. Upon completion of the Work, the Contractor shall submit licensed weighmaster certificates for materials remaining on the Work site but not used in the Work. The weight of materials used in the Work will be calculated by deducting the weight of remaining materials from the weight of delivered materials.

302-2.11 Payment. Payment for chip seals will be made at the Contract Unit Price per square yard for each combination of size of screenings and grade of emulsified asphalt or modified paving asphalt, or the Contract Unit Price per ton (tonne) for each size of screenings and each grade of emulsified asphalt or modified paving asphalt used in the Work. The basis of payment shall be as specified in the Bid.

Unless otherwise specified, the Contract Unit Price shall include:

a) surface preparation,

b) materials,

c) temporary traffic control,

d) application and spreading,

e) finishing,

f) sweeping, and

g) maintenance of the completed chip seal.

302-3 Not Used.

302-4 SLURRY SEAL SURFACING.

302-4.1 General. Slurry seal surfacing shall consist of mixing, spreading, and application of slurry seal conforming to 203-5 at the Work site. The combined aggregate gradation and emulsified asphalt grade shall be as shown on the Plans or specified in the Special Provisions.

302-4.2 Aggregate Stockpile. The Contractor shall make arrangements for and provide an aggregate stockpile site a minimum of 3 Working Days prior to starting the Work. The stockpile site shall be clean and free from objectionable material.

302-4.3 Continuous Flow Mixers.

302-4.3.1 General. Slurry seal mixed at the Work site shall be mixed in hydraulic or mechanical continuous flow mixers (mixers). The Contractor shall have a minimum of 2 fully-operational mixers available for use at the Work site at all times.

Mixers shall be multi-blade or spiral continuous flow units capable of accurately proportioning and mixing aggregate, water, emulsion, Portland cement and set control agents, and discharging the mixture to a spreader box on a continuous basis. Mixers shall be equipped with a counter to count the revolutions of the aggregate belt head pulley, a metering device capable of measuring the quantity of water in gallons (liters), and a separate metering device capable of measuring the quantity of emulsified asphalt used to produce each load of slurry seal.

Each emulsion pump shall have its own identification number as determined by the Contractor. Variable rate emulsion pumps shall not be used. The identification number shall be affixed in a location visible to the Engineer.

302-4.3.2 Hydraulic Continuous-Flow Mixers. The drive shaft of the hydraulic motor shall be connected directly to the emulsion pump and have the same or a parallel shaft connected to the hydraulic motor that drives the aggregate belt head pulley.

302-4.3.3 Mechanical Continuous-Flow Mixers. The emulsion pump and aggregate belt head pulley shall be driven off the same drive shaft.

302-4.3.4 Calibration.

302-4.3.4.1 General. Each continuous-flow mixer to be used in the Work shall be calibrated annually by the Contractor. The calibration procedure shall conform to the ISSA "Inspector's Manual MA-1" except as modified in 302-4.3.4.2. A Registered Civil Engineer in the State of California shall sign and seal the calibration report.

The calibration shall be valid for one year from the date the procedure was performed.

Re-calibration will be required if:

a) the emulsion pump or the sprocket drive ratio is changed, and/or

b) the aggregate source is changed and the loose unit weight, as determined by 302-4.3.4.2, varies by more than 5 percent from the loose unit weight determined at the time of calibration of the mixer.

Slurry seal surfacing work shall not begin until the calibration report has been reviewed and accepted by the Engineer.

302-4.3.4.2 Procedure. The ISSA procedure shall be modified to require a minimum sample size of 6,000 pounds (2,700 kg) of aggregate for each gate opening and each test run. The calibration of the emulsion pump shall require a minimum of 25 revolutions of the aggregate belt. The difference in the weight of aggregate delivered shall not vary by more than 2 percent from the average of 3 test runs. The number of revolutions of the head pulley shall be the same for each test run for the gate openings being tested. The emulsion calibration need only be verified for one gate setting. The emulsion delivery rate shall not vary by more than 2 percent from the average of 3 test runs. The Contractor may elect to use larger samples of aggregate or emulsion.

The Contractor shall reproduce and complete the "Emulsion Calibration Worksheet" in the Appendix of the ISSA "Inspector's Manual MA-1." In addition to the information required on the worksheet, the Contractor shall also provide the following:

a) the type and grade of emulsified asphalt,
b) the aggregate source and type,
c) the proposed gate setting based upon the approved mix design,
d) the date of calibration, and
e) the loose unit weight of aggregate determined in accordance with ASTM C29 with a minimum 0.1 cubic feet (3 L) bucket.

The Contractor shall also include the following information on all worksheets and graphs:

f) the identification number for the sprocket and emulsion pump, and
g) the model of the vehicle and type of mixer used for the calibration.

The graph showing pounds (kg) of aggregate vs. gate openings inches (mm) shall also be signed and dated by the Registered Civil Engineer that signed and sealed the calibration report. A copy of the gate opening curve and calibration data shall be kept with each mixer for review by the Engineer.

302-4.4 Verification Testing. The Contractor shall adjust each continuous-flow mixer to be used in the Work to produce slurry seal conforming to the approved mix design(s) required in 203-5.2. The Contractor shall allow 2 Working Days prior to the start of the Work for verification testing of each continuous flow and plant mixer. The Contractor shall provide field samples at the time of verification testing for extraction tests (ASTM D6307), consistency tests, and modified wet track abrasion tests (ASTM D3910). When the field samples conform to the Specifications, the Engineer will notify the Contractor it may start the Work. If not, additional tests shall be performed at the Contractor's expense until an acceptable mix is produced.

302-4.5 Scheduling, Public Convenience and Traffic Control. In addition to the requirements of Part 6, the Contractor shall comply with the following:

At least 5 Working Days prior to commencing the Work, the Contractor shall submit its proposed schedule to the Engineer for approval. Based upon the approved schedule, the Contractor shall, at least 48 hours in advance, notify residents and businesses of the Work and post temporary "No Parking" signs. Requests for changes in the approved schedule shall be submitted to the Engineer for approval at least 3 Working Days before the street is scheduled to be sealed.

Streets where slurry seal is scheduled to be applied shall be closed from the time the Contractor begins to clean the street surface until the Engineer determines the slurry seal has achieved sufficient set to be opened to traffic.

Rock dust or sand shall be spread, as directed by the Engineer, to eliminate tracking or damage and to provide vehicular or pedestrian crossings. Rock dust or sand used for this purpose shall conform to 200-1.2 and 200-1.5, respectively.

302-4.6 Emulsion-Aggregate Slurry (EAS).

302-4.6.1 General. EAS shall conform to 203-5.4. Field adjustments to the set control agents may be made in accordance with the approved mix design. The amount of set control agents to be included shall be that amount necessary to ensure that quick-set EAS can support vehicular traffic within 60 minutes after the completion of application.

302-4.6.2 Mixing. Mixing shall be performed on the Work site by the use of continuous flow mixers conforming to 302-4.3.

302-4.6.3 Application Temperature. EAS shall not be applied if either the pavement or the ambient temperature is less than 50°F (10°C) and falling, but may be applied when the pavement and ambient temperatures are both above 45°F (7°C) and rising.

302-4.6.4 Aggregate Application Rate.

302-4.6.4.1 General. The aggregate application rate shall conform to the requirements shown in Table 302-4.6.4.1 unless otherwise specified in the Special Provisions or shown on the Plans.

TABLE 302-4.6.4.1

Aggregate Type	Aggregate Application Rate	
	MINIMUM	MAXIMUM
Type I	8 lbs/yd^2 (4.3 kg/m^2)	10 lbs/yd^2 (5.4 kg/m^2)
Type II	12 lbs/yd^2 (6.5 kg/m^2)	15 lbs/yd^2 (8.1 kg/m^2)
Type III	20 lbs/yd^2 (10.8 kg/m^2)	25 lbs/yd^2 (13.5 kg/m^2)

302-4.6.4.2 Corrective Action. When the aggregate application rate is less than the minimum shown in Table 302-4.6.4.1, the Contractor shall apply additional EAS to the nonconforming areas as necessary to conform to the Specifications.

When the aggregate application rate exceeds the maximum shown in Table 302-4.6.4.1, the nonconforming material shall be removed and replaced, or be left in place at no additional cost to the Agency, as determined by the Engineer.

302-4.7 Rubberized Emulsion Aggregate Slurry (REAS).

302-4.7.1 General. REAS shall conform to 203-5.5.

302-4.7.2 Mixing. REAS shall be mixed by one of the following methods as specified in the Special Provisions:

a) in a continuous flow mixer conforming to 302-4.3 at the Work site, or

b) at a central mixing plant conforming to 203-5.5.3.

302-4.7.3 Transporting. Transporting of REAS mixed at a central mixing plant shall conform to 203-5.5.3.2.

302-4.7.4 Work Site Storage. REAS mixed at a central mixing plant may be stored at the Work site in tanks specifically designed for this purpose and which are equipped with an agitator similar to that in a central mixing plant. The agitator shall be capable of continuous operation.

302-4.7.5 Application Temperature. REAS shall not be applied if either the pavement or the ambient temperature is less than 55°F (13°C) and falling, but may be applied when the pavement and ambient temperatures are both above 50°F (10°C) and rising.

302-4.7.6 Application Rate.

302-4.7.6.1 Continuous-Flow Mixer. The aggregate application rate of REAS mixed on the Work site in a continuous-flow mixer shall conform to the requirements shown in Table 302-4.7.6.1 unless otherwise specified in the Special Provisions or shown on the Plans.

TABLE 302-4.7.6.1

Type	Aggregate Application Rate	
	Minimum	Maximum
Type Fine REAS	2.8 lbs/yd^2 (1.5 kg/m^2)	3.4 lbs/yd^2 (1.8 kg/m^2)
Type I REAS	4.4 lbs/yd^2 (2.4 kg/m^2)	5.2 lbs/yd^2 (2.8 kg/m^2)
Type II REAS	7.5 lbs/yd^2 (4.1 kg/m^2)	10.0 lbs/yd^2 (5.4 kg/m^2)
Type III REAS	15.7 lbs/yd^2 (8.5 kg/m^2)	21.8 lbs/yd^2 (14.7 kg/m^2)

302-4.7.6.2 Central Mixing Plant. The application rate of REAS mixed at a central mixing plant shall conform to the requirements shown in Table 302-4.7.6.2 unless otherwise specified in the Special Provisions or shown on the Plans.

TABLE 302-4.7.6.2

Type	Application Rate (REAS)	
	Minimum	Maximum
Type Fine REAS	5.0 lbs/yd^2 (2.7 kg/m^2)	6.0 lbs/yd^2 (3.2 kg/m^2)
Type I REAS	7.1 lbs/yd^2 (3.8 kg/m^2)	8.4 lbs/yd^2 (4.5 kg/m^2)
Type II REAS	11.3 lbs/yd^2 (6.1 kg/m^2)	15.0 lbs/yd^2 (8.1 kg/m^2)
Type III REAS	22.5 lbs/yd^2 (12.2 kg/ m^2)	28.1 lbs/yd^2 (15.2 kg/ m^2)

302-4.7.6.3 Corrective Action. When the application rate is less than the minimum shown in the tables above, the Contractor shall apply additional REAS to the nonconforming areas as necessary to conform to the Specifications.

When the application rate exceeds the maximum shown in the tables above, the nonconforming material shall be removed and replaced, or be left in place at no additional cost to the Agency, as determined by the Engineer.

302-4.8 Spreading and Application. Prior to spreading, the Contractor shall clean the existing pavement unless otherwise specified in the Special Provisions. Immediately ahead of the spreader truck, the existing pavement shall be pre-wetted by a pressurized water distribution system equipped with a fog-type spray bar capable of completely covering the surface of the pavement.

Slurry seal mixed at the Work site shall be spread by a spreader box attached to a continuous-flow mixer truck conforming to 302-4.3. REAS produced at a central mixing plant shall be spread by a spreader box attached to an agitator truck conforming 203-5.5.3.2.

The spreader box shall be equipped with flexible material in continuous contact with the existing pavement and shall be capable of controlling the rate of application. The spreader box shall have adjustable width and strike-off height, and be capable of controlling and providing uniform spreading.

The maximum speed of the spreader truck shall not exceed 270 feet per minute (80 m/min.).

REAS mixed at a central mixing plant shall be continuously agitated during spreading.

Hand squeegees and other equipment shall be provided for spreading and spillage removal in areas inaccessible to the spreader box.

Slurry seal shall be applied in such a manner that no ridges remain. Areas in which there is evidence of solidification of the emulsified asphalt, balling or lumping of the aggregates, or uncoated aggregates shall be removed and replaced to the satisfaction of the Engineer.

The Contractor shall prevent slurry seal from being deposited on other than asphalt concrete surfaces and shall remove it from surfaces not designated to be sealed. The method of removal shall be approved by the Engineer.

Where the completed slurry seal surfacing is not uniform in color, the street shall be treated by a method approved by the Engineer to eliminate the color variation.

302-4.9 Field Sampling and Testing.

302-4.9.1 Field Sampling. During the performance of the Work, the Contractor shall provide the Engineer with at least 2 field samples, from separate loads, of mixed slurry seal per mixer per day.

WTAT specimens shall be cast and struck off within 60 seconds of obtaining the sample. WTAT specimens shall not be transported until the slurry seal has set as defined by ASTM D3910.

Field samples shall conform to the requirements shown in Table 302-4.9.1.

TABLE 302-4.9.1

Tests	ASTM Test Method	Requirements	
		Min.	Max.
Wet Track Abrasion Test, Weight loss, gm/ft^2 (gm/m^2) Type Fine Aggregate	D3910[1]	0	50 (540)
Wet Track Abrasion Test, Weight loss, gm/ft^2 (gm/m^2) Type I Aggregate	D3910[1]	0	50 (540)
Wet Track Abrasion Test, Weight loss, gm/ft^2 (gm/m^2) Type II Aggregate	D3910[1]	0	60 (650)
Wet Track Abrasion Test, Weight loss, gm/ft^2 (gm/m^2) Type III Aggregate[4]	D3910[1]	0	60 (650)
Consistency Test (mm)	D3910[1]	20	40
Extraction Test (Calculated Emulsion Content, %)	D6307[2], CT 382[2]	± 1 % of mix design for EAS. ± 3 % of mix design for REAS	
Water Content (% of Dry Slurry)	See Note 3	Type I, II and III EAS < 25 Type Fine and I REAS < 40 Type II and III REAS < 31	

1. Modified ASTM D3910 to include No. 4 (4.75 mm) aggregate or greater and to be performed using field samples. Subsection 6.4.4.7, ASTM D3910 may be modified to use a microwave oven for drying the specimen after the abrasion cycle is complete and the debris washed off.
2. Modified ASTM D6307 and California Test Method 382 to allow a minimum of 500 ± 50 gram sample.
3. Weigh a minimum of 500 grams of homogenized mixed slurry into a previously tared 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 220°F ± 10°F (110° C ± 5°C).
4. The 3/8 inch (9.5 mm) template shall be used.

If the test results fail to meet the Specifications, the Contractor shall cease spreading slurry seal produced by the nonconforming mixer until the Contractor demonstrates the mixer is producing slurry seal which conforms to the Specifications.

302-4.10 Measurement.

302-4.10.1 General. The basis of measurement shall be the weight of materials, in tons (tonnes), used in the Work, as determined by licensed weighmaster's certificates. Upon completion of the Work, the Contractor shall submit to the Engineer licensed weighmaster's certificates for materials delivered to the Work site and for excess materials not incorporated into the Work.

302-4.10.2 Slurry Seal Mixed in Continuous-Flow Mixers. Slurry seal mixed in continuous-flow mixers shall be measured by each ton (tonne) of emulsified asphalt and each ton (tonne) of each type of aggregate used in the Work.

302-4.10.3 REAS Mixed at a Central Mixing Plant. REAS mixed in a central mixing plant shall be measured by each ton (tonne) used in the Work, including aggregate, RPME, additives and water.

302-4.11 Payment.

302-4.11.1 Payment Reduction for Noncompliance.

302-4.11.1.1 General. Payment to the Contractor will be reduced for failure of the field test samples to conform to the WTAT requirements specified in 302-4.9.1.

302-4.11.1.2 Reduction in Payment Based on WTAT. If the average of all WTATs performed per mixer, per day, fails to conform to the requirements specified in 302-4.10.1, the Contractor agrees that payment for the Work represented by the failed tests shall be reduced as shown in Table 302-4.11.1.2 (A) or (B).

TABLE 302-4.11.1.2 (A)

WTAT Loss gm/ft^2 (gm/m^2)	Payment Reduction (Percent) Type Fine & I Aggregate
0 – 50 (0 – 540)	0
50.1 – 60 (540.1 – 650)	5
60.1 – 70 (650.1 – 750)	15
70.1 – 80 (750.1 – 860)	30
80.1 – 99 (860.1 – 1070)	70
99.1 or greater (1070.1 or greater[1])	100

1. Slurry seal surfacing with WTAT loss greater than 99.1 gm/m^2 (1070.1 gm/ft^2) shall be removed to the satisfaction of the Engineer.

TABLE 302-4.11.1.2 (B)

WTAT Loss gm/ft^2 (gm/m^2)	Payment Reduction (Percent) Type II and III Aggregate
0 – 60 (0 – 540)	0
60.1 – 75 (650.1 – 810)	15
75.1 – 80 (810.1 – 860)	30
80.1 – 99 (860.1 – 1070)	70
99.1 or greater (1070.1 or greater[1])	100

1. Slurry seal surfacing with WTAT loss greater than 99.1 gm/m^2 (1070.1 gm/ft^2) shall be removed to the satisfaction of the Engineer.

302-4.11.2 Slurry Seal Mixed in Continuous-Flow Mixers. Payment for slurry seal surfacing for slurry seal mixed in continuous-flow mixers shall be at the Contract Unit Price per ton (tonne) for emulsified asphalt and the Contract Unit Price per ton (tonne) for each type of aggregate. No separate payment will be made for calibration, scheduling, public convenience, or traffic control unless otherwise specified in the Special Provisions.

302-4.11.3 REAS Mixed at a Central Mixing Plant. Payment for slurry seal surfacing for REAS mixed in a central mixing plant shall be at the Contract Unit Price per ton (tonne). No separate payment will be made for calibration, scheduling, public convenience, or traffic control unless otherwise specified in the Special Provisions.

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.

302-5.2 Not Used.

302-5.3 Prime Coat. When specified, a prime coat consisting of Grade SC-250 liquid asphalt shall be applied at a rate between 0.10 and 0.25 gallon per square yard (0.45 L/m^2 and 1.15 L/m^2). 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 PG 64-10 paving asphalt at an approximate rate of 0.05 gallon per square yard (0.25 L/m^2) or SS-1h emulsified asphalt at an approximate rate of 0.05 to 0.10 gallon per square yard (0.25 L/m^2 to 0.45 L/m^2) 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.

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 specified in the Special Provisions. Such headers shall remain in place upon completion of the improvements.

Headers shall be 2-inch (50 mm) nominal size lumber, the vertical dimension of which shall be within 1/2 inch (12.5 mm) of the thickness of the pavement at the header line. The minimum vertical dimension of a header shall be 3-1/2 inches (88 mm). 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 2 inches by 3 inches (50 mm x 75 mm) nominal size, 18 inches (450 mm) long, or longer, and spaced not over 4 feet (1.2 m) apart, shall be driven on the outside of the headers to a depth of 1 inch (25 mm) 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 1 inch (25 mm) thick nominal size board of the same height as the header and not less than 24 inches (600 mm) long.

The temperature of the mixture directly behind the paving machine, before the breakdown roller, shall not be lower than 270°F (132°C) or higher than 320°F (160°C), 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 50°F (10°C) 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 270°F (132°C).

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 4 inches (100 mm) in thickness unless otherwise approved by the Engineer.

TABLE 302-5.5

Specified Total Thickness of Pavement		Minimum Number of Courses	Class of Mixture
Greater Than inches (mm)	But Not More Than inches (mm)		
0	1 (25)	1	D1 or D2
1 (25)	1-1/2 (38)	1	C1, C2, D1 or D2
1-1/2 (38)	3 (75)	1	C1, C2, B or A (as directed)
3 (75)	4 (100)	1	B or A (as directed)
4 (100)	5 (125)	2	C1, C2, B or A (as directed)
5 (125)	—	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 6 inches (150 mm) or less above grade. Such warping shall not extend more than 18 inches (450 mm) 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

Rollers Required[1]		
Tons (Tonnes) Placed per Hour	Compacted Thickness	
	1-1/2" (38 mm) or less	More than 1-1/2" (38 mm)
Less than 100 (90)	1	1
100 to 200 (90 to 180)	2	2
201 to 300 (181 to 270)	3	2
300 (More than 270)	3	3

1. Additional rollers may be necessary to meet the requirements herein.

Self-propelled compacting rollers shall meet the following criteria:

a) Each roller manufactured after 1998 shall have a Manufacturer's identification plate that is readily accessible and readable with the following information:
   1) Name of Manufacturer.
   2) Model Number.
   3) Static pounds per lineal inch (PLI) (newton per millimeter (N/mm)) of each drum.

4) Static PLI (N/mm) of ballasted drum.

5) PLI (N/mm) 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 Work site.

b) 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 250 PLI (44 N/mm).

c) Vibratory rollers used for breakdown or intermediate rolling shall have a compactive effort of not less than 250 PLI (44 N/mm) of centrifugal force at the setting indicated by the manufacturer's ID plate.

d) Finish rolling shall be performed by static or vibratory steel rollers in static mode

e) Pneumatic-tired rollers used for intermediate rolling shall be the oscillating type having a width of not less than 4 feet (1.2 m) 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 90 pounds per square inch (620 kPa) or such lower pressure as designated by the Engineer, and maintained so that the air pressure will vary not more 5 pounds per square inch (35 kPa) 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 2,000 pounds (900 kg). 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 100 tons (90 tonnes) per hour the roller shall have a minimum compactive force of 150 PLI (26 N/mm).

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 260°F (126°C) and not displace under the roller. Except when compacting lifts greater than 4 inches (100 mm) 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 180°F (82°C). 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 4 inches (100 mm) 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 Work site. 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. Asphalt concrete pavement shall be true to grade and cross section. When a 10-foot (3 m) straightedge is laid on the finished surface parallel to the centerline of the roadway, the finished surface shall not vary from the edge of the straightedge more than 1/8 inch (3 mm), 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 or 302-9.4, 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 cold milling, to provide a minimum laying depth of 1 inch (25 mm), or 2 times the maximum aggregate size, whichever is greater, of the new pavement at the join line. Repairs shall not be made to the pavement surface by tapering the thickness at the join lines.

The compaction after rolling shall be a minimum of 95 percent of the density obtained on samples compacted with the California Kneading Compactor per California Test 304. The density shall be determined in accordance with California Test 308, Method A. Method C may be used if the absorption of the compacted specimen is less than 2 percent.

The field density of compacted asphalt concrete shall be determined by:

a) A properly calibrated nuclear asphalt testing device in the field, or

b) California Test 308, Method A when slabs or cores are taken for laboratory testing.

In case of dispute, method b) (above) shall be used.

Paved areas not to be subject to vehicular traffic shall be compacted to 90 percent of the density determined as specified above.

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 1-1/2 inches (38 mm) 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 2 inches (50 mm) 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 2 inches (50 mm) 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 1-1/2 inches (38 mm) 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 1-1/2 inches (38 mm) with an asphalt concrete wearing surface mixture to match the 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 foot (m^2), or at the Contract Unit Price per ton (tonne) 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 Work 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 Work 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 foot (m) 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 3-inch (75 mm) nominal lumber in pieces not less than 16 feet (4.9 m) 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 1/2 inch (12.5 mm) 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 4 feet (1.2 m) apart and driven into the subgrade vertically to a depth not less than 12 inches (300 mm), 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 4 feet (1.2 m) long, 1 inch (25 mm) thick, and at least 6 inches (150 mm) 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 5 feet (1.5 m) 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 1-1/4 inches (32 mm) 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 1/8 inch (3 mm) when checked with a 10-foot (3 m) straightedge placed on the surface of the pavement. The 10-foot (3 m) 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 5 feet (1.5 m) wide, following which the surface of the concrete shall be finished smooth and true to grade, with a wooden float 16 feet (4.9 m) long, 2 inches (50 mm) thick, and 6 inches (150 mm) 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 16 feet (4.9 m) nor more than 20 feet (6.1 m) in length, having a troweling surface not less than 8 inches (200 mm) nor more than 10 inches (255 mm) 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 2/3 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 1/2 inch (12.5 mm) radius; and transverse contact joints, expansion joints, and joints adjacent to an existing pavement shall be rounded to a 1/4 inch (6 mm) 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 shown on the Plans or specified in the Special Provisions.

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:

a) A plain face,

b) Use of tie bars,

c) Construction of keyways.

The bars or keyways shall be as designated on the Plans or in the Special Provisions.

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 1/2 inch (12.5 mm), a maximum thickness of 3/4 inch (19 mm), 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 edger of 1/4 inch (6 mm) 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 1-1/2 inches (38 mm) or 1/6 of the pavement thickness, whichever is greater; the groove for a longitudinal joint shall be cut to a minimum depth of 1-1/2 inches (38 mm) or 1/4 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 1/4 inch (6 mm). 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 Special Provisions.

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 yard (m^3) or square foot (m^2) 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 material shall conform to 213-4.

302-7.2 Placement.

302-7.2.1 General. The existing pavement surface shall be prepared as shown on the Plans or specified in the Special Provisions prior to placement of the tack coat and pavement fabric. The entire surface to be covered shall be free of water, foreign matter, vegetation, and dust before application of the tack coat. The temperature of the underlying asphalt concrete shall not exceed 150°F (66°C) when the fabric is placed.

After placement, pavement fabric material shall be overlaid with asphalt concrete pavement or covered with a chip seal. Pavement fabric shall not be placed in areas where the asphalt concrete overlay is less than 1-1/2 inches (38 mm) thick.

302-7.2.2 Tack Coat.

302-7.2.2.1 General. Tack coat shall be PG 64-10 or PG 70-10 paving asphalt as specified in the Special Provisions. Tack coat shall be applied uniformly prior to placing fabric.

Tack coat shall be sprayed with a truck-mounted sprayer at the rate of 0.25 ± 0.02 gallon per square yard (1.13 ± 0.09 L/m^2). On a new asphalt concrete leveling course, the rate shall be 0.2 ± 0.02 gallon per square yard (0.91 ± 0.09 L/m^2). The application rate may be adjusted as directed by the Engineer. Hand spraying shall be kept to a minimum.

The width of the sprayer application shall be no more than 6 inches (150 mm) and no less than 2 inches (50 mm) wider than the fabric width.

The temperature of the tack coat shall not exceed 325°F (163°C) when the fabric is placed.

302-7.2.2.2 Calibration of Truck-Mounted Sprayer Units. The Contractor shall calibrate each sprayer unit used in the Work prior to the start of spreading the tack coat. Spreading shall not proceed until the calibration has been accepted by the Engineer.

302-7.2.2.3 Testing Apparatus. Testing apparatus shall consist of the following:

a) Portable measuring scale accurate to within ± 2 grams.

b) Test units shall be a 12-inch x 12-inch (300 mm x 300 mm) square of 1/8 inch (3 mm) or 1/4 inch (6 mm) thick hardboard or plywood.

302-7.2.2.4 Calibration Procedure. The calibration procedure shall be as follows:

a) Pre-weigh hardboard or plywood square (minimum of 1, maximum of 3) and write the weight on the underside. The number of test units to be used shall be determined by the Engineer.

b) Locate the truck mounted sprayer unit at the starting point of tack coat placement.

c) The operator sets the application to that rate specified in 302-7.2.2.1 or as specified in the Special Provisions.

d) Place test units on the pavement directly in front of the truck mounted sprayer unit. If 1 unit is used, place it in the center of the truck mounted sprayer unit. If 3 units are used, place 1 unit in center of the sprayer unit and 1 unit outside of each wheel path.

e) Retrieve test units after the truck mounted sprayer unit has passed over them and re-weigh.

302-7.2.2.5 Calculation of the Application Rate. The application rate shall be calculated as follows:

a) Subtract the original weight, recorded on the underside of the test unit, from the weight of the test unit including the tack coat.

b) The difference is the weight of the tack coat on the test unit.

c) Multiply by 9 to calculate the number of grams applied per square yard.

d) Divide the number of grams per square yard by 3861.03 grams per gallon at 60°F.

e) The tack coat application rate shall be expressed in gallons per square yard.

f) Retest as necessary until the specified application rate is confirmed.

302-7.2.3 Laydown. If manual laydown methods are used, pavement fabric material shall be unrolled, stretched, aligned, and placed in increments of approximately 15 feet (4 m).

Adjacent borders of the fabric material shall be lapped 2 to 4 inches (50 mm to 100 mm). The preceding roll shall lap 2 to 4 inches (50 mm to 100 mm) over the following roll in the direction of paving at ends of rolls or at any break. If the lap exceeds 4 inches (100 mm), tack coat shall be placed to bond the layers of fabric material together and both the tack coat and pavement fabric material shall lap by the same amount.

Pavement fabric material 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 material shall not be placed more than 800 feet (180 m) in advance of paving operations or chip sealing unless otherwise approved by the Engineer. No more pavement fabric material shall be placed than can be covered that day.

If the pavement fabric material is placed within 50 feet (15 m) of the tack coat spray unit, the first 15 feet (4 m) of each roll shall be placed by hand, if directed by the Engineer, to allow inspection of the tack coat application.

Pavement fabric material shall be placed with no wrinkles that lap. The test for lapping shall be made as follows:

a) By gathering together the pavement fabric material in a wrinkle.
b) The two sides of the wrinkle shall be pressed together from pavement surface to a fold point with equal amounts of pavement fabric material on both sides of the fold point down to the pavement surface.
c) If the height of the doubled portion of extra pavement fabric material exceeds 1/2 inch (12.5 mm), the pavement fabric material shall be cleanly cut to remove the wrinkle.
d) The cut shall be made on the side of the wrinkle away from the paving operation.
e) 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.
f) Any lap in excess of 2 inches (50 mm) shall be cleanly cut away, and then overlapped in the same manner as for smaller laps.
g) A minimum 1/2 inch (12.5 mm) overlap shall be provided in all cases when a wrinkle area is re-laid.

Pavement fabric material shall not be reduced more than 2 inches (50 mm) on each side after being placed on the tack coat. If the overall width is reduced more than 4 inches (100 mm), then the operation shall be stopped and the temperature of the tack coat immediately prior to placement of the pavement fabric material or the type of pavement fabric material shall be changed.

Care shall be taken to avoid tracking tack coat onto the pavement fabric material or distorting the fabric during seating of the fabric material 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 material immediately in advance of placing asphalt concrete overlay in order to prevent pavement fabric material from being picked up by construction equipment.

Public traffic shall not be allowed to drive over bare pavement fabric material. However, public traffic may be allowed to cross the fabric material under traffic control. The Contractor may place a small quantity of asphalt concrete over the fabric material to protect it from damage if so directed by the Engineer.

302-7.3 Measurement. Pavement fabric material will be measured by the square yard (m^2) for the actual pavement area covered.

302-7.4 Payment. Payment for pavement fabric shall be made at the Contract Unit Price per square yard (m^2). The Contract Unit Price for pavement fabric shall include cleaning of the existing pavement, tack coat, calibration of the truck mounted sprayer unit, and furnishing and placing pavement fabric material.

Payment for advance spreading of asphalt concrete over the fabric shall be considered as included in the Contract Unit Price for asphalt concrete.

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-quart (2 L) 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 2 applications. Unless otherwise specified, the total quantity applied shall be 50 gallons per 1,000 square feet (2 L/m^2).

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 3 parts clean, potable water and one part SS-1h emulsion and shall be applied at the rate of 0.05 gallon per square yard (0.25 L/m^2).

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 55°F (13°C) 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 1/8 inch (3 mm) 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 80°F (27°C) 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 yard (m^2) or as shown in the Bid.

302-9 ASPHALT RUBBER HOT MIX (ARHM).

302-9.1 General. ARHM shall conform to 203-11.

302-9.2 Tack Coat. Tack coat shall conform to 302-5.4.

302-9.3 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 shall be between 300°F (149°C) and 330°F (166°C). The atmospheric temperature shall be 50°F (10°C) and rising. When the

atmospheric temperature is above 85°F (29°C), the temperature of the ARHM at the time of delivery to the Work site may be reduced to 290°F (143°C) if so approved by the Engineer.

302-9.4 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 temperature falls below 290°F (143°C). If the atmospheric temperature is above 85°F (29°C), the initial breakdown rolling temperature may be reduced to 280°F (138°C). Pneumatic rollers shall not be used. If the initial breakdown rolling temperature is reduced, the Contractor shall not be relieved of the density requirements.

302-9.5 Joints. Joints shall conform to 302-5.7.

302-9.6 Manholes (and Other Structures). Manhole and other structures shall conform to 302-5.8.

302-9.7 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 2 pounds per square foot (1.1 kg/m^2) to 4 pounds per square foot (2.2 kg/m^2). When the ARHM pavement has cooled to below 150°F (66°C), the rock dust blotter may not be required.

302-9.8 Measurement. ARHM will be measured by the ton (tonne) or by the square foot (m^2).

The Contractor shall furnish to the Engineer at the time of delivery to the Work site, a legible copy of a licensed weighmaster certificate showing gross, tare, and net weights of each truckload of ARHM. When an automatic batching system is used, the certificate may show only the net weight of ARHM in the truckload.

302-9.9 Payment. Payment for ARHM will be made at Contract Unit Price per ton (tonne) or square foot (m^2). No separate payment for tack coat, rock dust blotter, or sweeping will be made.

Failure of the Contractor to provide a licensed weighmaster certificate to the Engineer by the end of the day on which the ARHM represented by such certificate was delivered to the Work site may, at the discretion of the Engineer, result in forfeiture of payment.

302-10 ASPHALT RUBBER AND AGGREGATE MEMBRANE (ARAM).

302-10.1 Application. Asphalt rubber shall be placed upon a clean dry surface. The pavement surface temperature shall be a minimum of 55°F (13°C) including shaded areas; the atmospheric temperature shall be a minimum of 60°F (16°C) ; 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:

a) 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 425°F (218°C).

b) The distributor shall have a platform on the rear of the vehicle and an observer shall accompany the distributor.

c) 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.

d) Material shall be applied at a rate between 0.55 to 0.65 gallons per square yard (2.5 to 3.0 L/m^2) as directed by the Engineer.

e) Material spreading shall not be in excess of that which can be covered with aggregate within 15 minutes maximum.

f) At the time of delivery to the Work site, the temperature of the asphalt rubber shall be 300°F (149°C) minimum.

The asphalt rubber mixture may be applied to the roadway immediately following mixing and reacting at a temperature between 375°F (191°C) minimum to 425°F (218°C) maximum. However, if the material is not to be used within 6 hours of mixing, the mixture shall be allowed to cool below 300°F (149°C) for 12 hours maximum, or to ambient temperature for longer periods, and shall be uniformly reheated to a temperature between 375°F (149°C) minimum to 425°F (218°C) 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 4 inches (100 mm). 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 203-12.3 shall be placed over all areas receiving asphalt rubber. Screenings shall be applied (within a maximum of 15 minutes) at a temperature between 260°F (127°C) minimum to 325°F (163°C) maximum at a rate of 28 to 40 pounds per square yard (15 to 22 kg/m^2) 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 yard (m^2). 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 3 self-propelled, pneumatic-tired rollers meeting the requirements of 302-5.6.1 except that the tires shall be inflated to 100 pounds per square inch (690 kPa). The operating weight of each roller shall be a minimum of 16,000 pounds (7200 kg). If in the opinion of the Engineer, complete coverage may be provided by 2 rollers in one pass, then 2 pneumatic-tired rollers will be sufficient. The initial rolling equipment shall maintain a distance of not more than 200 feet (60 m) behind the cover-aggregate spreader on the first pass. There shall be at least 4 complete coverages (single pass in one direction) by the pneumatic-tired rollers before final roller coverage. A steel-drum roller weighing 8 tons (7.2 tonnes) minimum to 10 tons (9.1 tonnes) 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 2 pounds per square yard (1.1 kg/m^2) minimum to 4 pounds per square yard (2.2 kg/m^2) maximum. 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.

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 0.06 gallons per square yard (0.27 L/m^2) minimum to 0.12 gallons per square yard (0.54 L/m^2) 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 yard (m^2). Unless otherwise specified, such price shall include full compensation for pavement preparation, furnishing and placing materials required, including rock dust blotter, sweeping, and incidentals needed to complete the work in place.

The Contractor shall include in the Contract Unit Price for ARAM the full cost of applying rock dust blotter to all areas of ARAM, as directed by the Engineer.

The Contractor shall include in the Contract Unit Price for ARAM the full cost of applying a flush coat (if required) to all areas of ARAM, as directed by the Engineer.

302-11 CRUMB RUBBER MODIFIED ASPHALT CONCRETE-GAP GRADED (CRUMAC-GG).

302-11.1 General. CRUMAC-GG shall conform to 203-13.

302-11.2 Tack Coat. Tack coat shall conform to 302-5.4.

302-11.3 Distribution and Spreading. Distribution and spreading shall conform to 302-9.3, except that at the time of delivery to the Work site the maximum temperature shall be 340 °F (171 °C).

302-11.4 Rolling. Rolling shall conform to 302-9.4.

302-11.5 Joints. Joints shall conform to 302-5.7.

302-11.6 Manholes (and Other Structures). Manholes and other structures shall conform to 302-5.8.

302-11.7 Rock Dust Blotter. Rock dust blotter shall conform to 302-9.7.

302-11.8 Measurement. CRUMAC-GG will be measured by the ton (tonne) or by the square foot (m^2).

The Contractor shall furnish to the Engineer at the time of delivery to the Work site, a legible copy of a licensed weighmaster certificate showing gross, tare, and net weights of each truckload of CRUMAC-GG. When an automatic batching system is used, the certificate may show only the net weight of CRUMAC-GG in the truckload.

302-11.9 Payment. Payment for CRUMAC-GG will be made at the Contract Unit Price per ton (tonne) or at the Contract Unit Price per square foot (m^2). No separate payment for tack coat, rock dust blotter, or sweeping will be made.

Failure of the Contractor to provide a licensed weighmaster certificate to the Engineer by the end of the day on which the ARHM represented by such certificate was delivered to the Work site may, at the discretion of the Engineer, result in forfeiture of payment.

302-12 TIRE RUBBER MODIFIED ASPHALT CONCRETE (TRMAC).

302-12.1 General. TRMAC shall conform to 203-14.

302-12.2 Tack Coat. Tack coat shall conform to 302-5.4.

302-12.3 Distribution and Spreading. Distribution and spreading shall conform to 302-9.3.

302-12.4 Rolling. Rolling shall conform to 302-9.4.

302-12.5 Joints. Joints shall conform to 302-5.7.

302-12.6 Manholes (and Other Structures). Manholes and other structures shall conform to 302-5.8.

302-12.7 Rock Dust Blotter. Rock dust blotter shall conform to 302-9.7.

302-12.8 Measurement. TRMAC will be measured by the ton (tonne) or by the square foot (m^2).

The Contractor shall furnish to the Engineer at the time of delivery to the Work site, a legible copy of a licensed weighmaster certificate showing gross, tare, and net weights of each truckload of TRMAC. When an automatic batching system is used, the certificate may show only the net weight of TRMAC in the truckload.

302-12.9 Payment. Payment for TRMAC will be made at the Contract Unit Price per ton (tonne) or at the Contract Unit Price per square foot (m^2). No separate payment for tack coat, rock dust blotter, or sweeping will be made.

Failure of the Contractor to provide a licensed weighmaster certificate to the Engineer by the end of the day on which the TRMAC represented by such certificate was delivered to the Work site may, at the discretion of the engineer, result in forfeiture of payment.

302-13 POROUS ASPHALT CONCRETE PAVEMENT.

302-13.1 General. Porous asphalt concrete shall conform to 203-15.

302-13.2 Distribution and Spreading. Distribution and spreading shall conform to 302-5.5, except each successive course shall 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 and preclude the necessity of tack coat between courses.

302-13.3 Rolling. Rolling shall be performed using an 8 to 10 ton static steel drum roller conforming to 302-5.6. The surface temperature during rolling shall be between 210°F (99°C) and 260°F (127°C). Rolling shall be limited to a maximum of 2 passes. No vehicular traffic shall be permitted on porous asphalt concrete pavement for 24 hours after rolling.

302-13.4 Infiltration Rate. Porous asphalt concrete pavement shall have an infiltration rate of a minimum of 100 inches per hour (254 cm/hr) when tested in accordance with 211-3 unless otherwise specified in the Special Provisions.

302-13.5 Measurement. Porous asphalt concrete will be measured by the ton (tonne). The Contractor shall furnish to the Engineer at the time of delivery to the Work site a legible copy of a licensed weighmaster's certificate showing gross, tare, and net weights of each truckload of porous asphalt concrete. When an automatic batching system is used, the licensed weighmaster's certificate may show only the net weight of material in the truckload.

302-13.6 Payment. Payment for porous asphalt concrete will be made at the Contract Unit Price per ton (tonne). Failure 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 Work site, may, at the discretion of the Engineer, result in the forfeiture of payment for such material.

SECTION 303 - CONCRETE AND MASONRY CONSTRUCTION

303-1 CONCRETE STRUCTURES.

303-1.1 General. Concrete bridges, culverts, catch basins, retaining walls, abutments, piers, 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 201-1. The cylinders shall be cured in accordance with ASTM C31, 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 Work 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 Special Provisions.

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 48-inch (1.2 m) widths and in uniform lengths of not less than 96 inches (2.4 m) 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 5/8 inch (15 mm) thick, and the studs or joists shall be spaced not more than 12 inches (300 mm), center to center. Plywood less than 5/8 inch (16 mm) thick, otherwise conforming to the requirements specified herein, may be used with a continuous backing of 3/4 inch (19 mm) 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 1-1/2 inches (38 mm) 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 3/4 inch x 3/4 inch (19 mm x 19 mm) 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 1 inch (25 mm) 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:

a) 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.

b) 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 2,000 pounds per square inch (14 MPa).

   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.

c) The reinforcing steel shall be set accurately and held firmly in place.

d) The Contractor shall assume all risks of damage to the Work or to existing improvements that may be attributable to this method of construction.

e) Should this method of construction prove unsatisfactory, the Contractor shall discontinue this method and construct the conduit by using outside forms.

f) 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 in the 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 3,000 pounds per square inch (21 MPa) 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 Plans, 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 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, 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 -
   (i) Type II cement - 48 hours or 6 hours per foot (20 hours per meter) of span between supports, whichever is greater.
   (ii) Type III cement - 24 hours or 3 hours per foot (10 hours per meter) of span between supports, whichever is greater.
   (iii) Type V cement - 56 hours or 7 hours per foot (23 hours per meter) 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:

$C_{US} = 20\ S + 1000$ For U.S. Standard Measures

($C_{SI} = 0.45\ S + 7$ For Metric Units)

Where S = Span length in feet (m) from center to center of supports (maximum span 20 feet (6 m) unless otherwise approved by the Engineer).

Where C_{US} (C_{SI}) = Required compressive strength in pounds per square inch (MPa) 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 1,000 pounds per square inch (7 MPa). 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 Working Drawings 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 Occupational Safety and Health. 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 8 feet (2.4 m) 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 20 tons (180 kN).

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 2,000 pounds per square inch (14 MPa) 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 2,000 pounds per square foot (96 kN/m^2), 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:

a) Tunnel centering - 100 percent of the concrete load where concrete is placed by pneumatic process.

b) All other structures - a live load of 30 pounds per square foot (1.5 kN/m^2) of horizontal area.

c) 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	1,400 psi (9.7 MPa)
Compression perpendicular to grain	350 psi (2.4 MPa)
End grain bearing	1,300 psi (9.0 MPa)
Shear parallel to grain	125 psi (0.9 MPa)
Timber Columns:	
U.S. Standard Measure	$S_{US} = 1300 (1 - L/60d)$
Metric Units	$S_{SI} = 9.0 (1 - L/60d)$

Where:

S_{US} (S_{SI}) = Maximum allowable stress in psi (MPa).

d = Least side dimension of column in inches (mm).

L = Unbraced length of column in inches (mm).

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 Working Drawing 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 2 inches (50 mm) unless otherwise noted on the Plans. Reinforcement shall terminate 2 inches (50 mm) 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 2 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 upgrade 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 6 feet (1.8 m) without the use of tremies or other suitable conveyance. Tremies shall be at least 6 inches (150 mm) 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 2 vibrators in good operating condition shall be available at the site of the structure in which more than 25 cubic yards (19 m^3) 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 Bid price for the item of work of which they are a part.

303-1.8.7 Application of Joint Sealants.

a) **General.** Joint sealants shall conform to 201-3. 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 50°F (10°C), or when weather conditions indicate that the temperature may fall below 32°F (0°C) 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 1/4 inch (6 mm) and 3/8 inch (9.5 mm) 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 3/16 inch (5 mm). 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 1/8 inch (3 mm) of the width shown on the Plans. The groove width measured at the bottom shall not vary from the top width by more than 1/16 inch (1.5 mm) for each 2 inches (50 mm) 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 40°F (4°C). 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 130°F (54°C).

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 1-1/4 inches (32 mm) below the level of the finished surface.

The sealing material components shall be maintained at temperatures of not less than 60°F (16°C). To ensure adequate mixing and application, they may be preheated to a maximum of 90°F (32°), 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 1/2 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 1/16 inch (1.5 mm).

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 35°F (2°C), 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 35°F (2°C), or when conditions indicate that the temperature may fall to 35°F (2°C) 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 115°F (46°C) 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 90°F (32°C).

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 10 inches (250 mm) 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 1 inch (25 mm) 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:

a) The undersurfaces of slab spans, box girders, filled-spandrel arch spans, and floor slabs between T-girders of superstructures except for grade separation structures.

b) The exposed surfaces of channel walls and the inside vertical surface of T-girders of superstructures except for grade separation structures.

c) 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.

d) 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:

a) All surfaces of superstructures for grade separation structures.

b) All surfaces of bridge piers, columns, and abutments; culvert headwalls; and retaining walls above finished ground and to at least 1 foot (300 mm) below finished ground.

c) 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.

d) All surfaces of open spandrel arch rings, spandrel columns, and abutment towers.

e) Surfaces inside of culvert barrels having a height of 4 feet (1.2 m) or more for a distance inside the barrel at least equal to the height of the culvert.

f) 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 2 layers of not lighter than 10-ounce per linear yard, 40 inches wide (305 g/m^2) 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 2 inches (50 mm) 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 Special Provisions.

When the surface is covered with plastic sheeting, it shall remain covered for at least 10 Days. The plastic sheeting shall be laid either with edges butted together and sealed with a 2-inch (50 mm) wide sealing tape or with edges lapped not less than 3 inches (75 mm) 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 Contract Unit Prices or lump sums as set forth in the Bid.

Where concrete is scheduled for payment on the basis of cubic yards (m^3), 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, as 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 5 square feet (0.5 m^2) 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 foot (m) specified in ASTM A615/615M, A616/616M, and A617/617M.

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 2 consecutive construction joints, unless otherwise authorized by the Engineer. The standard mill length for bar sizes No. 4 (No. 13M) and larger is 60 feet (18 m).

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.

303-2.1 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 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 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 45 pounds per square inch (310 kPa) on the gun tank when 100 feet (30 m) or less of hose is used and the pressure shall be increased 5 pounds per square inch (35 kPa) for each additional 50 feet (15 m) of hose. The pressure shall also be increased 5 pounds per square inch (35 kPa) for each 25 feet (8 m) that the nozzle is located above the elevation of the gun tank. The maximum nozzle diameter shall be 1-5/8 inches (41 mm)

unless otherwise permitted by the Engineer. Water pressure at the nozzle shall be at least 15 pounds per square inch (100 kPa) 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 3-inch (75 mm) diameter steel pipe or flexible hose reduced to 2-inch (50 mm) diameter at the point of expulsion. Aluminum pipe will not be permitted. The air compressor shall have the capacity to deliver at least 100 cubic feet (2.8 m^3) per minute for each operating nozzle.

303-2.3 Materials, Proportioning, and Mixing.

303-2.3.1 Method A. Aggregate and cement shall conform to 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 conform to 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 6-inch (150 mm) diameter x 12-inch (300 mm) long containers of 3/4 inch-square (19 mm x 19 mm) 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 C31 and tested in accordance with ASTM C39.

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. Four-inch (100 mm) minimum-diameter core specimens shall be obtained from the completed work or test panels and tested in accordance with ASTM C42 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 3 specimens. If the test specimens are 6-inch x 12-inch (150 mm x 300 mm) cylinders, one shall be tested at 7 Days. If the test specimens are cores, one shall be tested at 14 Days. The remaining 2 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)..... 2,000 psi (14 MPa)
14-Day (cores)..... 2,300 psi (16 MPa)
28-Day..... 3,250 psi (23 MPa)

When a test specimen shows deficient strength, 2 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. 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 Special Provisions.

Overexcavation shall be backfilled with material 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 3/4 inch (19 mm) 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 an 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 (gunite 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 Special Provisions.

303-3 PRESTRESSED CONCRETE CONSTRUCTION.

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 Working 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 Working 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 560 pounds (330 kg) nor more than 750 pounds (445 kg) of cement per cubic yard (m^3) 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 the Working 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 lift 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:

a) After placement of the concrete, members shall be held for a 4-hour-minimum presteaming period. If the ambient air temperature is below 50°F (10°C), steam shall be applied during the presteaming period to hold the air surrounding the members at a temperature between 50°F and 90°F (10°C and 32°C).

b) All exposed surfaces of the members shall be kept wet continuously during the holding and curing period.

c) 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.

d) 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.

e) During application of the steam the temperature gradient within the enclosure shall not exceed 40°F (22°C) per hour. The curing temperature shall not exceed 150°F (66°C) and shall be maintained at a constant level for a sufficient time necessary to develop the required compressive strength.

f) 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 40°F (22°C) per hour until a temperature has been reached 20°F (11°C) above the temperature of the air to which the concrete will be exposed.

g) 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 A421/A421M, high-tensile wire strand conforming to ASTM A416/A416M, or uncoated high-strength steel bars conforming to ASTM A722/A722M, 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:

a) Protected from corrosion during shipping by a factory treatment or process.

b) Protected against abrasion during shipment and handling.

c) Installed in members to be post-tensioned after steam curing, when steam curing is used, unless otherwise approved by the Engineer.

d) Grouted in the enclosures of post-tensioned members within 48 hours after the wire or strand has been tensioned, and within 10 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 2 inches (50 mm) 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 1/4 inch (6 mm) 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:

a) The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 pounds per square inch (21 MPa), and a suitable grillage of reinforcing steel shall be used in the stressed area.

b) 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 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 3/8 inch (9.5 mm) 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 1/2 inch (12.5 mm) 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 2 inches (50 mm) 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 6 inches (150 mm) 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 25,000 pounds per square inch (172 MPa).

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 35,000 pounds per square inch (241 MPa).

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, inches (mm)	Compressive Strength psi (MPa)
3/8 (9.5)	3,500 (24)
7/16 (11)	4,000 (28)
1/2 (12.5)	4,000 (28)

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 3 times the diameter of the steel or 1-1/2 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 1-1/2 inches (38 mm) or 1-1/2 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 conforming to 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 5 gallons per 100 pounds (42 L/100 kg) 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 100 pounds per square inch (700 kPa) and shall be furnished with a pressure gage having a full-scale reading of not more than 300 pounds per square inch (2100 kPa).

Standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch (1700 kPa) 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 0.1 pounds (12 grams) of hydrated lime or quicklime per gallon (L) 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 0.07 inch (1.8 mm) 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 A416/A416M, A421/A421M, 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:

a) For wire or strand, 2, 7-foot (2.1 m) long samples shall be furnished for each heat or reel; for bars, 2, 6-foot (1.8 m) long samples shall be furnished for each heat.

b) If the prestressing tendon is to be prefabricated, one completely fabricated prestressing tendon 5 feet (1.5 m) 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 5 feet (1.5 m) in length for each size of tendon shall be furnished, including anchorage assemblies.

c) If the prestressing tendon is a bar, one 6-foot (1.8 m) length complete with two end anchorages shall be furnished, and, in addition, if couplers are to be used with the bars, 2, 3-foot (1.0 m) 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 Work 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 for furnishing and erecting the member.

303-4 MASONRY CONSTRUCTION.

303-4.1 Concrete Block Masonry[1].

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 1/4 inch (6 mm) minimum-diameter steel ties at 24 inches (600 mm) on centers (maximum).

Where stack bond is indicated on the Plans, approved metal ties shall be provided horizontally at 24 inches (600 mm) 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 3/8 inch (9.5 mm) 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 4 feet (1.2 m) The maximum height of pour shall be 8 feet (2.4 m). 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 3/8 inch (9.5 mm) 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.

303-5.1 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 specified in 201-1. The finish coat to be applied to curbs shall consist of Class "B" mortar prepared as specified in 201-5.1. Subgrade preparation shall conform to 301-1.

Unless otherwise shown on the Plans, and except as otherwise specified in 303-5.1.3, the minimum thickness of walks shall be 3 inches (75 mm). 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 as shown on the Plans or specified in the Special Provisions.

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 1 inch (25 mm) 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 3/4 inch (19 mm).

Where a walk is to be constructed across driveways to commercial establishments, the thickness thereof shall be 6 inches (150 mm) unless otherwise specified or shown on the Plans. At residential driveways, the thickness of the walk will be 4 inches (100 mm) unless otherwise specified or shown on the Plans.

303-5.2 Forms.

303-5.2.1 Standard Forms. Forms 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 1-1/2 inches (38 mm). 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 10 inches (250 mm) or less, except for those used on curb returns. Forms used on curb returns shall be not less than 3/4 inch (19 mm) 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 4 feet (1.2 m), 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 5 feet (1.5 m). 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 6 inches (150 mm) in thickness, each layer being spaded along the forms and thoroughly tamped. Concrete may be placed in layers of more than 6 inches (150 mm) 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 3/8 inch (9.5 mm) of the free mortar for finishing purposes.

Concrete shall be placed in cross gutters in horizontal layers of not more than 4 inches (100 mm) 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 specified herein unless otherwise shown on the Plans. 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.

Joints 1/4 inch (6 mm) thick 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 1/4 inch (6 mm) 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. Joints 1/4 inch (6 mm) thick 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 1 inch (25 mm) 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 1/4 inch (6 mm) 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 10 feet (3 m). 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 20 feet (6 m). 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 2 inches (50 mm) 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 1/2 inch (12.5 mm) and a radius of 1/8 inch (3 mm). The finished joint opening shall not be wider than 1/8 inch (3 mm).

c) **Plastic Control Joint.** The joint material shall be a T-shaped plastic strip at least 1 inch (25 mm) deep, having suitable anchorage to prevent vertical movement, and having a removable stiffener with a width of at least 3/4 inch (19 mm). After preliminary troweling, the concrete shall be parted to a depth of 2 inches (50 mm) 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 1/8 inch (3 mm), 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 2 inches (50 mm) 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 1/4 inch (6 mm) toward the gutter, with both edges rounded to a radius of 1/2 inch (12.5 mm). 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 1/4 inch (6 mm) 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 1/4 inch (6 mm) in letters not less than 3/4 inch (19 mm) 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 1/2 inch (12.5 mm). Edges at expansion joints shall be rounded to a radius of 1/8 inch (3 mm). 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 1/4 inch (6 mm) and a radius of 1/8 inch (3 mm). When longitudinal scoring lines are required, they shall be parallel to, or concentric with, the lines of the work. Walk 20 feet (6 m) 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 Work site.

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 4 inches (100 mm) for integral curb and gutter and 4 inches (100 mm) 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 1/2 inch (12.5 mm).

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 10 square feet (1 m^2) 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 4 inches (100 mm). The maximum size aggregate in the top 2 inches (50 mm) shall be 3/8 inch (9.5 mm).

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 3/8 inch (9.5 mm) in width, not to exceed 1/2 inch (12.5 mm) 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 C309. 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.

303-8 PERVIOUS CONCRETE.

303-8.1 General. Pervious concrete shall conform to 201-1.1.6. Pervious concrete shall be constructed a minimum of 6 inches (150 mm) thick unless otherwise shown on the Plans.

303-8.2 Test Section. The Contractor shall construct a test section using the same equipment and placing crew as it proposes to use for the remainder of the pervious concrete work. The test section shall be a minimum of 225 square feet (21 m^2). The test section(s) may be incorporated into the Work if so approved by the Engineer.

303-8.3 Subgrade. The subgrade shall be compacted to a relative compaction between the minimum specified in the Special Provisions and a maximum of 96 percent. The subgrade shall not be treated or stabilized with Portland cement or lime.

303-8.4 Forms. Forms shall conform to 302-6.2. Forms shall be placed for the full-depth of the thickness of pervious concrete to be constructed and be capable of supporting mechanical equipment without deformation during or following placement operations.

303-8.5 Placement. Prior to placement, plastic pervious concrete shall have a density within ± 5 pounds per cubic foot (80 kg/m^3) of that shown on the approved mix design when tested in accordance with ASTM C1688. Placement shall conform to the lines, grades, and cross sections shown on the Plans. Placement operations shall not result in the voids becoming sealed.

Pervious concrete shall be uniformly deposited over the entire formed area. A self-propelled roller screed shall be used for strike-off, spreading, and compaction. Hand-rodding may be used in areas inaccessible to the roller-screed if so approved by the Engineer. Adjacent to the edge of each form, hand tampers shall be used for compaction.

The finished surface shall not deviate more than 3/8 inch (9.5 mm) from a 10 foot (3 m) straightedge laid on the surface. Surface depressions shall be corrected immediately after compaction by placing fresh pervious concrete in the depressions and compacting using a hand tamper.

After compaction, the surface shall be protected from rapid evaporation by water fogging, covering with 1 mil polyethylene sheeting, or the application of a chemical evaporation retardant approved by the Engineer.

303-8.6 Joints.

303-8.6.1 Weakened-Plane Joints.

303-8.6.1.1 General. Weakened-plane joints shall be constructed at the locations shown on the Plans or at regular intervals not to exceed 2 times the width of the placement or 15 feet (4.6 m) on-center, whichever is less. Joints shall be constructed to a depth of 1/4 of the thickness, or a minimum of 1-1/2 inches (38 mm), whichever is greater.

303-8.6.1.2 Construction Methods. Unless otherwise specified, weakened-plane joints shall be constructed by one of the following methods:

a) Rolling with a roller equipped with a circumferential beveled fin immediately after compaction and prior to curing.

b) Saw cutting as soon as the pervious concrete can be saw cut without causing raveling along the joint edges. Only the area occupied by the concrete saw shall be uncovered and exposed. Immediately after sawing each joint, the exposed area shall be fogged with water and re-covered in accordance with 302-8.7.

303-8.6.2 Transverse Construction Joints. Transverse construction joints shall be constructed whenever placement is suspended for more than 20 minutes.

303-8.7 Curing. Curing shall consist of covering the surface and, as necessary, the application of water. Curing shall begin within 20 minutes of placement. The surface shall be securely covered with polyethylene sheeting having a minimum thickness of 6 mils (150 μm). The cover shall be checked daily to verify that it has not been displaced or damaged, and that condensation is evident underneath the sheeting. Damaged sheeting shall be repaired. Displaced sheeting shall be replaced. When there is no observable condensation, 1.5 gallons of water per square yard (5.7 L/m^2) shall be applied to the surface.

303-8.8 Acceptance. Pervious concrete shall have a consistent, uniform surface with no visible excess cement paste, tears, or gouges. Roller-constructed joints shall have smooth, rounded, and uniformly compacted edges. Saw-cut joints shall not contain cement paste or dust nor exhibit evidence of spalling. Unless otherwise specified in the Special Provisions, pervious concrete shall have a minimum infiltration rate of 100 inches per hour (2540 mm/hr) when tested in accordance with ASTM C1701.

303-8.9 Measurement. Pervious concrete will be measured by the square foot (m^2) for each thickness shown on the Plans, or by the cubic yard (m^3).

303-8.10 Payment. Payment for pervious concrete will be made at the Contract Unit Price per square foot (m^2) for each thickness shown on the Plans, or per cubic yard (m^3), as shown in the Bid.

SECTION 304 - METAL FABRICATION AND CONSTRUCTION

304-1 STRUCTURAL STEEL.

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. Shop Drawings required to be submitted by the Contractor shall conform to the applicable provisions of 304-1.4.

When required by the Plans or Special Provisions, 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 Working Drawings of falsework to be used. Approval of such Working Drawings will be based upon compliance with the design criteria set forth for falsework for concrete structures in 303-1.6.2. Approval of falsework Working Drawings will not relieve the Contractor of responsibility for the results obtained by use of such Working Drawings. 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 Work, the design and construction of such work shall conform to ASTM A325.

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 Special Provisions 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 1/16 inch (1.5 mm) 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 3/32 inch (2.4 mm).

a) **Shop Rivets.** Holes for shop rivets shall be subpunched, or subdrilled at the fabricator's option, 1/4 inch (6 mm) 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 7/8 inch (22 mm) 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 1/8 inch (3 mm) 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 1/8 inch (3 mm).

   3) Holes in material not more than 7/8 inch (22 mm) 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 1/8 inch (3 mm) 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, 1/4 inch (6 mm) 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 7/8 inch (22 mm) 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 1/16 inch (1.5 mm) 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 1/16 inch (1.5 mm) 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 1/16 inch (1.5 mm) 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 1/2 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 3/4 of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the rivets, and cylindrical erection pins shall be 1/32 inch (0.8 mm) 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 bucker 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 pounds per square inch (700 kPa) 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 Special Provisions.

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 1/4 inch (6 mm) beyond. Bolts in tension shall have 2 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 1/32 inch (0.8 mm) 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 1/4 inch (6 mm) thick shall be furnished, as specified.

Bolted connections using high strength steel bolts shall conform to ASTM A325.

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 1/8 inch (3 mm) 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 1/32 inch (0.8 mm) and that no more than 20 percent of the holes shall provide as much offset as 1/32 inch (0.8 mm).

304-1.6 Joint and Connections.

304-1.6.1 Edge Planing. Sheared edges of plates more than 5/8 inch (16 mm) in thickness and carrying calculated stress shall be planed to a depth of 1/4 inch (6 mm).

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 1/32 inch (0.8 mm) tolerance in 12 inches (300 mm) and to within 1/16 inch (1.5 mm) 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 1/8 inch (3 mm) tolerance in 12 inches (300 mm) and to within 3/16 inch (5 mm) 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 1/4 inch (6 mm).

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 1/8 inch (3 mm) 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 7 inches (175 mm) in diameter shall be forged and annealed.

In pins larger than 9 inches (230 mm) 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 2 inches (50 mm) 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 1/32 inch (0.8 mm). 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 1/50 inch (0.5 mm) for pins 5 inches (125 mm) or less in diameter, or 1/32 inch (0.8 mm) 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 8 ounces per square yard (270 g/m^2) 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 10,000 pounds per square inch (70 MPa) 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 1/16 inch (1.5 mm) in greatest dimension, and provided further that the sum of the greatest dimension of all such defects in any 1 square inch (625 mm^2) weld area does not exceed 3/8 inch (9.5 mm).

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

$$\text{In US Std. Units} = \frac{\text{Minimum specified tensile strength of parent metal (psi)}}{500}$$

$$\text{In SI Units} = \frac{\text{Minimum specified tensile strength of parent metal (MPa)}}{3.5}$$

Maximum Brinnell Hardness

$$\text{In US Std. Units} = \frac{\text{Maximum specified or tested tensile strength of parent metal (psi)} + 50}{500}$$

$$\text{In SI Units} = \frac{\text{Maximum specified or tested tensile strength of parent metal (MPa)} + 50}{3.5}$$

All welding of structural steel (ASTM A36, A242, and A441) 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 300°F to 400°F (150°C to 205°C) 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 450°F to 500°F (232°C to 260°C) 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 300°F to 400°F (150°C to 205°C) after rebaking.

Areas contiguous to welding operations shall be preheated to a minimum temperature of 300°F (150°C) when necessary to prevent distortion of weld cracking. Preheating to a temperature in excess of 400°F (205°C) will not be required.

Unless otherwise shown on the Plans or specified in the Special Provisions, 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 fill 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 1/16 inch (1.5 mm).

Unless otherwise shown on the Plans or specified in the Special Provisions, 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 3/4 inch (19 mm). To determine the net area of members so cut, 1/8 inch (3 mm) 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 1/16 inch (1.5 mm). 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:

a) They shall be taken from the stock plates so that the direction of bending will be at right angles to the direction of rolling.

b) 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:

c) Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch (1.5 mm) 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 a) above.

TABLE 304-1.11

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 Contract Unit Price per pound (kg) for structural steel, and at Contract Unit Prices per pound (kg) 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 A6/A6M.

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 percent for each coat of oil

0.5 percent for each shop coat of paint

3.5 percent 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:

a) The density of structural and cast steel shall be assumed at 0.2833 pounds per cubic inch (7849 kg/m^3). The density of cast iron shall be assumed at 0.2604 pounds per cubic inch (7208 kg/m^3).

b) 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.

c) 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 Contract Unit Price per pound (kg) 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 inches (mm)	Weight of 100 Heads lbs (kg)
1/2 (13)	5.0 (2.3)
5/8 (16)	9.7 (4.4)
3/4 (19)	16.0 (7.3)
7/8 (22)	24.0 (10.9)
1 (25)	35.0 (15.9)
1-1/8 (29)	49.0 (22.2)
1-1/4 (32)	78.0 (35.4)

Should computed weights be used to determine pay quantities of high strength steel bolts, the weights of portions of bolts outside the grip (including 2 washers and 1 nut) shall be assumed as follows:

TABLE 304-1.12.3 (B)

Diameter of Bolt inches (mm)	Weight of 100 Bolts (Each complete with 2 washers and one nut, less grip length) lbs (kg)
5/8 (16)	46 (21)
3/4 (19)	71 (32)
7/8 (22)	105 (48)
1 (25)	145 (66)
1-1/8 (29)	194 (88)
1-1/4 (32)	259 (117)

d) 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.

e) 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.

f) The weight of bolts, cap screws, anchor bolts, nuts, washers, except as limited by c) 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.

g) No allowance will be made for the weight of paint in computing the weights of metal for payment.

h) The weight of shop an field fillet welds shall be assumed as follows:

TABLE 304-1.12.3 (C)

Size of Filled Weld inches (mm)	Weights lbs per ft (kg/m)
3/16 (5)	0.08 (0.098)
1/4 (6)	0.14 (0.141)
5/16 (8)	0.22 (0.251)
3/8 (10)	0.30 (0.392)
1/2 (13)	0.55 (0.663)
5/8 (16)	0.80 (1.005)
3/4 (19)	1.10 (1.417)
7/8 (22)	1.50 (1.899)
1 (25)	2.00 (2.453)

i) 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 A153.

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 packing, 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 Contract Unit Price per pound for structural steel.

Cleaning and painting structural steel will be paid for as provided in 310.

304-2 METAL HAND RAILINGS.

304-2.1 General. The materials for metal hand railings shall conform to 206-5.1. Except where a Standard Plan is referred to on the Plans, the Contractor shall submit Shop Drawings showing the details and dimensions of all metal hand railings.

304-2.2 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 1/16 inch (1.5 mm). 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.

304-2.3 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 1/8 inch (3 mm).

After erecting the railing, any abrasions or exposed steel shall be repaired in accordance with 210-3.5.

304-2.4 Measurement and Payment. The various types of railing will be measured and paid for by the linear foot (m) from end to end along the face of the railing, including terminal sections.

304-3 CHAIN LINK FENCE.

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 10 foot (3 m) 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. Footings shall be crowned at the top to shed water. Line post footings for fabric 5 feet (1.5 m) or less in height shall have a minimum depth of 30 inches (750 mm) and a minimum diameter of 8 inches (200 mm). Line post footings for fabric more than 5 feet (1.5 m) in height shall have a minimum depth of 36 inches (900 mm) and a minimum diameter of 8 inches (200 mm). All other footings, unless otherwise indicated on the Plans or in the Special Provisions, shall have a minimum depth of 36 inches (900 mm) and a minimum diameter of 12 inches (300 mm).

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 12 inches (300 mm) below the top of the fence fabric and a diagonal tension member. The tension member shall be a 3/8 inch (9.5 mm) 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.

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 12 inches (300 mm) below the top of the fence fabric and a diagonal tension member. The tension member shall be a 3/8 inch (9.5 mm) 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 3 inches (75 mm). 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 2 inches (50 mm) 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 1 inch (25 mm) of the bottom of fabric.

The fabric shall be fastened to end, corner, slope, and gate posts with 3/16 inch (5 mm) thick by 3/4 inch (19 mm) wide carbon steel tension bars and the tension bars shall be fastened with steel tension bar bands spaced at 16 inches (400 mm) intervals. Steel tension bar bands shall have a minimum thickness of 1/8 inch (3 mm) and a minimum width of 1 inch (25 mm). 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 16 inches (400 mm), and on top rail and tension wire at intervals of approximately 24 inches (600 mm).

304-3.3 Installation of Gates. The widths of any gates to be installed will be indicated on the Plans.

Gates with fabric 7 feet (2 m) or more in height shall have a horizontal stiffener. Vertical stiffeners shall be installed at a maximum of 8-foot (2.4 m) centers. A 3/8 inch (9.5 mm) adjustable tension rod shall be installed on all gates over 4 feet (1.2 m) 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 16-inch (400 mm) intervals.

The swing gates shall be hung by at least 2 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 foot (m) of fence and no additional compensation will be made therefore.

304-5 SECURITY FENCING.

304-5.1 General. Security fencing shall conform to 206-6.9, the Plans, and the Special Provisions. Security fencing shall completely enclose all open excavations and remain in place until backfill has been placed to the approximate level of the adjacent ground.

304-5.2 Payment. Unless otherwise specified in the Special Provisions, payment for security fencing shall be included in the various Bid items that require security fencing.

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 Special Provisions 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 2 dissimilar thicknesses are involved in one cross section of an installation, the thickness of structure steel plates will be identified in the Plans or in the Special Provisions.

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:

Pipes using 0.280 inch or 0.249 inch (7.11 mm or 6.32 mm) top and side plates ..... 1%.

Pipes using 0.218 inch or 0.188 inch (5.54 mm or 4.78 mm) top and side plates .....2%.

Pipes using 0.168 inch, 0.138 inch, or 0.109 inch (4.27 mm, 3.31 mm, or 2.77 mm) 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 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 1/4 inch per foot (20 mm/m) 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 Special Provisions, 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 5 feet (1.5 m), 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 6 inches (150 mm). 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 25 feet (7.5 m) of any concrete that has not attained a minimum compressive strength of 2,000 pounds per square inch (14 MPa).

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 1/8 inch (3 mm) per blow at the required bearing value, and shall develop energy per blow at each full stroke of the piston of not less than 1 foot-pound for each pound (3 Joules for each kilogram) 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 3,000 pounds (1350 kg) and shall be equipped with proper leads and hoisting equipment to handle the work efficiently. The fall of the hammer shall not exceed 10 feet (3 m).

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 3 feet (1 m) to specified bearing.

The cost of any jetting or drilling that may be required shall be included in the Contract Unit Price 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 5 feet (1.5 m) 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 5 feet (1.5 m) nor less than 1 foot (0.3 m) 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 10 feet (3 m) 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 4 inches (100 mm). 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 20 tons (180 kN). The bearing value shall be determined from the applicable formula in the following schedule:

For piles driven with a drop hammer

U.S. Standard Measures Equation: $$P = \frac{2WL}{s+1}$$

Metric Equation: $$P = \frac{WL}{6(s+2.54)}$$

For piles driven with a single acting steam or air hammer

U.S. Standard Measures Equations: $$P = \frac{2WL}{s+0.1} \quad \text{or} \quad P = \frac{2E}{s+0.1}$$

Metric Equations: $$P = \frac{WL}{6(s+2.54)} \quad \text{or} \quad P = \frac{E}{6(s+2.54)}$$

For piles driven with a double acting steam or air hammer

U.S. Standard Measures Equations: $$P = \frac{2L(W+ap)}{s+0.1} \quad \text{or} \quad P = \frac{2E}{s+0.1}$$

Metric Equations: $$P = \frac{L(W+ap)}{6(s+2.54)} \quad \text{or} \quad P = \frac{E}{6(s+2.54)}$$

Where:

P = Safe bearing load developed by the pile in pounds (kN).

W = Weight of the hammer in pounds (N).

L = Length of stroke or height of fall of the hammer in feet (meters).

s = Penetration of the pile into the ground per blow in inches (mm) 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 in^2 (m^2).

p = Mean effective steam pressure in the case of steam hammers or means effective air pressure in the case of air hammers, in psi (pascals).

E = Manufacturer's rating of energy developed by the hammer in foot-pounds (joules).

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 Work 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 2,000 pounds per square inch (14 MPa).

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 1/4 inch (6 mm).

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 foot (m) 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 foot (m) 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 Special Provisions.

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 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 Special Provisions.

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 Special Provisions, shall be considered as included in the Contract Unit Price for driving piles.

305-2 TIMBER STRUCTURES AND TIMBER CONSTRUCTION.

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. Materials shall be as shown on the Plans or specified in the Special Provisions.

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 1/16 inch (1.5 mm) 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 1/16 inch (1.5 mm) 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 3/4 inch (19 mm) 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 3-inch-square (75 mm x 75 mm) and not less than 3/8 inch (9.5 mm) 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 8 inches (200 mm) 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 1/8 inch (3 mm). 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 310.

The surface of wooden guard rails above the ground shall be painted as prescribed in 210-1.5 and 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 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 Contract Unit Price per board measure, per linear foot (m) of structure, or the lump sum, shall include full compensation for furnishing all nails, hardware, paint, and wood preservative.

SECTION 306 - OPEN TRENCH CONDUIT CONSTRUCTION

306-1 GENERAL. This section includes specifications for trench excavation, construction of buried conduits, testing, backfill, and resurfacing.

306-2 DELIVERY, STORAGE, HANDLING, AND PROTECTION OF PIPELINE MATERIALS, FITTINGS, VALVES, AND APPURTENANCES.

306-2.1 General. Delivery, storage and handling of pipeline materials, fittings, valves and appurtenances shall conform with the pipe-specific installation instructions shown in Tables 306-2.1 (A) and 306-2.1 (B). Instructions shall be submitted to the Engineer in accordance with 2.5.3.

TABLE 306-2.1 (A)

Gravity Pipe Material	Material Specification	Delivery, Storage, and Handling Reference Specification
Vitrified Clay Pipe	207-8	ASTM C12 Section 8
Nonreinforced Concrete Pipe	207-1	ASTM C1479
Reinforced Concrete Pipe	207-2	ASTM C1479
Lined Reinforced Concrete Pipe	207-3	ASTM C1479
Cast Iron Soil Pipe	207-9	California Plumbing Code Chapters 3 and 7
Corrugated Steel Pipe and Pipe Arches	207-11	ASTM A798 Section 8
Structural Steel Plate Pipe and Pipe Arches	207-12	ASTM A807
Corrugated Aluminum Pipe and Pipe Arches	207-13	ASTM B788
Structural Aluminum Plate Pipe and Arches	207-14	ASTM B789
ABS Solid Wall Pipe	207-15	ASTM D2321 Section 8
ABS or PVC Composite Pipe	207-16	ASTM D2321 Section 8
PVC Plastic Sewer Pipe	207-17	ASTM D2321 Section 8
Annular HDPE Pipe with Smooth Interior and Corrugated Exterior	207-18	ASTM D2321 Section 8
Polyethylene Solid-Wall Pipe	207-19	ASTM D2321 Section 8
FRPM Pipe	207-20	ASTM D2321 Section 8 or AWWA M45

TABLE 306-2.1 (B)

Pressure Pipe Material	Material Specification	Delivery, Storage, and Handling Reference Specification
Ductile Iron Pipe	209-1	AWWA C600 and AWWA M41 Chapter 11
Steel Pipe	209-2	AWWA C604 or AWWA M11 Chapter 12
Concrete Pressure Pipe	209-3	AWWA M9 Chapter 13
PVC Pressure Pipe	209-4	AWWA C605 or AWWA M23 Chapter 6
HDPE Pressure Pipe	209-5	AWWA M55 Chapter 7
Fiberglass Pressure Pipe	209-6	AWWA M45 Chapter 6
Valves, Hydrants, and Appurtenances	212	Manufacturer's Installation Instructions

306-2.2 Shipment and Delivery.

306-2.2.1 General. Shipment and delivery to the Work site shall conform to 7-8.4 and the following.

306-2.2.2 Factory Testing. In accordance with 4-1.3, pipe, valves, motors, actuators and mechanical equipment shall be operated and tested at the factory before shipping.

306-2.2.3 Packaging. Pipeline materials, fittings, valves and appurtenances shall be delivered to the Work site in the manufacturer's original, unopened, labeled packaging, containers, or bundles. Packages, containers, or bundles shall be tagged or labeled to identify the contents and equipment of which the contents form a part.

306-2.2.4 Lubricated Components. Oil or grease-lubricated gearing, bearings and components shall be shipped with an oil-soluble protective coating which shall provide protection for one year after

completion of the Work and conform to the manufacturer's operation, maintenance, and warranty instructions. Oil-soluble coatings for parts which will be in contact with potable water shall conform to NSF 60 or 61 as appropriate.

306-2.2.5 Shipping Records. The Contractor shall maintain records of deliveries showing the Contractor's order number, purchase order number, and equipment item number. Labeling or shipping tags shall be included in the records. The records shall be furnished to the Engineer for review if so requested.

306-2.3 Storage. Pipeline materials, fittings, valves, and appurtenances shall be stored at the Work site in accordance with the manufacturer's installation instructions.

Unless otherwise specified in the delivery, storage, and handling Reference Specification shown in Table 306-2.1 (A) or Table 306-2.1 (B), storage shall conform to the following requirements:

a) Products shall be stored in a protected dry area at a temperature between 35°F (2°C) and 110°F (43°C).

b) Exposed metals shall be protected from moisture, rust and corrosion, even when such items may be sandblasted or otherwise cleaned before painting. Any corrosion in evidence prior to completion of the Work shall be removed, or the product shall be removed or replaced.

c) Items not designed for outdoor exposure shall be stored off-ground and under cover. Items with factory-applied primers or non-cementitious coatings shall be stored off-ground.

d) Fasteners and connectors shall be stored in their original unopened containers until used.

e) Stored products shall be covered with a tarpaulin or other covering. Coverings shall be secured in-place.

f) Plastic and ultraviolet-sensitive items shall be covered.

g) Products shall be stored so as to preserve their quality and fitness in a location facilitating inspection. The Contractor shall be responsible for damage or loss to products until completion of the Work.

h) Products shall be protected against damage from improper handling, improper storage, vandalism or theft.

i) Flammable products shall be stored in conformance with applicable safety codes for storage of flammable materials.

j) Stringing of pipe and appurtenances along right of way shall be done in a manner that will not interfere with the requirements of Part 6.

k) Exterior surfaces of delivered items shall be free from imperfections that render products unfit for service.

l) The Contractor shall notify the Engineer in writing if any delivered or stored product is damaged. Damaged products shall not be repaired without the Engineer's prior written approval.

306-2.4 Handling.

306-2.4.1 General. Products shall be handled in accordance with the manufacturer's installation instructions. Items weighing over 100 pounds (45 kg) shall be lifted only at points designated by the manufacturer. Products shall not be dropped, dragged, bent, or handled in a manner that causes abrasions, bruises, cracks, mars, scars, scratches, or other damage. Padded slings and hooks shall be used for lifting as needed to prevent damage. Mishandled products will not be accepted.

306-2.4.2 Coated Products. Coated pipe, valves, and other products shall be lifted, lowered or suspended using rubber or canvas belt slings or pneumatic-tired cradles. The sling width shall equal or exceed the pipe or product diameter. Coated products shall not be handled using ropes, hooks, chains, calipers, or cables.

Coated products shall be stored on padded or wooden skids.

306-2.4.3 Pre-Installation Inspection. Before installation, each product shall be inspected for damage, defects, completeness, and correct operation.

306-2.4.4 Pre-Installation Cleaning. Before installation, joints and interiors of piping materials, fittings, valves, and appurtenances shall be swabbed to remove foreign matter and contaminants.

306-2.4.5 Protection of Machined Surfaces. Machined surfaces and shafting shall be kept clean and protected from corrosion by using the type and amount of coating specified in the manufacturer's warranty requirements.

306-2.5 Protection of Pipe Interiors. Completed portions of pipeline shall not be used as a drain for removing water that has infiltrated into the trench. Pipe interiors shall be maintained in a clean condition free from foreign materials until completion of the Work.

For pressure pipe and clean water gravity pipe, pipe ends, fitting ends, valve ends, and equipment openings shall be covered with rubber, plastic, or canvas. Open ends of pressure pipe or clean water gravity pipe with tight-fitting caps or plugs shall be closed when pipe installation is not in progress. These provisions shall apply during work breaks in excess of 40 minutes, as well as overnight.

For potable water pipelines, failure to provide adequate protection will result in the Engineer requiring additional bacteriological testing to be performed in accordance with 306-8.9.4.6.

306-2.6 Compliance with Warranty Instructions. The Contractor shall conform to the submitted operation, maintenance, and warranty instructions. These instructions shall be deemed to be a part of the manufacturer's installation instructions. The Contractor shall perform the Work in such manner that the applicable manufacturer's warranty is not voided by its activities.

306-2.7 Shutdowns of Existing Pipelines.

306-2.7.1 General. All work needed to shut down an existing pipeline for the Contractor will be performed by forces employed by the affected utility owner unless otherwise specified. The Contractor shall not operate valves, hydrants or other appurtenances owned by the affected utility unless otherwise specified.

306-2.7.2 Preparation. The Contractor shall be prepared to employ pumping and dewatering equipment if a watertight seal cannot be achieved by the utility owner or Agency forces using existing valves.

306-2.7.3 Temporary Bypasses. When main shutdowns in excess of 4 hours are required, the utility owner will determine what temporary bypasses or service connections will be required unless specified in the Special Provisions.

The Contractor shall provide and maintain temporary water service. Piping, hoses and associated equipment used shall be flushed and disinfected in accordance with 306-8.9.4.

306-2.8 Advance Preparation before Connecting to Existing Pipelines. When connections are to be made to any existing pipe, conduit, or other structure or appurtenance, where the Plans require verification, or where the actual elevation, size, material, joint type, or position is not shown on the Plans or cannot be ascertained with certainty without excavation, the Contractor shall excavate for and expose the existing improvement before ordering materials or laying any pipe or conduit.

The Contractor shall provide advance notice to the Engineer and allow a minimum 2-hour window for the Engineer to inspect the existing pipe or conduit before connection materials are ordered. The Contractor shall prepare a sketch of the materials found at the proposed point of connection and submit to the Engineer along with any proposed changes to the specified connection requirements and/or to the lines and grades shown on the Plans. Any resultant changes shall be approved by the Engineer before ordering materials.

306-3 TRENCH EXCAVATION.

306-3.1 General. Pursuant to Section 6500 of the Labor Code, prior to commencing the excavation of a trench 5 feet (1.5 m) 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 State of California Department of Industrial Relations, Division of Occupational Safety and Health.

Excavation shall include the removal of materials of any nature which interfere with the Work.

Excavation 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.

306-3.2 Removal of Surface Improvements. Removal of surface improvements shall conform to 300-1.3.

306-3.3 Removal and Abandonment of Existing Conduits and Structures. When conduits have been or are proposed to be abandoned and are found to interfere with construction of new conduit, the interfering portion(s) shall be removed and the remaining open portion(s) securely sealed. Where the inside diameter of the existing conduit is 4 feet (1.2 m) or less, the seal shall consist of a wall of concrete not less than 6 inches (150 mm) thick or a wall of brick and mortar 8 inches (200 mm) thick. For larger openings, details of the seal shall be as 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.

Structures shown 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 material approved by the Engineer 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 component owners and, if requested, shall load such material onto an owner-furnished truck at the Work site. Otherwise, such material shall become the property of the Contractor and shall be disposed of off the Work site.

306-3.4 Minimum and Maximum Pipe Zone Trench Width. For pipe, unless otherwise shown on the Plans, the minimum and maximum trench width measured at the top of the bedding zone located 1 foot (0.3 m) above the crown of the pipe shall be as shown in Tables 306-3.4 (A) and 306-3.4 (B), where D is the nominal pipe diameter.

TABLE 306-3.4 (A)

Gravity Pipe Material	Applicable Specification	Nominal Pipe Size inches (mm)	Side Clearance, inches (mm)	
			Minimum	Maximum
Vitrified Clay Pipe	306-7.4 and ASTM C12 Section 6	All sizes	6 (150) or as shown on the Plans	As shown on the Plans
Prefabricated Concrete Pipe	306-7.3 and ASTM C1479	Up to and including 36 (900)	6 (150) or as shown on the Plans	D or as shown on the Plans
		Over 36 (900)	D/6 or as shown on the Plans	As shown on the Plans
Cast-in-Place Concrete Pipe	306-9	All sizes	306-9	
Corrugated Metal Pipe	306-7.6	All sizes	8 (200)	As shown on the Plans
Plastic Pipe	ASTM D2321 Paragraph 6.3	Up to and including 16 (400)	8 (200)	12 (300)
		Over 16 (400) to and including 30 (750)	6 (150) + D/8	18 (450)
		Over 30 (750)	As shown on the Plans	

TABLE 306-3.4 (B)

Pressure Pipe Material	Applicable Specification	Nominal Pipe Size inches (mm)	Side Clearance inches (mm)	
			Minimum	Maximum
Ductile Iron Pipe	AWWA C600 Section 4.3.2.3 and AWWA M41	All sizes	12 (300)	As shown on the Plans
Steel Pipe	AWWA C604 Section 4.4.2.3 and AWWA M11	All sizes	6 (150) or as shown on the Plans	As shown on the Plans
Concrete Pressure Pipe	AWWA C604 Section 4.4.2.3 and AWWA M9	All sizes	6 (150) or as shown on the Plans	As shown on the Plans
PVC Pressure Pipe	AWWA C605 AWWA M23	Up to and including 16 (400)	8 (200)	12 (300)
		Over 16 (400) to and including 30 (750)	6 (150) + D/8	18 (450)
		Over 30 (750)	As shown on the Plans	
HDPE Pressure Pipe	AWWA M55	Up to and including 16 (400)	8 (200)	12 (300)
		Over 16 (400) to and including 30 (750)	6 (150) + D/8	18 (450)
		Over 30 (750)	As shown on the Plans	
Fiberglass Pressure Pipe	AWWA M45 Section 6.6	Up to and including 16 (400)	8 (200)	12 (300)
		Over 16 (400) to and including 30 (750)	6 (150) + D/8	18 (450)
		Over 30 (750)	As shown on the Plans	

If the maximum trench width is exceeded, the Contractor shall provide additional bedding, another type of bedding, or a higher strength of pipe as approved by the Engineer.

306-3.5 Maximum Length of Open Trench. Unless otherwise specified in the Special Provisions or approved by the Engineer, the maximum length of open trench where prefabricated pipe, including field fused/welded pipe, is to be placed shall be 500 feet (150 m) or the distance necessary to accommodate the length of pipe to be installed in a single Day, whichever is greater. This distance shall be defined as the total length at any location of open trench excavation, pipe laying and appurtenant construction, and backfill over which temporary resurfacing has not been placed.

Unless otherwise specified in the Special Provisions or approved by the Engineer, the maximum length of open trench in any one location where concrete structures are cast-in-place shall be that which is necessary to permit uninterrupted progress of the structure construction.

306-3.6 Trench Access Ladders. Ladders for trench access shall be provided for each 50 feet (15 m) of open trench, or fraction thereof, for trenches over 4 feet (1.2 m) in depth. Ladders shall project 2 feet (0.6 m) above the top of the trench and be so located that workers in the trench need not move more than 25 feet (7.5 m) to a ladder.

306-4 SHORING AND BRACING. 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.

The manner of bracing excavations shall be as set forth in the rules, orders, and regulations of the Division of Occupational Safety and Health.

The Contractor shall be responsible for the installation and removal of all shoring and bracing materials used during trenching and excavations unless otherwise specified or directed by the Engineer. The Contractor shall be responsible for the repair of all existing damaged utilities and structures.

At locations where the drilling of holes for soldier piles 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, the Engineer may approve the use of means other than drilling for the purpose of placing the vertical supports. Such other means, however, shall prevent damage to existing surface or subsurface improvements.

If sheeting is used to support an excavated trench, the Contractor shall remove the sheeting, 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.

306-5 DEWATERING. The Contractor shall install, operate, and maintain a dewatering system of sufficient capacity so as to maintain the trench bedding zone free of standing or ponded water, and in a condition suitable for prosecution and progress of the Work. Unless otherwise specified, dewatering shall conform to 7-8.6.4.

Groundwater shall be allowed to rise to ambient groundwater elevation upon completion of final trench backfill operations to finished grade or subgrade of permanent surfacing. The rate at which groundwater is allowed to rise shall be controlled by the Contractor to assure protection of the Work in conformance with 4-1.

306-6 BEDDING.

306-6.1 General. Bedding material shall conform to 217. Concrete used for bedding shall conform to 201-1. The bedding zone shall be defined as the area containing the material supporting, surrounding

the pipe, and extending to 1 foot (0.3 m) above the top of the pipe. Where concrete is specified to cover the pipe, the top of the concrete shall be considered the top of the bedding.

Unless otherwise shown on the Plans, or specified in the Special Provisions or Reference Specifications, the minimum dimensions of bedding material placement shall be as follows:

a) 4 inches (100 mm) below the pipe barrel on ferrous, concrete and clay pipe,

b) 4 inches (100 mm) below the pipe barrel on plastic pipe,

c) 6 inches (150 mm) below the pipe barrel on pipe above a rock foundation,

d) 1 inch (25 mm) below a projecting bell for non-plastic sewer, storm drain and water pipe, and

e) the dimensions shown in Tables 306-3.4 (A) and 306-3.4 (B) from the outermost dimension of each side of the pipe barrel.

Bedding material shall be placed on a firm and unyielding subgrade so the pipe is supported for the full-length of the barrel.

Where it becomes necessary to remove boulders or other interfering objects at subgrade, the resulting voids below such subgrade shall be backfilled with bedding material of the type shown in Table 217-1.2. Soft, spongy, unstable, or other unsuitable material encountered upon which the bedding material or pipe is to be placed shall be removed to the depth directed or approved by the Engineer and replaced with the aforementioned bedding material.

When so specified in the Special Provisions or shown on the Plans, native free-draining granular material may be used as bedding. The trench shall be excavated to a depth above the invert grade and the trench bottom hand-shaped so as to provide firm support on undisturbed material for the entire length of the pipe.

Pipe shall bear uniformly on the subgrade or bedding material except for sockets or collars which shall not bear upon the subgrade or bedding material.

306-6.2 Bedding for Narrow Trenches. Narrow trenches shall be defined as trenches 10 inches (250 mm) or less in width.

Bedding requirements for narrow trenches will be specified by the owner of the installation, and shall be placed on firm and unyielding subgrade so as to support the pipe or conduit for its full length. Bedding shall not be jetted unless authorized in writing by the owner of the installation.

When the Contractor is permitted to place the pipe or conduit without bedding, it shall be placed on firm and unyielding subgrade.

306-6.3 Bedding for Plastic Pipe and Fittings. Plastic pipe and fittings shall include the following:

a) ABS solid wall pipe conforming to 207-15.

b) ABS or PVC composite pipe conforming to 207-16.

c) PVC solid wall sewer pipe conforming to 207-17.

d) Annular HDPE pipe conforming to 207-18.

e) PE solid wall drainage pipe conforming to 207-19.

f) FRPM pipe conforming to 207-20.

g) PVC Pressure Pipe conforming to 209-4.

h) Polyethylene (HDPE) Solid-Wall Pressure Pipe conforming to 209-5.

i) Fiberglass pressure pipe conforming to 209-6.

Bedding material for plastic pipe shall conform to 217. The limits of the bedding zone shall conform to Table 217-1.2.

306-6.4 Concrete Cradles, Arches, or Encasements When pipe is laid in a sheeted trench, sheeting against which a concrete cradle, arch or encasement 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 specified in 306-4.1.

306-6.5 Placement and Compaction.

306-6.5.1 General. The material in the bedding zone shall be placed and compacted either mechanically or by jetting. Unless the sheeting or shoring is to be cut off and left in place, compaction of bedding material for pipe shall be performed after the sheeting or shoring has been removed form the bedding zone, and prior to the placement of backfill.

Mechanical compaction shall conform to 306-12.3.

Jetting shall conform to 306-12.4 except each lift of bedding material shall not exceed 4 feet (1.2 m) in thickness. The jet pipe shall be of sufficient length to reach within 2 feet (0.6 m) of the bottom of the pipe. Jetting shall provide enough water to thoroughly saturate and compact, without voids, the bedding material around the pipe. The jet pipe shall be inserted at intervals of 3 feet (1 m) maximum, contiguous along each side of the pipe. Neither flooding, nor free standing water will be permitted.

306-6.5.2 Plastic Pipe and Fittings. Bedding material shall be placed as shown on the Plans, or specified in the Special Provisions or Reference Specifications. Crushed rock bedding material shall be placed by slicing, shovel-spading, or shovel rodding to ensure complete filling of the haunch areas below the pipe. No minimum relative compaction requirement shall apply to crushed rock.

306-7 PREFABRICATED GRAVITY PIPE.

306-7.1 General. Prefabricated gravity pipe shall include pipe installations where:

a) no portion of the system (excluding siphons) is designed to operate under continuous pressure, and
b) pipes are designed to drain by gravity in a downhill direction.

Installation of pipeline materials, fittings, and appurtenances shall conform to the requirements shown in Table 306-7.1.

TABLE 306-7.1

Gravity Pipe Material	Material Specification	Installation Specification
Nonreinforced Concrete Pipe (NRCP)	207-1	306-7.2
Reinforced Concrete Pipe (RCP)	207-2	306-7.3
Lined Reinforced Concrete Pipe	207-3	306-7.3
Vitrified Clay Pipe (VCP)	207-8	306-7.4
Cast Iron Soil Pipe	207-9	306-7.5 California Plumbing Code[1]
Corrugated Steel Pipe	207-11	306-7.6
Structural Steel Plate Pipe and Arches	207-12	306-7.6
Corrugated Aluminum Pipe	207-14	306-7.6
Structural Aluminum Plate Pipe and Arches	207-12	306-7.6
ABS Solid Wall Pipe	207-15	306-7.7
ABS or PVC Composite Pipe	207-16	306-7.7
PVC Plastic Sewer Pipe	207-17	306-7.7
Annular HDPE Pipe with Smooth Interior and Corrugated Exterior	207-18	306-7.7
Polyethylene (HDPE) Solid-Wall Pipe	207-19	306-7.7
FRPM Pipe	207-20	306-7.7
Valves, Manholes, Waterstops, and Appurtenances	212	Manufacturer's installation instructions[1]

1. Submit to the Engineer in accordance with 2.5.3.
2. Any conflicts or discrepancies between the installation specifications shown above and the manufacturer's installation instructions shall be brought to the Engineer's attention in writing for resolution prior to the start of pipe installation.

Gravity pipe shall be laid to the lines and grades shown on the Plans. The socket or collar ends of the pipe shall be laid upgrade unless otherwise shown on the Plans or approved by the Engineer.

Gravity pipe shall be laid and jointed such that the offset of the inside of the pipe at any joint is 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 3/8 inch (9.5 mm), whichever is smaller. In joining socket-and-spigot pipe, the spigot shall be so seated in the socket of the adjacent pipe as to provide a minimum of 3/8 inch (9.5 mm) annular space around the circumference of the pipe in the socket. Offsets shall be distributed around the circumference of the pipe in such a manner that the minimum offset occurs at the invert.

After the joints have been constructed, the pipe shall not be disturbed.

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 approved by the Engineer.

306-7.2 Non-Reinforced Concrete Pipe (NRCP).

306-7.2.1 General. NRCP shall conform to 207-1.

306-7.2.2 Tongue and Groove Self-Centering Joints. Tongue and groove self-centering joints shall conform to 306-7.3.2.1.

306-7.2.3 Mortar 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 to fill that portion of the joint in which it is placed. The mortar shall be beveled on a 1:1 slope from the outer socket edge, and the interior of the pipe cleaned of surplus mortar or other foreign material and neatly wiped.

When approved by the Engineer, a gasket of material approved by the Engineer may be caulked into joints in wet trenches, after which the mortar shall be placed therein.

306-7.2.4 Gasket-Type Joints. Gasket-type joints shall conform to 306-7.3.2.3.

306-7.2.5 Acceptance Testing. NRCP shall successfully pass the following tests prior to completion of the Work:

TABLE 306-7.2.5

Item	Test For	Test Standard Reference
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	207-1
Installed NRCP	Allowable Cracking	Table 207-2.9.2
	Joint Offset Tolerances	306-1.2.2
	Pressure Testing and Leakage Inspection of Gravity Pipelines	306-8.2
	11-Month Anniversary Warranty Inspection	306-8.8.6

306-7.3 Reinforced Concrete Pipe (RCP).

306-7.3.1 General. Circular RCP 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 4-inch-high (100 mm) "T". RCP shall be laid with the socket end upgrade starting at the downgrade end of the line. Plastic liner installation shall conform to 311-1.

306-7.3.2 Joints.

306-7.3.2.1 Tongue and Groove Self-Centering Joints. Each joint shall be cleaned with a wire brush and wetted before mortaring. Mortar shall be Class "C" conforming to 201-1.5.

Mortaring of outside joints will not be required except where RCP is used on curves unless otherwise specified in the Special Provisions or shown on the Plans.

RCP installed along curves shall have one or both ends beveled or be pulled to provide a smooth curve. If the extreme ends do not overlap, and the resulting clear space between the extreme ends does not exceed 1 inch (25 mm), 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 is more than 1 inch (25 mm) but less than 3 inches (75 mm), the joint shall be covered using Class 520-C-2500 (310-C-17) concrete to a minimum depth of 6 inches (150 mm) for a width of 15 inches (380 mm) centered about the joint. Such concrete cover shall be placed from the bottom of the pipe to a point where the extreme ends overlap. Sandbags or dirt sacks may be used as side forms. The inside of the joint shall be mortared as specified above. If the clear space between the extreme ends is 3 inches (75 mm) or greater, but less than 6 inches (150 mm), a concrete collar is required. If the clear space is 6 inches (150 mm) or greater, a transition structure is required. Concrete collars and transition structures shall conform to the details shown on the Plans.

When RCP is under 24 inches (600 mm) in diameter, the outer joint space shall be filled with mortar.

When RCP is 24 inches (600 mm) or greater in diameter, the interior annular space of each joint shall be filled full-depth with mortar, a smooth, troweled finish applied, and excess mortar removed. The jointing procedure shall be as follows:

a) When the entire trench is to be jetted, no joints shall be mortared before the next 2 joints in advance are laid. However, the mortaring of joints shall be completed before the beginning of jetting.
b) When the entire trench is to be compacted mechanically, no interior joints shall be mortared until compaction has been completed. Joints shall then be mortared.
c) Where the lower portion of the trench is to be jetted and the remainder mechanically compacted, joints shall be mortared in 2 separate operations. Before jetting is begun, mortar shall be pressed into interior joints to within 1 inch (25 mm) of the inside surface. After jetting and mechanical compaction have both been completed, the interior joints shall be cleaned and completed.
d) 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.

306-7.3.2.2 Collar Joints. RCP with collar joints shall be laid with the collar end up-grade. The pipes shall be butted together and a uniform caulking space left between the pipe length and the collar. When the entering pipe length has been laid and checked for line and grade, the pipe length shall be backfilled on both sides. The caulking space shall then be filled with mortar tamped using a caulking tool and hammer.

306-7.3.2.3 Gasket-Type Joints. Gasket-type joints shall be watertight and flexible. Each joint shall contain a gasket conforming to 208-3 unless otherwise shown on the Plans or specified in the Special Provisions. This gasket shall be the sole element responsible for watertightness of the 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.

The length and cross-sectional dimension of the gasket, the annular space provided for the gasket, and other joint details shall produce a watertight, flexible joint after installation.

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 2 inches (50 mm) of the inside surface of the socket shall be thoroughly cleaned, then lubricated with a soft vegetable soap compound approved by the Engineer.

The gasket, after lubrication, shall be uniformly stretched when being placed in the spigot groove.

For pipe in which the inside joints are to be pointed, spacers shall be placed against the inside shoulder of the socket to provide the proper space between abutting ends.

For profile-type gaskets, the manufacturer's requirements for lubrication and assembly shall be followed.

After the joint is assembled, a metal feeler gauge 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 from the joint, the gasket checked to see that it is not cut or damaged, the pipe re-inserted and re-bedded, and the gasket position re-checked.

Where steel joint rings are used, a 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 other method approved by the Engineer, and shall completely and tightly 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 material by jetting begins. 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. Mortar shall completely fill the outside annular space between the ends of the pipe and around the 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 material have been densified, the inside joint recess shall first be moistened with water, then filled with stiff Class "C" mortar. The finished joint shall be smooth and flush with the adjacent pipe surfaces.

306-7.3.3 Acceptance Testing. RCP shall successfully pass the following tests prior to completion of the Work:

TABLE 306-7.3.3

Item	Test For	Test Standard Reference
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	207-2 or 207-3 as applicable
Installed RCP	Allowable Cracking	Table 207-2.9.2
	Joint Offset Tolerances	306-1.2.2
	Pressure Testing and Leakage Inspection of Gravity Pipelines	306-8.2
	11-Month Anniversary Warranty Inspection	306-8.8.6

306-7.4 Vitrified Clay Pipe (VCP).

306-7.4.1 General. VCP shall be "extra strength" or "high strength" as shown on the Plans or specified in the Special Provisions.

306-7.4.2 Installation.

306-7.4.2.1 General. Unless otherwise shown on the Plans or specified in the Special Provisions, any of the following joints may be used.

306-7.4.2.2 Type "D" Joints (Rubber-Sleeve Coupling with Shear Ring for Plain-End Clay Pipe). Type "D" joints shall conform to 208-2.2. Unless otherwise specified in the Special Provisions, pipe shall be delivered to the Work site 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-based lubricant. The lubricant shall not be detrimental to the sleeve, stainless steel bands, or plastic shear ring. Joints installed on pipe at the manufacturing plant shall have compression bands torqued to 70 inch-pounds (8 N-m), minimum. When joints are 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 70 inch-pounds (8 N-m), minimum, and shall provide uniform tension. Type "D" Joints may be used on pipe on curves in accordance with 306-7.4.2.4.

306-7.4.2.3 Type "G" Joints (Polyurethane Compression). Type "G" joints shall conform to 208-2.3.

Prior to jointing, the matting surfaces shall be cleaned and lubricated with a lubricant recommended by the pipe manufacturer and approved by the Engineer. Pipe shall be joined spigot into socket. When jointing is completed, joints shall be within the tolerance shown in Table 306-7.4.2.3.

TABLE 306-7.4.2.3

Pipe Size inches (mm)	Joint Space inches (mm)
15 - 18 (375 - 450)	5/8 (16)
21 - 42 (525 - 1050)	7/8 (22)

The joint space shall not be increased because of deflections along curved sections. Straight pipe with Type "G" joints may be used on pipe on curves in accordance with 306-7.4.2.4.

306-7.4.2.4 Straight Non-Beveled Pipe On Curves. Straight nonbeveled pipe with Type "D" or Type "G" joints may be used along curves, provided the radius of curvature is not less than that shown in Table 306-7.4.2.4 (A). For a radius of curvature less than that shown, beveled pipe or shorter pipe lengths shall be used.

TABLE 306-7.4.2.4 (A)

D Pipe Size inches (mm)	For Pipe Length ft (m)	Min. Radius of Curvature ft (m)	Max. Deflection Per Joint (degrees)	Max. Deflection Per Length inches (mm)
6 to 12 (150 to 300)	5 (1.5)	120 (37)	2.4	2-1/2 (63)
	5-1/2 (1.7)	132 (40)	2.4	2-3/4 (70)
	6 (1.8)	144 (44)	2.4	3 (76)
15 to 24 (375 to 600)	5 (1.5)	160 (49)	1.8	1-7/8 (47)
	5-1/2 (1.7)	176 (54)	1.8	2-1/16 (52)
	6 (1.8)	192 (59)	1.8	2-1/4 (57)
	7-1/2 (2.3)	240 (73)	1.8	2-13/16 (71)
27 to 36 (675 to 900)	5 (1.5)	240 (73)	1.2	1-1/4 (31)
	5-1/2 (1.7)	264 (80)	1.2	1-3/8 (34)
	6 (1.8)	288 (88)	1.2	1-1/2 (38)
	7-1/2 (2.3)	360 (110)	1.2	1-7/8 (47)
39 to 42 (975 to 1050)	5 (1.5)	320 (97)	0.9	15/16 (23)
	5-1/2 (1.7)	352 (107)	0.9	1-1/16 (27)
	6 (1.8)	384 (117)	0.9	1-1/8 (28)

For pipe lengths not shown in Table 306-7.4.2.4 (A), the requirements shown in Table 306-7.4.2.4 (B) shall be applicable.

TABLE 306-7.4.2.4 (B)

D Pipe Size inches (mm)	Maximum Allowable Deflection Δd inches per ft (mm per m) of pipe	Equation for Minimum Radius of Curvature (L = Pipe Length)
6 to 12 (150 to 300)	1/2 (42)	r = 24L
15 to 24 (375 to 600)	3/8 (31)	r = 32L
27 to 36 (675 to 900)	1/4 (21)	r = 48L
39 to 42 (975 to 1050)	3/16 (16)	r = 64L

306-7.4.3 Acceptance Testing. VCP shall successfully pass the following tests prior to completion of the Work:

TABLE 306-7.4.3

Item	Test For	Test Standard
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	207-8
VCP	Joint Offset Tolerances	306-1.2.2
	Pressure Testing and Leakage Inspection of Gravity Pipelines	306-8.2
	11-Month Anniversary Warranty Inspection	306-8.8.6

306-7.5 Cast Iron Soil Pipe.

306-7.5.1 General. The type of joint to be installed shall be as shown on the Plans or specified in the Special Provisions. If not designated, the type of joint may be any of the following.

306-7.5.2 Installation.

306-7.5.2.1 Cement Joints. Cement joints shall consist of a gasket of untarred jute or oakum twisted into a rope of approximately the same diameter as the joint space and saturated with neat cement grout driven against the base of the socket. After placement, caulking cement shall be pushed into the socket with a steel caulking tool until the interior of the socket is completely filled, then 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. Completed joints shall be protected from the sun immediately following caulking.

306-7.5.2.2 Slip-On Joints. 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 pushed into place. Any lubricant other than that furnished with the pipe shall not be used unless otherwise approved by the Engineer.

306-7.5.3 Acceptance Testing. Cast iron soil pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-7.5.3

Item	Test For	Test Standard Reference
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	207-9
Installed Cast Iron Soil Pipe	Pressure Testing and Leakage Inspection of Gravity Pipelines	306-8.2
	11-Month Anniversary Warranty Inspection	306-8.8.6

306-7.6 Corrugated Metal Pipe (CMP).

306-7.6.1 General. CMP shall include corrugated steel pipe and corrugated aluminum pipe. Installation of pipe arches shall be as shown on the Plans or specified in the Special Provisions.

306-7.6.2 Installation. Pipe sections shall be laid with a maximum spacing between sections of 1-1/2 inches (38 mm). Annular CMP shall be laid with external laps of the circumferential seams or circumferential joints upgrade. Pipe coupling corrugations or projections shall properly engage the pipe sections before bolts are tightened. Where pipe and/or couplings and pipe and/or couplings with metallic coatings are joined with dissimilar metals, the contact points shall be coated with asphalt mastic conforming to 207-11.5.2.

Corrugated aluminum pipe and aluminized corrugated steel pipe shall not come into contact with reinforcing steel or structural steel members. Corrugated aluminum pipe and aluminized corrugated steel pipe shall be coated with asphalt mastic conforming to 207-11.5.2 where concrete or trench backfill slurry 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 backfilling.

When so specified in the Special Provisions, 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.

Watertight joints, when shown on the Plans or specified in the Special Provisions, shall conform to 207-11.2.2.

Corrugated steel pipe installation shall conform to ASTM A798 Section 8.

Corrugated steel plate pipe and arch installation shall conform to ASTM A807 Section 8.

Corrugated aluminum pipe installation shall conform to ASTM B788.

Corrugated aluminum plate pipe and arch installation shall conform to ASTM B789.

306-7.6.3 Acceptance Testing. CMP shall successfully pass the following tests prior to completion of the Work:

TABLE 306-7.6.3

Item	Test For	Test Standard Reference
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	207-11, 12, 13, or 14 as appropriate
Installed CMP	Barrel Deflection	306-7.8.2
	Joint Offset Tolerances	306-1.2.2
	Leakage Test	306-8.2.5
	11-Month Warranty Inspection	306-8.8.6

306-7.7 Plastic Sewer and Drainage Pipe.

306-7.7.1 General. Plastic pipe and fittings shall be defined as including the following:

a) ABS solid wall pipe conforming to 207-15,

b) ABS or PVC composite pipe conforming to 207-16,

c) PVC gravity pipe conforming to 207-17,

d) Annular HDPE pipe conforming to 207-18,

e) PE solid wall pipe conforming to 207-19, and

f) FRPM pipe conforming to 207-20.

Connections of pipe and fittings to a manhole shall be watertight. The use of manhole waterstops shall be approved by the Engineer. Junctions connecting pipe or fittings to a pipe shall utilize a "wye" fitting. "Tee" connections will not be permitted. Pipe may be used on curves only if deflection fittings or couplings are used, or if solid wall pipe is bent without any application of heat. If deflection fittings or couplings are proposed for use on curves, the proposed alignment and method of joining shall be submitted to the Engineer in accordance with 2-5.3.

306-7.7.2 Installation.

306-7.7.2.1 Solvent-Welded ABS and PVC Pipe. Solvent cement shall conform to 207-15.1 for ABS pipe and 207-17.3.3 for PVC pipe.

The spigot end of the pipe shall be inserted to the proper depth of the socket as indicated by the "home mark."

306-7.7.2.2 Gasket-Type ABS, CHDPE and PVC Pipe. Gaskets shall conform to 208-4.

The spigot end shall be inserted to the proper depth of the socket as indicated by the "home mark." The home mark shall be shown as a circumferential line or by the words "home mark" on the outside of the pipe. The home mark shall be clearly and permanently indicated on the spigot end of the pipe by the manufacturer at the factory.

306-7.7.2.3 Jointing of Injection-Sealed PVC Pipe. 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 compound 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 shall be cause for rejection of the joint.

306-7.7.3 Acceptance Testing. Plastic sewer and drainage pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-7.7.3

Item	Test For	Test Standard Reference
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	207-15, 16, 17, 18, 19, or 20 as appropriate
Installed Plastic Sewer and Drainage Pipe	Barrel Deflection	306-7.8.2
	Joint Offset Tolerances	306-1.2.2
	Pressure Testing and Leakage Inspection of Gravity Pipelines	306-8.2
	11-Month Anniversary Warranty Inspection	306-8.8.6

306-7.8 Gravity Pipeline Testing.

306-7.8.1 General. Gravity pipeline testing shall include pressure testing, leakage inspection, and barrel deflection testing.

306-7.8.2 Pressure Testing and Leakage Inspection .

306-7.8.2.1 General. Leakage tests and post-installation closed circuit television (CCTV) inspections shall be completed and approved prior to placing permanent resurfacing.

When leakage or infiltration exceeds the amount allowed by the Specifications, the Contractor shall locate the leaks and make the necessary repairs or replacements in conformance with the Specifications to reduce the leakage or infiltration to the specified limits. Individual detectable leaks shall be repaired regardless of the results of the tests. Leakage tests shall be performed on completed pipelines as follows:

a) Storm Drains: Not required unless shown on the Plans or specified in the Special Provisions.

b) Gravity Sanitary Sewers 24 inches (600 mm) or less in diameter where the difference in elevation between inverts of adjacent manholes is 10 feet (3 m) or less: Water exfiltration test or water infiltration test as specified in the Special Provisions. The Engineer may allow substitution of an air pressure test for the water exfiltration test.

c) Gravity Sanitary Sewers 24 inches (600 mm) or less in diameter where the difference in elevation between inverts of adjacent manholes is greater than 10 feet (3 m): Air pressure test or water infiltration test as specified in the Special Provisions.

d) Gravity Sanitary Sewers 24 inches (600 mm) or greater in diameter: Air pressure test or water infiltration test as specified in the Special Provisions.

e) Gravity Sanitary Sewers which are in service and a bypass system is not available: The Contractor shall perform post-installation CCTV inspection in accordance with 500-1.1.5.

f) Pressure Sanitary Sewers (force mains): Water pressure test at 120 percent of the maximum operating pressure.

g) Water Pipelines: Water pressure test. Pipe specified by pressure classification: 50 pounds per square inch (340 kPa) over the pressure classification. Other types of pipe: 120 percent of the maximum operating pressure.

306-7.8.2.2 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 4 feet (1.2 m)

above the invert of the sewer at the center of the upper manhole; or if groundwater is present, 4 feet (1.2 m) above the average adjacent groundwater level.

The allowable leakage will be computed by the formulae:

$E_{US} = 0.0001\ LD\ \sqrt{H}$ for mortared joints.

($E_{SI} = 0.00009\ LD\ \sqrt{H}$ for mortared joints)

$E_{US} = 0.00002\ LD\ \sqrt{H}$ for all other joints.

($E_{SI} = 0.000018\ LD\ \sqrt{H}$ for all other joints.)

Where:

L = length of sewer and house connections tested, in feet (meters).

E_{US} (E_{SI}) = the allowable leakage in gallons (liters) per minute of sewer tested.

D = the internal diameter of the pipe in inches (mm).

H = is the difference in elevation feet (meters) 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.

Unless otherwise specified, the Contractor shall furnish the water, labor, and equipment necessary and perform the required tests. Tests shall be performed in the presence of the Engineer.

306-7.8.2.3 Water Infiltration Test. If, in the opinion of the Engineer, excessive groundwater is encountered during the construction of a section of a 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 the sewer between adjoining manholes shall not exceed that allowed by the formula specified in 306-7.8.2.1 where H is the difference in the elevation in feet (meters) between the groundwater surface and the invert of the sewer at the downstream manhole.

306-7.8.2.4 Air Pressure Test. Air test equipment shall be approved by the Engineer unless otherwise shown on the Plans or specified in the Special Provisions.

The Contractor may conduct an initial air test of the sewer mainline after compaction 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, 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 may, at its option, wet 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 30 pounds per square inch (210 kPa) gauge pressure has been reached, at which time the flow of air shall be reduced and the internal air pressure shall be maintained between 2.5 and 3.5 pounds per square inch (17 kPa and 24 kPa) gauge 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 gauge and hose arrangement separate from the hose used to introduce air into the line. Pressure in the pipeline shall not be allowed to exceed 5 pounds per square inch (34 kPa) gauge 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 2.5 pounds per square inch (17 kPa) gauge pressure, a stopwatch or sweep-second-hand watch shall be used to determine the time lapse required for the air pressure to drop to 1.5 pounds per square inch (10 kPa) gauge pressure.

If the time lapse (in seconds) required for the air pressure to decrease from 2.5 to 1.5 pounds per square inch (17 to 10 kPa) gage pressure exceeds that shown in Table 306-7.8.2.4, the pipe shall be presumed to be within the 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 the acceptance limits.

TABLE 306-7.8.2.4

Time in Seconds for Pressure to Drop from 2.5 to 1.5 pounds per square inch (17 to 10 kPa) Gauge Pressure

Main Line	4-inch (100 mm) House Connection						Main Line	6-inch (150 mm) House Connection					
Nominal Diameter inches (mm)	Length ft (m)	House Connection Length					Nominal Diameter inches (mm)	Length ft (m)	House Connection Length				
		0 ft (0 m)	100 ft (30 m)	200 ft (60 m)	300 ft (90 m)	400 ft (120 m)			0 ft (0 m)	100 ft (30 m)	200 ft (60 m)	300 ft (90 m)	400 ft (120 m)
8 (200)	0 (0)	0	20	40	50	70	8 (200)	0 (0)	0	40	80	100	100
	50 (15)	40	50	70	90	80		50 (15)	40	70	110	110	110
	100 (30)	70	90	100	100	90		100 (30)	70	110	120	110	110
	150 (45)	110	120	110	100	100		150 (45)	110	120	120	120	110
	200 (60)	140	120	110	110	100		200 (60)	140	130	120	120	120
	300 (90)	140	130	120	110	110		300 (90)	140	130	120	120	120
	400 (120)	140	130	120	120	110		400 (120)	140	130	130	120	120
10 (250)	50 (15)	50	70	90	100	90	10 (250)	50 (15)	50	90	120	120	110
	100 (30)	110	130	120	110	110		100 (30)	110	140	130	130	120
	150 (45)	170	150	140	130	120		150 (45)	170	150	140	140	130
	200 (60)	170	160	150	140	130		200 (60)	170	160	150	140	140
	300 (90)	170	160	150	150	140		300 (90)	170	160	150	150	140
12 (300)	50 (15)	80	100	110	110	110	12 (300)	50 (15)	80	120	140	130	120
	100 (30)	160	170	150	140	130		100 (30)	160	170	150	140	140
	150 (45)	200	180	170	160	150		150 (45)	200	180	170	160	150
	200 (60)	200	190	180	170	160		200 (60)	200	190	180	170	160
	300 (90)	200	190	180	180	170		300 (90)	200	190	180	180	170
15 (375)	50 (15)	120	140	160	140	130	15 (375)	50 (15)	120	160	160	150	140
	100 (30)	250	220	190	170	160		100 (30)	250	210	190	170	160
	150 (45)	260	230	220	200	190		150 (45)	260	230	210	200	190
	200 (60)	260	240	230	220	210		200 (60)	260	240	220	210	200
	300 (90)	260	240	230	220	220		300 (90)	260	240	230	220	210
18 (450)	50 (15)	180	200	190	170	150	18 (450)	50 (15)	180	220	190	170	160
	100 (30)	310	260	230	210	190		100 (30)	310	260	220	200	190
	150 (45)	310	280	260	250	230		150 (45)	310	280	260	240	220
	200 (60)	310	290	280	260	250		200 (60)	310	290	270	260	240
	300 (90)	310	290	280	270	260		300 (90)	310	290	280	270	260
21 (525)	50 (15)	240	260	230	200	180	21 (525)	50 (15)	240	260	220	200	180
	100 (30)	360	310	280	250	230		100 (30)	360	300	260	240	200
	150 (45)	360	330	310	290	280		150 (45)	360	330	300	280	260
	200 (60)	360	340	320	310	300		200 (60)	360	330	320	300	290
	300 (90)	360	340	330	320	310		300 (90)	360	340	330	310	300
24 (600)	50 (15)	320	320	270	240	210	24 (600)	50 (15)	320	310	260	220	200
	100 (30)	410	360	320	290	270		100 (30)	410	350	310	280	260
	150 (45)	410	380	360	340	320		150 (45)	410	370	350	320	310
	200 (60)	410	390	370	360	350		200 (60)	410	380	360	350	330
	300 (90)	410	390	380	370	360		300 (90)	410	390	370	360	350
27 (675)	50 (15)	400	370	310	280	250	27 (675)	50 (15)	400	350	290	260	230
	100 (30)	460	410	370	340	310		100 (30)	460	390	350	320	290
	150 (45)	460	430	410	390	370		150 (45)	460	420	390	370	350
	200 (60)	460	440	420	410	390		200 (60)	460	430	410	390	380
	300 (90)	460	450	430	420	410		300 (90)	460	440	420	410	390

TABLE 306-7.8.2.4 *(Continued)*

Time in Seconds for Pressure to Drop from 2.5 to 1.5 pounds per square inch (17 to 10 kPa) Gauge Pressure

Main Line	4-inch (100 mm) House Connection					Main Line	6-inch (150 mm) House Connection					
Nominal Diameter inches (mm)	Length ft (m)	House Connection Length					Nominal Diameter inches (mm)	Length ft (m)	House Connection Length			
		0 ft (0 m)	100 ft (30 m)	200 ft (60 m)	300 ft (90 m)	400 ft (120 m)			0 ft (0 m)	100 ft (30 m)	200 ft (60 m)	300 ft (90 m)	400 ft (120 m)
30 (750)	50 (15)	490	420	360	310	280	30 (750)	50 (15)	480	490	330	290	260
	100 (30)	510	460	420	380	360		100 (30)	510	440	390	360	330
	150 (45)	510	480	460	440	420		150 (45)	510	470	440	420	390
	200 (60)	510	490	470	460	440		200 (60)	510	480	460	440	420
	300 (90)	510	500	480	470	460		300 (90)	510	490	470	460	440
33 (825)	50 (15)	560	460	400	350	320	33 (825)	50 (15)	560	440	370	320	290
	100 (30)	560	510	460	430	400		100 (30)	560	490	440	400	370
	150 (45)	560	530	510	490	460		150 (45)	560	520	490	460	440
	200 (60)	560	540	520	510	490		200 (60)	560	530	510	490	470
	300 (90)	560	550	530	520	510		300 (90)	560	540	520	510	490
36 (900)	50 (15)	610	510	440	390	360	36 (900)	50 (15)	610	480	410	360	320
	100 (30)	610	560	510	480	440		100 (30)	610	540	480	440	410
	150 (45)	610	580	560	530	510		150 (45)	610	570	540	510	480
	200 (60)	610	600	580	560	540		200 (60)	610	590	560	540	520
	300 (90)	610	600	580	570	560		300 (90)	610	590	570	560	540
39 (975)	50 (15)	660	560	490	440	390	39 (975)	50 (15)	660	530	450	390	350
	100 (30)	660	610	560	520	490		100 (30)	660	590	530	480	450
	150 (45)	660	630	610	580	560		150 (45)	660	620	590	560	530
	200 (60)	660	640	620	610	590		200 (60)	660	640	610	590	570
	300 (90)	660	650	630	620	610		300 (90)	660	640	620	610	590
42 (1050)	50 (15)	710	610	540	480	430	42 (1050)	50 (15)	710	580	490	430	390
	100 (30)	710	660	610	570	540		100 (30)	710	640	580	530	490
	150 (45)	710	680	660	630	610		150 (45)	710	670	640	610	580
	200 (60)	710	690	680	660	640		200 (60)	710	690	660	640	620
	300 (90)	710	700	680	670	660		300 (90)	710	690	670	650	640

306-7.8.2.5 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 10 feet (3.0 m) 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 0.60 gallon per inch (90 mL/mm) of inside diameter per 100 feet (30 m) of pipe per hour. Any leakage in excess of this amount shall be stopped in a manner accepted by 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 accepted by the Engineer, whether or not the leakage from the line exceeds that permitted herein.

306-7.8.3 Maximum Allowable Barrel Deflection Testing of Plastic Sewer and Storm Drain Pipe.

306-7.8.3.1 General. Pipe and fittings shall be tested to ensure vertical deflections and measured diameter do not exceed the maximum allowable barrel deflection. The maximum allowable barrel deflection as a percentage of the nominal pipe internal diameter shall conform to the requirements shown in Table 306-7.8.3.1.

TABLE 306-7.8.3.1

Nominal Pipe Diameter		Percentage Barrel Deflection Allowed[1,2]				
Inches	Millimeters	Sewer Pipe			Storm Drain	
		ABS or PVC Composite	ABS, FRPM, HDPE or PVC Solid-wall or CHDPE	Clay, Concrete or DIP	ABS, PVC, FRPM, CMP, HDPE or composite	Clay, Concrete or DIP
0 through 12	0 through 300	3.0%	5.0%	n/a	6.5%	n/a
Over 12 through 30	Over 300 through 750	3.0%	4.0%	n/a	6.5%	n/a
Over 30 through 60	Over 750 through 1500	n/a	3.0%	n/a	6.5%	n/a
Over 60 through 90	Over 1500 through 2250	n/a	2.5%	n/a	6.5%	n/a
Over 90 through 120	Over 2250 through 3000	n/a	2.0%	n/a	6.5%	n/a
Over 120	Over 3000	n/a	1.5%	n/a	6.5%	n/a

1. 30 Days after installation.
2. Deflection tests shall not be performed sooner than 30 Days after completion of placement and compaction of backfill. The pipe and fittings shall be cleaned and inspected for offsets and obstructions prior to testing.

306-7.8.3.2 24-Inch (600 mm) or Smaller Inside Diameters. A mandrel shall be pulled through the pipe by hand to ensure the maximum allowable deflection has not been exceeded. Fittings shall be visually inspected to ensure the maximum allowable deflection has not been exceeded.

The mandrel shall be:

a) a rigid, nonadjustable, odd-numbered-leg (9 legs minimum) mandrel having an effective length not less than its nominal diameter,
b) fabricated from steel and be fitted with pulling rings at each end,
c) stamped or engraved on a segment other than the runner, with 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 D2680-10"-9.584"), and
d) have a minimum diameter at any point along the full length conforming to Table 306-7.8.3.2.

TABLE 306-7.8.3.2

Pipe Material	Nominal Size		Minimum Mandrel Diameter[1]	
	Inches	mm	Inches	mm
PVC-ASTM D3034 (SDR 26)	6	150	5.331	135.4
	8	200	7.114	180.7
	10	250	8.875	225.4
	12	300	10.547	267.9
	15	375	13.032	331.0
PVC-ASTM D3034 (SDR 35)	6	150	5.455	138.6
	8	200	7.282	185.0
	10	250	9.085	230.8
	12	300	10.793	274.1
	15	375	13.342	338.9
PVC-ASTM F679 (T-1 Wall)	18	450	16.924	429.9
	21	525	19.952	506.8
	24	600	22.446	570.1
	27	675	25.297	642.5
	30	750	28.502	724.0
	33	825	32.399	822.9
	36	900	35.999	914.4
ABS or PVC Composite Pipe, ASTM D2680	6	150	5.578	141.7
	8	200	7.518	190.9
	10	250	9.458	240.2
	12	300	11.398	289.5
	15	375	14.308	363.4
FRPM, ASTM D3262, 46 psi (318 KPa)	8	200	7.363	187.0
	10	250	9.263	235.3
	12	300	11.163	283.5
	15	375	14.160	359.7
	18	450	17.040	432.8
	20	500	18.960	481.6
	21	525	19.920	506.0
	24	600	23.527	597.59
	27	675	25.661	651.8
	30	750	25.512	724.2
	36	900	34.571	878.1
	39	975	37.452	951.3
	42	1050	40.333	1024.4
	45	1125	43.214	1097.6
	48	1200	46.094	1170.8
	51	1275	48.975	1244.0
	54	1350	51.856	1317.1
	60	1500	57.618	1463.5
	66	1650	63.707	1618.1
	72	1800	69.498	1765.2
	78	1950	75.290	1912.4
	84	2100	81.081	2059.5
	90	2250	86.873	2206.6
	96	2400	93.139	2365.7
	102	2550	98.980	2514.1
	108	2700	104.86	2663.4
	114	2850	110.74	2812.8
	120	3000	116.62	2962.1
	132	3300	129.04	3277.5
	144	3600	140.86	3577.7

1. Metric mandrel diameters are direct conversions of mandrel diameters in U.S. Standard Measures. If the above types of pipe are available and specified by the appropriate ASTM in metric dimensions, as the primary measure, the Engineer will determine the appropriate mandrel diameter which conforms to this subsection.

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 through the pipe, the pipe will be deemed to be over-deflected.

306-7.8.3.3 Inside Diameters Between 24 Inches (600 mm) and 36 Inches (900 mm). Deflections shall be determined by a method submitted to the Engineer in accordance with 2-5.3. Fittings shall be visually inspected to ensure the maximum allowable deflection has not been exceeded.

306-7.8.3.4 Inside Diameters Greater Than 36 Inches (900 mm). Deflections shall be determined by using a 1 inch (25 mm) diameter, nonadjustable metal bar; a minimum-radius rigid template; or by a method approved by the Engineer. Fittings shall be visually inspected to ensure the maximum allowable deflection has not been exceeded.

306-7.8.3.5 Laser Testing. The Contractor may substitute laser profile testing for mandrel testing.

306-7.8.3.6 Defective Work Remediation. Over-deflected pipe shall be uncovered and, if not damaged, reinstalled. Pipe subjected methods or process other than removal, which attempts, even successfully, to reduce or cure any over-deflection, shall be uncovered, removed from the Work site, and replaced with new pipe.

306-8 PREFABRICATED PRESSURE PIPE.

306-8.1 General. Prefabricated pressure pipe (pressure pipe) shall include pipe installations where:

a) the pipeline is designed to operate under continuous pressure, or
b) the pipeline is designed for bi-directional flow.

Installation of pipeline materials, fittings, valves and appurtenances shall conform to the pipe-specific Reference Specifications shown in Table 306-8.1 which shall be submitted to the Engineer in accordance with 2.5.3.

TABLE 306-8.1

Pressure Pipe Material	Material Specification	Installation Reference Specification[1]
Ductile Iron Pipe	209-1	AWWA C600 and 306-8.2
Steel Pipe	209-2	AWWA C604, and 306-8.3
Concrete Pressure Pipe	207-3	AWWA M9 Chapter 14 and 306-8.4
PVC Pressure Pipe	209-4	AWWA C605 and 306-8.5
High Density Polyethylene (HDPE) Pressure Pipe	209-5	AWWA M55 Chapter 8 and 306-8.5
Fiberglass Pressure Pipe	209-6	AWWA M45 Chapter 6 and 306-8.6
Valves and Appurtenances	212	Manufacturer's installation and warranty requirements

1. Where the manufacturer issues installation instructions, these shall be submitted to the Engineer in accordance with 2.5.3 along with the specifications referenced above. Any conflicts or discrepancies between the Reference Specifications shown above and the manufacturer's installation instructions shall be brought to the Engineer's attention in writing prior to the start of pipe installation. The Contractor shall allow 10 Working Days for resolution.

Pressure pipe shall be laid to the lines and grades shown on the Plans.

Joint restraints shall be constructed using welds, flanges, mechanical joints, or manufactured joint restraints as shown on the Plans or specified in the Special Provisions.

After the joints have been constructed, the pipe shall not be disturbed in any manner.

The Engineer may require removal and relaying of any pipe which is not true in alignment or shows excessive settlement after laying.

At the close of work each Day, or whenever the Work ceases for any reason for more than 40 minutes, each exposed end of the pipe shall be securely closed unless otherwise approved by the Engineer.

306-8.2 Ductile Iron Pipe.

306-8.2.1 General. Ductile iron pipe shall be assembled in accordance with AWWA C600 and the applicable manufacturer's installation instructions.

306-8.2.2 Installation.

306-8.2.2.1 Push-On Joints. Push-on joints shall be assembled in accordance with AWWA C600 and the following:

a) On long radius curves, trenches shall be excavated wider than shown in Table 306-3.4 (B) to allow for straight-line assembly before deflection.

b) Cutting and machining shall conform to the manufacturer's installation and warranty requirements. Pipe shall not be cut with a cold chisel, standard iron pipe cutter, or any other method that may fracture the pipe or produce ragged, uneven edges.

c) Gasket recess and bell sockets of pipe or fittings and plain ends of mating pipe shall be cleaned. Joints shall be dirt-free.

d) Plain ends, sockets, and gasket shall be lubricated using soapy water or an approved pipe lubricant conforming to AWWA C600. Lubrication for spigot ends and instructions for lubricant use shall be supplied by the pipe manufacturer.

e) An elastomeric gasket ring shall be inserted into the gasket recess and be completely seated.

f) Spigot and bell ends shall slide together without displacement of elastomeric gasket.

g) The pipe shall be installed with the bell end facing in the direction of laying unless otherwise approved by the Engineer.

h) The spigot shall be inserted into the bell and forced slowly into position, using a large bar lever and wood block across the pipe end. For large pipe, a come-along (with padding that will not scratch the pipe) may be used.

i) After assembling the pipe in a straight line, horizontal or vertical deflections shall be made at the joints to conform with the alignment shown on Plans.

Push-on restrained joints shall incorporate flex-ring, split-ring or ring segments and shall be installed in accordance with the manufacturer's installation instructions for the joint design used.

Allowable push-on joint deflections shall not exceed the following:

TABLE 306-8.2.2.1

Pipe Nominal Diameter	Allowable Push-on-Joint Deflection	Allowable Restrained Joint Deflection
3-inch through 4-inch (75 to 100 mm)	4.0°	n/a
6-inch through 12-inch (150 to 300 mm)	4.0°	3.2°
14-inch (350 mm) and larger	2.4°	1.6°

1. The values shown in Table 306-8.2.2.1 are based on 80 percent of that recommended by AWWA M41 Table 11-4 and 11-5 in accordance with paragraph 4.3.4.4 of AWWA C600.

306-8.2.2.2 Mechanical Joints. Mechanical joints shall be assembled in accordance with AWWA C600, and the following:

a) On long radius curves, trenches shall be excavated wider than shown in Table 306-3.4 (B) to allow for straight-line assembly before deflection.

b) Pipe cutting and machining shall conform to the manufacturer's installation and warranty requirements. Pipe shall not be cut with a cold chisel, standard iron pipe cutter, or any other method that may fracture the pipe or produce ragged, uneven edges.

c) Plain ends, sockets, and gaskets shall be lubricated using soapy water or an approved pipe lubricant as recommended in AWWA C600. Lubrication for spigot ends and instruction for lubricant use shall be supplied by pipe manufacturer.

d) An elastomeric gasket ring shall be inserted into the gasket recess and completely seated.

e) Spigot and bell ends shall slide together without displacement of the elastomeric gasket.

f) Joints shall be dirt free.

g) The pipe shall be installed with the bell end facing in the direction of laying unless otherwise approved by the Engineer.

h) The spigot end shall be inserted into the bell and forced slowly into position using a large bar lever and wood block across the pipe end. For large pipe, a come-along (with padding that will not scratch the pipe) may be used.

i) The gland shall be pushed toward the socket and centered around the pipe with the gland lip against the gasket.

j) Bolts shall then be inserted and nuts hand-tightened.

k) After assembling the pipe in a straight line, horizontal or vertical deflections shall be made at the joints to conform with the alignment shown on the Plans.

Allowable joint deflections for mechanical joints shall not exceed the following:

TABLE 306-8.2.2.2

Pipe Nominal Diameter	Allowable Mechanical Joint Deflection	Allowable Restrained Joint Deflection
3-inch through 4-inch (75 to 100 mm)	6.6°	n/a
6-inch (150 mm)	5.7°	3.2°
8-inch through 12-inch (200 to 300 mm)	4.3°	3.2°
14-inch through 16-inch (350 to 400 mm)	2.9°	1.6°
18-inch through 20-inch (450 to 500 mm)	2.4°	1.6°
24-inch (600 mm)	1.8°	1.6°
30-inch through 64-inch (750 to 1600 mm)	n/a	1.6°

1. The values shown in Table 306-8.2.2.2 are based on 80% of that recommended by AWWA M41 Table 11-4 and 11-5 in accordance with paragraph 4.3.4.4 of AWWA C600.

After the joints are deflected, bolts shall be tightened to within the normal range of bolt torque recommended by the manufacturer or AWWA M41 Table 11-3.

306-8.2.2.3 Installation of Polyethylene (PE) Film Wrap on Iron Fittings. PE film wrap (film) shall be installed on ductile iron and cast iron fittings and pipe in accordance with AWWA C105 and the following:

a) Film shall be wrapped snugly around all exterior ferrous surfaces and 8 inches (200 mm) beyond bells, overlapping at least 2 inches (50 mm) at each seam.

b) Pipe shall be completely encased to prevent contact between the pipe and surrounding soil. Soil or bedding material shall be prevented from becoming trapped between the pipe and film.

c) Film shall not be installed on pipe sections or fittings to be installed through concrete slope anchors.

d) Film wrap shall be secured in place using 2-inch (50 mm)-wide plastic tape.

e) At least 3 circumferential turns of plastic tape shall seal the film wrap ends over the pipe and above valve bonnets.

f) Place circumferential wraps of tape at 3-foot (1 m) intervals along the pipe barrel to minimize the space between the film and the pipe.

g) Cuts, tears, punctures or damage to the film shall be repaired with adhesive tape or with a short length of polyethylene tube cut open, wrapped around the pipe, and secured in place.

In addition to wrapping ductile iron pipe with polyethylene, service lines of dissimilar metals and the attendant corporation stop shall be wrapped with polyethylene film or an approved dielectric tape for a minimum clear distance of 3 feet (1 m) from the main.

306-8.2.3 Acceptance. Ductile iron pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-8.2.3

Item	Test For	Test Standard
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	209-1
Installed DIP	Alignment Deviation	As specified in the Special Provisions but not more than 1-foot (300 mm) horizontal, 0.25 foot (75 mm) vertical, or 0.1 foot (30 mm) vertical variation over 10 feet (3 m) of pipe having the same slope
	Hydrostatic Pressure Test	306-8.9.2.2
	Bacteriological Sampling and Testing	306-8.9.4.6
	11-Month Anniversary Warranty Inspection	306-8.9.6

306-8.3 Steel Pipe.

306-8.3.1 General. Steel pipe shall be assembled in accordance with AWWA C604 and the applicable manufacturer's installation instructions.

306-8.3.2 Installation.

306-8.3.2.1 Welded Steel Pipe Joints. The Contractor shall submit welder qualification certificates for all personnel welding steel pressure pipe under the standard qualification procedure of the ASME Boiler and Pressure Vessel Code Section IX, "Welding Qualifications."

306-8.3.2.2 Welded Joints. Welded joints shall be constructed in accordance with AWWA C206, and the following:

a) Welders assigned to the Work shall be qualified under the AWS standard qualification procedure.

b) Joints to be welded shall be cleaned prior to placing pipe in the trench. Loose scale, heavy rust, paint, cement, and grease shall be removed. At least a 1/2 inch (12.5 mm) recess shall be provided between adjacent mortar-covered surfaces to place the weld.

c) After the pipe is in its final position, lap-welded slip joints or butt-welded joints shall be completed in accordance with the Plans.

d) During hand welding, metal shall be deposited in successive layers.

e) The minimum number of passes or beads in completed welds shall be as follows:

TABLE 306-8.3.2.2

Steel Cylinder Thickness	Fillet Weld Minimum Number of Passes
Smaller than 3/16 inch (5 mm)	1
3/16 inch through 1/4 inch (5 to 6 mm)	2
Greater than 1/4 inch (6 mm)	1 pass for each 1/8 inch (3 mm) of cylinder or fraction thereof.

f) After welding, surfaces of welds shall be cleaned, removing all dirt, scale, or welding flux.

g) For cement-mortar-lined and coated pipe, the interior surface of welded pipe shall be coated with cement mortar. Excess mortar shall be swabbed out.

h) For steel pipe with other lining systems, the interior surface shall be coated in accordance with the manufacturer's recommendations to obtain a lining of similar thickness and life to factory-applied lining.

306-8.3.2.3 Butt-Strap Closure Joints. Butt-strap closure joints shall be constructed in the trench after the pipe has been laid to the alignment and grade shown on Plans. Butt strap closure joints shall conform to the following:

a) Butt-strap closure joints shall be field-welded by full-circumferential fillet welds, or one edge may be shop welded and the other field welded. Welding shall conform to 306-8.3.2.2.

b) The joint exterior shall be coated with mortar to a minimum thickness of 1-1/2 inches (38 mm). Immediately prior to applying mortar to interior or exterior of joints, cement wash shall be applied to the metal to be coated.

c) The joint interior shall be filled with stiff cement mortar and finished smoothly with the inside of the pipe wall. Wire mesh, 2-inch (50 mm) x 4-inch (100 mm), No. 13 gauge (1.828 mm), clean, and free from rust, shall be applied to joint interiors so that the wires run circumferentially around the pipe on 2-inch (50 mm) spacing. Wires on 4-inch (100 mm) spacing shall be crimped in such manner to hold the mesh 3/8 inch (9.5 mm) from the metal joint surface. Mesh shall be lapped at least 8 inches (200 mm), and the wire held securely in position.

306-8.3.3 Acceptance. Steel pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-8.3.3

Item	Test For	Test Standard
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	209-2
Installed Steel Pipe and Fittings	Alignment Deviation	As specified in the Special Provisions but not more than 1-foot (300 mm) horizontal, 0.25 foot (75 mm) vertical, or 0.1 foot (30 mm) vertical variation over 10 feet (3 m) of pipe having the same slope
	Joint Offset Tolerances	306-1.2.2
	Hydrostatic Pressure Test	306-8.8.2.2
	Bacteriological Sampling and Testing	306-8.9.4.6
	Field Performance	Demonstrate compliance to Contract Documents and Manufacturer's printed literature
	11-Month Anniversary Warranty Inspection	306-8.9.6

306-8.4 Concrete Pressure Pipe.

306-8.4.1 General. Concrete pressure pipe shall be assembled in accordance with AWWA M9 Chapter 14 and the applicable manufacturer's installation instructions.

306-8.4.2 Installation. Push-on joints shall be assembled in accordance with AWWA M9 Chapter 14 and the following:

a) Pipe shall be supported free of bedding or foundation material during jointing.

b) Pipe shall not be driven to grade by striking with an excavator bucket or other equipment.

c) The bell and spigot shall be cleaned and free of dirt and mud. A thin layer of NSF60-compliant lubricant shall be applied to the bell face, the gasket recess of the spigot, and the gasket.

d) The elastomeric gasket stretch around the joint circumference shall be equalized by inserting a round rod under the gasket once it is placed in the spigot gasket recess and moving the rod around the full pipe circumference.

e) Upon completion, a steel feeler gauge 0.5 inch (12.5 mm) wide and 0.010 inch (250 µm) thick shall be inserted into the joint to determine by feel if the gasket is properly seated in the gasket recess. The full circumference of the gasket shall be checked..

f) A come-along, backhoe, or power winch shall be used to pull the pipe into the proper position by applying pressure to a wire-rope choker used to lay pipe. The pipe spigot shall be installed into the bell using a straight axial force to ensure proper gasket installation. The pipe shall not be tipped during insertion.

g) If interior protective coatings have not been pre-applied to the interior metal, exposed metal surfaces shall be cleaned and pipe joint interiors shall be coated with NSF 61-compliant Portland cement mortar consisting of no more than 3 parts sand to one part cement.

h) The full circumference of exterior joint space shall be grouted with a band of grout consisting of no more than 3 parts sand to one part cement. The grout band shall be filled from one side only. Grout shall be routed or agitated to ensure no voids are present, then routed or agitated along

both sides of the pipe alternately to settle the grout. The grout shall be allowed to stiffen for 15 minutes. More grout shall then be added to fill the joint completely. The top of the grout band shall be capped to protect the grout from backfill. The grout band shall not be removed from the joint.

i) The grout shall be allowed to fully harden before placing any bedding or backfill above the pipe bottom.

306-8.4.3 Acceptance. Concrete pressure pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-8.4.3

Item	Test For	Test Standard Reference
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	209-3
Installed Concrete Pressure Pipe and Fittings	Alignment Deviation	As specified in the Special Provisions but not more than 1-foot (300 mm) horizontal, 0.25 foot (75 mm) vertical, or 0.1 foot (30 mm) vertical variation over 10 feet (3 m) of pipe having the same slope
	Joint Offset Tolerances	306-1.2.2
	Hydrostatic Pressure Test	306-8.9.2.2
	Bacteriological Sampling and Testing	306-8.9.4.6
	11-Month Anniversary Warranty Inspection	306-8.9.6

306-8.5 PVC Pressure Pipe.

306-8.5.1 General. PVC pressure pipe shall be assembled in accordance with AWWA C605 and the applicable manufacturer's installation instructions.

306-8.5.2 Installation.

306-8.5.2.1 Push-on Joints. Push-on joints shall be assembled in accordance with AWWA C605 and the following:

a) Spigots and bells shall slide together without displacement of the elastomeric gasket. Joints shall be dirt-free. Pipe shall be installed with the bell facing in the direction of laying unless otherwise approved by the Engineer.

b) The full circumference of the spigot end, including beveled ends, shall be lubricated using an NSF 61-compliant lubricant supplied by the pipe manufacturer. If dirt or sand adhere to the lubricant, the spigot shall be cleaned and re-lubricated.

c) An elastomeric gasket ring shall be inserted and completely seated into the gasket recess. The lubrication for the spigot and instructions for lubricant use shall be supplied by the pipe manufacturer.

d) The spigot shall be inserted into the bell and forced slowly into position using a large bar lever and wood block across the pipe end. For large pipe, a come-along (with padding that will not scratch the pipe) may be used.

e) If undue resistance to spigot insertion is encountered or a reference mark does not reach the flush position, the joint shall be disassembled and the position of the elastomeric gasket checked. If twisted or dislodged, the gasket, bell, and spigot shall be cleaned and re-assembled. If the gasket is not out of position, the distance between the reference mark and the spigot end shall be measured and checked against the correct values provided by the pipe manufacturer.

f) Allowable joint deflections shall not exceed the following:

TABLE 306-8.5.2.1

Pipe Nominal Diameter	Allowable Push-on-Joint Deflection	Allowable Joint Deflection with High Deflection Coupling	Allowable Bending for 20-Foot Length
4" (100 mm)	2.0°	4.0°	Longitudinal bending not permitted
6" (150 mm)	2.0°	4.0°	
8"-10" (200 mm-250 mm)	2.0°	4.0°	
12" (300 mm)	1.7°	4.0°	
14"-24" (350 mm-600 mm)	0.8°	4.0°	

1. The values shown in Table 306-8.5.2.1 are based on 80% of that recommended by AWWA M23 Table 13 or the coupling manufacturer. In no case shall deflection exceed 2 degrees in any direction without the use of high-deflection couplings.

306-8.5.3 Acceptance. PVC pressure pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-8.5.3

Item	Test For	Test Standard
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	209-4
Installed PVC Pressure Pipe	Alignment Deviation	As specified in the Special Provisions but not more than 1 foot (300 mm) horizontal, 0.25 foot (75 mm) vertical, or 0.1 foot (30 mm) vertical variation over 10 feet (3 m) of pipe having the same slope
	Hydrostatic Pressure Test	306-8.8.2.2
	Bacteriological Sampling and Testing	306-8.9.4.6
	11-Month Anniversary Warranty Inspection	306-8.9.6

306-8.6 High-Density Polyethylene (HDPE) Pressure Pipe.

306-8.6.1 General. HDPE pressure pipe shall be assembled in accordance with AWWA M55 Chapter 8 and the applicable manufacturer's installation instructions.

306-8.6.2 Installation. Butt fusion joints shall be assembled in accordance with AWWA M55 and the following:

a) Pipe sections shall be joined above-ground and at the Work site into continuous water-tight leak-proof lengths. Pipe sections shall be joined in true alignment using equipment and methods which conform to the manufacturer's recommendations.

b) Plain end pipes may be joined using either butt fusion or saddle fusion, and with either heat fusion or electrofusion.

c) Butt fusion shall conform to ASTM D2657, PPI TR33 and AWWA M55.

d) Electrofusion shall conform to ASTM F1290 and AWWA M55.

e) Saddle fusion shall conform to ASTM D2657, ASTM F905, PPI TR41 and AWWA M55.

f) Hot fusion joining of HDPE end sections, service, taps, and fittings may be performed in excavations.

g) Plain end pipes and fittings shall be joined by butt fusion conforming to ASTM D2657.

h) Branch connections to main shall be made with saddle fittings or tees. Main and saddle branch fittings shall be joined using saddle fusion procedures conforming to ASTM F905.

i) Fusions of unlike wall thicknesses are acceptable as long as the difference is limited to one SDR difference. Transitions between unlike wall thicknesses greater than one SDR shall be made with a transition nipple (a short length of heavier-wall pipe with one end machined to the lighter-wall) or by mechanical means.

j) Pressure shall not be removed until the joint has adequately cooled.

k) Rollback beads will result from the use of proper temperatures and pressures. External and internal beads from butt welding shall not be removed.

l) Joints shall be equal in tensile strength to that of the adjacent pipe.

m) HDPE pipe and fittings may be joined together or joined to other materials using electro-fusion, flanged connections, or mechanical couplings designed for joining HDPE pipe to mating material only when heat-fusion joining is not practical as determined by the Engineer. When joining pipe by any of the aforementioned methods, the installation instructions of the joining device manufacturer shall be followed.

n) Flange faces shall be centered and aligned to each other before assembling and tightening bolts. Flange bolts shall not be used to draw flanges into alignment. Bolt threads shall be lubricated and flat washers shall be installed under flange nuts. Bolts shall be tightened evenly according to the tightening pattern and torque step recommendations. At least 1 hour after the initial assembly, flange connections shall be retightened, following the manufacturer's tightening pattern and torque step recommendations. Final tightening torque shall be 100 foot-pounds (136 N-m) or as recommended by the manufacturer.

o) Mechanical joints using outside diameter compression mechanical couplings shall be installed with the stiffener in the bore of the HDPE pipe.

p) Plain ends of 16-inch (400 mm) iron pipe size (IPS) and larger fabricated fittings shall be butt-fused to the end of the pipe length. Flanged directional outlet connections to fittings shall be constructed in the trench. Flanged connections shall be assembled and tightened in accordance with the flange adapter manufacturer's instructions. No more than one pipe length shall be connected to a 16-inch (400 mm) IPS or larger directional fitting before placing the fitting in the trench.

q) Threaded or solvent-cement joints and connections will not be allowed.

r) Allowable pipe deflections shall not exceed the following:

TABLE 306-8.6.2

Nominal Pipe OD	Minimum Cold-Bending Radius and Maximum Deflection per Foot (m) of Pipe Length				
	DR ≤ 9	9 < DR ≤ 13.5	13.5 < DR ≤ 21	DR > 21	Adjacent to Fitting or Flange
<3" (75 mm)	6.3' – 9.2°/LF (1.92 m – 30.2°)	7.8' – 7.3°/LF (2.38 m – 24.0°)	8.4' – 6.8°/LF (2.56 m – 22.3°)	9.4' – 6.1°/LF (2.87 m – 20.0°)	31.3' – 1.83°/LF (9.54 m – 6.00°)
3" (75 mm)	6.3' – 9.2°/ LF (1.92 m – 30.2°)	7.8' – 7.3°/LF (2.38 m – 24.0°)	8.4' – 6.8°/LF (2.56 m – 22.3°)	9.4' – 6.1°/LF (2.87 m – 20.0°)	31.3' – 1.83°/LF (9.54 m – 6.00°)
4" (100 mm)	8.3' – 6.9°/ LF (2.53 m – 22.6°)	10.4' – 5.5°/ LF (3.17 m – 18.0°)	11.3' – 5.1°/ LF (3.44 m – 16.7°)	12.5' – 4.6°/ LF (3.81 m – 15.1°)	41.7' – 1.38°/ LF (12.7 m – 4.53°)
6" (150 mm)	12.5' – 4.6°/ LF (3.81 m – 15.1°)	15.6' – 3.7°/ LF (4.75 m – 12.1°)	16.9' – 3.4°/ LF (5.15 m – 11.2°)	18.8' – 3.1°/ LF (5.73 m – 10.2°)	62.5' – 0.92°/ LF (19.0 m – 3.02°)
8" (200 mm)	16.7' – 3.4°/LF (5.09 m – 11.2°)	20.8' – 2.8°/LF (6.34 m – 9.19°)	22.5' – 2.6°/LF (6.86 m – 8.53°)	25.0' – 2.3°/LF (7.62 m – 7.55°)	83.3' – 0.70°/LF (25.4 m – 2.30°)
10" (250 mm)	20.8' – 2.8°/LF (6.34 m – 9.19°)	26.0' – 2.2°/LF (7.92 m – 7.22°)	28.1' – 2.04°/LF (8.56 m – 6.69°)	31.3' – 1.83°/LF (9.54 m – 6.00°)	104.2' – 0.60°/LF (31.76 m – 1.97°)
12" (300 mm)	25.0' – 2.3°/LF (7.62 m – 7.55°)	31.3' – 1.83°/LF (9.54 m – 6.00°)	33.8' – 1.70°/LF (10.3 m – 5.58°)	37.5' – 1.53°/LF (11.4 m – 5.02°)	125.0' – 0.46°/LF (38.1 m – 1.51°)
14" (350 mm)	29.2' – 1.96°/LF (8.90 m – 6.43°)	36.5' – 1.57°/LF (11.13 m – 5.15°)	39.4' – 1.46°/LF (12.01 m – 4.79°)	43.8' – 1.31°/LF (13.35 m – 4.30°)	145.8' – 0.39°/LF (44.44 m – 1.28°)
16" (400 mm)	33.3' – 1.72°/LF (10.15 m – 5.64°)	41.7' – 1.38°/LF (12.71 m – 4.53°)	45.0' – 1.27°/LF (13.72 m – 4.17°)	50.0' – 1.15°/LF (15.24 m – 3.77°)	166.7' – 0.34°/LF (50.81 m – 1.12°)
18" (450 mm)	37.5' – 1.53°/LF (11.43 m – 5.02°)	46.9' – 1.22°/LF (14.30 m – 4.00°)	50.6' – 1.13°/LF (14.42 m – 3.71°)	56.3' – 1.02°/LF (17.16 m – 3.35°)	187.5' – 0.31°/LF (57.15 m – 1.02°)
20" (500 mm)	41.7' – 1.38°/LF (12.71 m – 4.53°)	52.1' – 1.10°/LF (15.88 m – 3.61°)	56.3' – 1.02°/LF (17.16 m – 3.35°)	62.5' – 0.92°/LF (19.05 m – 3.02°)	208.3' – 0.28°/LF (63.49 m – 0.92°)
22" (550 mm)	45.8' – 1.25°/LF (13.96 m – 4.10°)	57.3' – 1.00°/LF (17.47 m – 3.28°)	61.9' – 0.93°/LF (18.87 m – 3.05°)	68.8' – 0.83°/LF (20.97 m – 2.72°)	229.2' – 0.25°/LF (69.86 m – 0.82°)
24" (600 mm)	50.0' – 1.15°/LF (15.24 m – 3.77°)	62.5' – 0.92°/LF (19.05 m – 3.02°)	67.5' – 0.85°/LF (20.57 m – 2.79°)	75.0' – 0.76°/LF (22.86 m – 2.49°)	250.0' – 0.23°/LF (76.20 m – 0.75°)
30" (750 mm)	62.5' – 0.92°/LF (19.05 m – 3.02°)	78.1' – 0.73°/LF (23.80 m – 2.40°)	84.4' – 0.68°/LF (25.73 m – 2.23°)	93.8' – 0.61°/LF (28.59 m – 2.00°)	312.5' – 0.18°/LF (95.25 m – 0.59°)
36" (900 mm)	75.0' – 0.76°/LF (22.86 m – 2.49°)	93.8' – 0.61°/LF (28.59 m – 2.00°)	101.3' – 0.57°/LF (30.88 m – 1.87°)	112.5' – 0.51°/LF (34.29 m – 1.67°)	375.0' – 0.15°/LF (114.3 mm – 0.49°)
42" (1050 mm)	87.5' – 0.65°/LF (26.67 m – 2.13°)	109.4' – 0.52°/LF (33.35 m – 1.71°)	118.1' – 0.49°/LF (36.00 m – 1.61°)	131.3' – 0.44°/LF (40.02 m – 1.44°)	437.5' – 0.13°/LF (113.4 m – 0.43°)
48" (1200 mm)	100.0' – 0.57°/LF (30.48 m – 1.87°)	125.0' – 0.46°/LF (38.10 m – 1.51°)	135.0' – 0.42°/LF (41.15 m – 1.38°)	150.0' – 0.38°/LF (45.72 m – 1.25°)	500.0' – 0.11°/LF (152.4 m – 0.36°)
54" (1350 mm)	112.5' – 0.51°/LF (34.29 m – 1.67°)	140.6' – 0.41°/LF (42.85 m – 1.35°)	151.9' – 0.38°/LF (46.30 m – 1.25°)	168.8' – 0.34°/LF (51.45 m – 1.12°)	562.5' – 0.10°/LF (171.5 m – 0.33°)
63" (1575 mm)	131.3' – 0.44°/LF (40.0 m – 0.44°)	164.1' – 0.35°/LF (50.0 m – 1.15°)	177.2' – 0.32°/LF (54.0 m – 1.05°)	196.9' – 0.29°/LF (60.0 m – 0.95°)	656.3' – 0.09°/LF (200.0 m – 0.30°)

1. The values shown in Table 306-8.6.2 are based on 125% of that recommended by AWWA M55 Table 8-2.

306-8.6.3 Acceptance. HDPE pressure pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-8.6.3

Item	Test For	Test Standard
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	209-5
Butt-Fusion or Saddle-Fusion Integrity	Bent-Strap Test	After fully cooling first trial fusion, cut fusion test straps at least 12" (300 mm) and at least 30 wall thicknesses long and at least 1" (25 mm) and at least 1.5 wall thicknesses wide. Fusion shall be in center of length. Bend test strap until ends of strap touch. If fusion fails at joint, a new trial fusion shall be made, cooled and tested. Do not begin butt fusion of pipe to be installed until trial fusion has passed bent strap test.
Installed HDPE Pressure Pipe	Alignment Deviation	As specified in the Special Provisions but not more than 1 foot (300 mm) horizontal, 0.25 foot (75 mm) vertical, or 0.1 foot (30 mm) vertical variation over 10 feet (3 m) of pipe having the same slope
	Mandrel Test	Pull mandrel through installed pipe to test for obstructions or pipe deformation beyond that specified below. Correct all obstructions in pipe at locations encountered by mandrel
	Hydrostatic Pressure Test	306-8.8.2.2
	Bacteriological Sampling and Testing	306-8.9.4.6
	11-Month Anniversary Warranty Inspection	306-8.9.6

306-8.7 Fiberglass Pressure Pipe.

306-8.7.1 General. Fiberglass pressure pipe shall be assembled in accordance with AWWA M45 Chapter 6 and the manufacturer's installation instructions.

306-8.7.2 Installation.

306-8.7.2.1 Push-On Joints. Push-on joints shall be assembled in accordance with AWWA C605 and the following:

a) Spigots and bells shall slide together without displacement of the elastomeric gasket. Joints shall be dirt-free. Pipe shall be installed with the bell facing in the direction of laying unless otherwise approved by the Engineer.

b) Joint lubricant shall be applied to the pipe ends and elastomeric seals of couplings. Only lubricants approved by the pipe manufacturer shall be used.

c) Pipes shall be pushed together using suitable hydraulic jacks. The maximum forces recommended by the pipe manufacturer shall not be exceeded.

d) Joints shall not be deflected during assembly. Pipes or fittings shall be joined in straight alignment then deflected to the required angle at deflection points.

e) Allowable joint deflections for push-on joints shall not exceed the following:

TABLE 306-8.7.2.1

Pipe Nominal Diameter	Allowable Push-on-Joint Deflection Push on Joint Pressure Class 200 or Less	Allowable Push-on-Joint Deflection Push on Joint Pressure Class 250
3"-18" (75 mm-450 mm)	2.4°	2.0°
20"-30" (500 mm-760 mm)	1.6°	1.2°
36"-64" (900 mm-1600 mm)	0.8°	0.64°

1. The values shown above are based on 80% of that recommended by AWWA M45 or the manufacturer.

f) Connection of fiberglass pressure pipe to manways, fittings, and transitions to other pipe materials shall be water-tight.

306-8.7.3 Acceptance. Fiberglass pressure pipe shall successfully pass the following tests prior to completion of the Work:

TABLE 306-8.7.3

Item	Test For	Test Standard
Bedding and Backfill	Suitability for Use as Backfill	217
	Compaction	ASTM D1557
Pipe Material	Materials Inspection	209-6
Installed Fiberglass Pressure Pipe	Alignment Deviation	As specified in the Special Provisions but not more than 1 foot (300 mm) horizontal or 0.25 foot (75 mm) vertical
	Hydrostatic Pressure Test	306-8.9.2.2
	Bacteriological Sampling and Testing	306-8.9.4.6
	11-Month Warranty Inspection	306-8.9.6

306-8.8 Valves, Hydrants, and Appurtenances.

306-8.8.1 General. Valves, hydrants, and appurtenances shall be constructed in accordance with the Plans and submitted Reference Specifications.

306-8.8.2 Installation.

306-8.8.2.1 General. Valves, hydrants, and appurtenances shall be installed in accordance with the manufacturer's installation instructions. Conflicts between the Plans and submitted Reference Specifications and the manufacturer's installation instructions shall be submitted to the Engineer for resolution.

306-8.8.2.2 Flanged Joints. Flanged joints shall be assembled as follows:

a) Flange surfaces shall be cleaned to mate with the gasket. Loose dirt, scale and laitance shall be removed.

b) Pits, corrosion, dents or scratches which may interfere with proper sealing shall be repaired.

c) The gasket shall be inspected and verified to be of proper material and style, free of defects or damage.

d) Flange bolts and studs shall be inspected for proper material, size, threading, and length.

e) Bolt threads and nut contact surfaces shall be cleaned and lubricated using a lubricant chemically compatible with all of the materials it will be in contact with.

f) The gasket shall be centered on the flange.

g) The mating flange bolt holes shall be aligned. Mating flange faces shall be flush against the gasket prior to bolt-up.

h) Bolts, nuts and washers shall be inserted and hand-tightened until snug.

i) Before tightening bolts beyond hand-tight, adjacent valves shall be operated through their full range of motion to ensure clear unobstructed operation of discs and other internal parts.

j) Bolts shall be tightened in 5-foot-pound (7 N-m) increments following a 180-degree opposing sequence. Tightening shall begin with the bolt nearest the "12-o'clock" position, then proceed to the opposing bolt nearest the "6-o'clock" position, then to the "3-o'clock" and "9-o'clock" positions, and continue in a similar alternating sequence until all bolts are tight.

k) Re-tighten bolts 24 hours after installation and pressure testing to compensate for any gasket relaxation.

l) Flange bolt torques shall be as recommended by the valve, appurtenance, or pipe manufacturer.

306-8.8.3 Thrust Blocks. Where pipe is not restrained, thrust blocks shall be constructed as follows:

a) Thrust blocks shall be constructed of concrete conforming to 201-1.

b) Concrete thrust blocks shall be constructed in accordance with 303 and as shown on the Plans.

c) Concrete blocks shall be constructed between undisturbed ground and fittings to be anchored.

d) The quantity of concrete and the bearing area of the pipe against undisturbed soil shall be as shown on the Plans or Standard Plans.

e) Unless otherwise shown, concrete shall be placed so pipe joints and fittings remain accessible to repairs.

306-8.8.4 Service Connections. Service connections shall be constructed as shown on the Plans. The minimum service connection size shall be 3/4 inch (19 mm). Where mains are laid in paved streets, service connections 2 inches (50 mm) and smaller shall be installed by boring unless otherwise approved by the Engineer.

Service laterals shall be placed under curbs and gutters by boring. The letter "W" shall be inscribed in the center of the curb face in line with each meter installation. The "W" shall be approximately 1-1/2 inches (38 mm) high and 1/16 inch (1.5 mm) deep. No kinks, flats, crushes or other reductions in the diameter of service laterals will be permitted.

306-8.8.5 Acceptance. Acceptance testing for valves and appurtenances shall conform to 306-8.9.3. Valves and appurtenances shall be pressure tested at the same time connecting pipelines are pressure tested. Valves, operators, or control and instrumentation elements whose pressure rating is less than the test pressure shall be protected or isolated during pressure testing.

306-8.9 Pipeline Pressure Testing, Disinfection, and Commissioning.

306-8.9.1 General. Pressure pipelines shall be pressure tested, disinfected, and commissioned in accordance with the requirements of this subsection.

306-8.9.2 Hydrostatic Pressure Test.

306-8.9.2.1 General. A minimum 4-hour hydrostatic pressure test shall be performed and successfully completed in accordance with AWWA C600 or C605 and the following.

306-8.9.2.2 Preparation. The Contractor shall apply test pressures at an approved outlet or fitting located within 5 feet (1.5 m) vertically of the lowest point of each pipe section to be tested. The Contractor shall provide and later securely plug such fittings. Where air valves or other suitable outlets

are unavailable, the Contractor shall provide approved taps and fittings for air release, and securely plug these later.

The Contractor shall flush all mains and services with potable water (or water as otherwise approved by the Engineer and jurisdictional regulatory agencies) after the completion of construction. A sufficient number of suitable outlets at the end(s) of line(s) being flushed shall be provided in addition to those shown on the Plans to permit flushing of mains with water at a velocity of at least 2.5 feet per second (750 mm/s) over its entire length. Outlets provided shall meet the requirements for the fittings specified for the type of main constructed. Velocity through outlets and fittings shall not exceed 25 feet per second (750 m/s) during flushing. Drainage facilities shall be constructed as necessary to ensure water lines do not become contaminated during flushing.

The Contractor shall provide sufficient hoses, fittings and equipment to direct flushing water to an established point of discharge. The discharge point shall be an improved drainage structure capable of accepting the flow without damaging existing improvements or creating a public hazard. The Contractor shall also provide dechlorination of the flushing water chlorine residual as required to meet applicable NPDES permit requirements. Flushing in or adjacent to public streets shall be scheduled during periods of low traffic volume. Traffic control during flushing and discharge of flushing water onto traffic lanes shall be as specified in the Special Provisions.

Unless otherwise specified, the Contractor shall make the arrangements for, and provide the water for, flushing and its subsequent discharge.

306-8.9.2.3 Allowable Leakage. Allowable leakage shall be determined as follows:

No ductile iron or PVC pipe installation will be accepted if leakage exceeds that determined by the following formula (taken from AWWA C600 or AWWA C605):

$$L_{US} = SD(P)^{1/2}/148{,}000$$

in which L = allowable leakage, in gallons per hour

S = length of pipe tested, in feet

D = nominal diameter of pipe, in inches

P = average observed test pressure of the pipe being tested, as shown, in pounds per square inch gauge, based on the elevation of the lowest point in the line or section under test and corrected to the elevation of the test gauge.

$$(L_{SI} = SD(P)^{1/2}/794{,}800)$$

(L_{SI} in liters per hour, S in meters, D in millimeters, P in kilopascals)

No gasketed steel pipe installation will be accepted if leakage exceeds that determined by the following formula (taken from AWWA C604):

L_{US} = 10 gallons per inch-diameter per mile of pipe per 24 hours

L_{SI} = 0.93 liters per millimeter-diameter per kilometer of pipe per 24 hours

When testing against closed valves, an allowance of 0.0078 gallons per hour per inch of nominal valve size may be added to that computed using formulas above to account for leakage around seals.

For PVC, ductile iron, or gasketed steel pipe, allowable leakage shall be as shown in Table 306-8.9.2.3.

TABLE 306-8.9.2.3

Allowable Leakage in PVC OR Ductile Iron Pipe, Gallons per Hour per 1000' (Liters per Hour per 1,000 m) of Pipe					Allowable Leakage in Gasketed Steel Pipe, Gallons per Hour per 1000' (Liters per Hour per 1,000 m) of Pipe	Additional Allowable Leakage through Seals of Closed Valves, Gallons (Liters) per Valve
Pipe Diameter	Test Pressure					
	150 psi (1.0 MPa)	200 psi (1.4 MPa)	250 psi (1.7 MPa)	300 psi (2.1 MPa)	All Pressures	All Pressures
3" (75 mm)	0.25 (3.10)	0.29 (3.60)	0.32 (3.97)	0.35 (4.35)	0.24 (2.98)	0.02 (0.08)
4" (100 mm)	0.33 (4.10)	0.38 (4.72)	0.43 (5.34)	0.47 (5.84)	0.32 (3.97)	0.03 (0.11)
6" (150 mm)	0.50 (6.21)	0.57 (7.08)	0.64 (7.95)	0.70 (8.69)	0.47 (5.84)	0.05 (0.19)
8" (200 mm)	0.66 (8.20)	0.76 (9.44)	0.85 (10.6)	0.94 (11.7)	0.63 (7.82)	0.06 (0.23)
10" (250 mm)	0.83 (10.3)	0.96 (11.92)	1.07 (13.29)	1.17 (14.53)	0.79 (9.81)	0.08 (0.30)
12" (300 mm)	0.99 (12.30)	1.15 (14.28)	1.28 (15.90)	1.40 (17.39)	0.95 (11.80)	0.09 (0.34)
14" (350 mm)	1.16 (14.41)	1.34 (16.64)	1.50 (18.63)	1.64 (20.37)	1.10 (13.66)	0.11 (0.42)
16" (400 mm)	1.32 (16.39)	1.53 (19.00)	1.71 (21.24)	1.87 (23.22)	1.26 (15.65)	0.12 (0.45)
18" (450 mm)	1.49 (18.50)	1.72 (21.36)	1.92 (23.85)	2.11 (26.20)	1.42 (17.64)	0.14 (0.53)
20" (500 mm)	1.66 (20.62)	1.91 (23.72)	2.14 (26.58)	2.34 (29.06)	1.58 (19.62)	0.16 (0.61)
24" (600 mm)	1.99 (24.71)	2.29 (28.44)	2.56 (31.79)	2.81 (34.90)	1.89 (23.47)	0.19 (0.72)
30" (750 mm)	2.48 (30.80)	2.87 (35.64)	3.21 (39.87)	3.51 (43.59)	2.37 (29.43)	0.23 (0.87)
36" (900 mm)	2.98 (37.01)	3.44 (42.72)	3.85 (47.81)	4.21 (52.59)	2.84 (35.27)	0.28 (1.06)
42" (1050 mm)	3.48 (43.22)	4.01 (49.80)	4.49 (55.76)	4.92 (61.10)	3.31 (41.11)	0.33 (1.25)
48" (1200 mm)	3.97 (49.30)	4.59 (57.00)	5.13 (63.71)	5.62 (69.80)	3.79 (47.07)	0.37 (1.40)
54" (1350 mm)	4.47 (55.51)	5.16 (64.08)	5.77 (71.66)	6.32 (78.49)	4.26 (52.91)	0.42 (1.59)
60" (1500 mm)	4.97 (61.72)	5.73 (71.16)	6.41 (79.61)	7.02 (87.18)	4.73 (58.74)	0.47 (1.78)
64" (1600 mm)	5.30 (65.82)	6.12 (76.01)	6.84 (84.95)	7.49 (93.02)	5.05 (62.72)	0.50 (1.89)

For welded steel pipe, no leakage will be permitted.

For HDPE pipe, no leakage will be permitted.

306-8.9.2.4 Test Procedure. A 4-hour hydrostatic pressure test shall be performed in accordance with the following:

Pipe, appurtenances, and permanent thrust blocks shall be submitted to a hydrostatic pressure test after they have been installed and backfilled sufficiently, and after temporary plugs, caps, thrust blocks and shoring have been installed to provide the required restraint.

The test pressure shall be 50 pounds per square inch (350 kPa) in excess of the working pressure shown on the Plans for the class of pipe constructed unless the test pressure is specified elsewhere in the Contract Documents.

The Contractor shall conduct pressure tests or retests subsequent to any trench backfill compactive effort that is performed using compacting equipment having an overall weight in excess of 100 pounds (45 kg).

If butterfly valves or other pipeline appurtenances may have a maximum working water pressure less than test pressure, the Contractor shall apply a minimum back pressure on these closed devices equal to the difference between the test pressure and the rated pressure of the device.

The Contractor shall complete and pass the pressure test and disinfection tests specified in 306-8.9.4 prior to connecting any new line to the existing pipe and mains. Test of new mains shall be conducted with the new valves open, and the open ends of pipes, valves, and fittings suitably closed or blind-flanged. Valves shall be operated and checked prior to the test period.

The maximum length of pipe to be included in any one test shall not exceed 2,500 feet (760 m) or the distance between the valves, whichever is greater. Suitable test bulkheads, blocking, and fittings shall be installed as necessary to permit such sectionalizing.

The Contractor shall fill the pipeline slowly and maintain at operating pressure for at least 24 hours prior to testing to satisfy any system water absorption. While filling and immediately prior to testing, all air shall be expelled from the pipeline.

The Contractor shall then pressurize the pipeline to the specified test pressure following a 48-hour soak period. When the test pressure has been reached, pumping shall be discontinued until the line pressure has dropped 10 pounds per square inch (70 kPa), at which time the line pressure shall again be pumped up to the test pressure. This procedure shall be repeated until 4 hours have elapsed from the time the test pressure was first applied. At the end of this period, the pressure shall be pumped up to the test pressure one last time.

Leakage shall be computed as the total quantity of water pumped into the pipeline during the test period, including water added to reach the specified test pressure for the final time. Leakage shall not exceed the rate specified for the type of pipe tested.

The Contractor shall repeat the testing until the leakage does not exceed the specified leakage rate. The Contractor shall repair all visible leaks regardless of the amount of leakage.

All tests shall be completed in the presence of the Engineer who will record the results.

306-8.9.3 Testing of Valves and Appurtenances. Field testing of valves and appurtenances shall conform to the following:

TABLE 306-8.9.3

Item	Test for	Test Standard
Valves and Appurtenances	Installation and Leakage	Visual Inspection for drip-tight service under pressure for all joints and for all valves in closed position.
	Anchorage and Support of Exposed Pipe	Visual inspection of finished installation. support in accordance with California Plumbing Code Table 3-1 and 3-2
	Pressure Test	See 306-8.9.2.2
	Bacteriological Test	See 306-8.9.4.6
	Valve Actuators	Operate valve through 10 full cycles of opening and closing. Valve shall operate from full open to full close without sticking, or binding and without required operating torque exceeding 150 ft-lbs at any point
	Field Performance	Demonstrate compliance to Contract Documents, AWWA standards and manufacturer's printed literature
	11-Month Anniversary Warranty Inspection	306-8.9.6

306-8.9.4 Disinfection

306-8.9.4.1 General. Potable water facilities shall be disinfected in accordance with AWWA C651 and the following.

306-8.9.4.2 Submittals. The following submittals are required:

TABLE 306-8.9.4.2

Submittal	Description
Testing, Disinfection, Flushing and Dechlorinating Plan	If requested by the Engineer, submit a detailed plan showing how the pipeline will be tested, disinfected, and flushed, and how the discharge from the flushing operation will be dechlorinated.
Written Permission to Discharge into Sewer or Storm Drain	Required from the owner of any sanitary sewer or storm drain prior to the discharge of flushing water into sewer or storm drain. The submittal shall include any special requirements for treatment of flushing water prior to discharge, an estimate of the expected maximum discharge rate of the flushing flow, and an analysis of the sewer or storm drain capacity.
Laboratory Report for Disinfection Testing	Submit a report from the Engineer-accepted testing laboratory

306-8.9.4.3 Potable Water System Disinfection Procedures. Following flushing and pressure testing, disinfection shall proceed as follows:

Pipelines, valves, hydrants, service laterals, fittings, tanks and other surfaces exposed to water shall be disinfected in accordance with AWWA C651 except as otherwise specified herein.

The Contractor shall provide sampling locations in accordance with AWWA C651 and the California Department of Public Health Safe Drinking Water Systems regulations.

After flushing, piping for potable water service shall be disinfected with a chlorine compound solution made with liquid chlorine, calcium hypochlorite in solution, or a sodium hypochlorite solution, which shall be water mixed and introduced into the mains to produce a dosage of not less than 50 mg/l nor more than 100 mg/L in all sections of the pipeline and appurtenances.

Treated water shall be retained within the system for at least 24 hours and shall, at the end of the retention period, produce a chlorine residual of not less than 25 mg/L in all sections of the pipeline being disinfected.

If the tests are not satisfactory, the Contractor shall provide additional disinfection as required until all tests are passed.

During the disinfection process, valves, hydrants, and other accessories shall be operated.

The Contractor shall not allow chlorinated water to remain in contact with internal waterway ports of pumps, valves, and sensor line assemblies for longer than necessary.

After chlorination, the Contractor shall flush water from the pipeline at its extremities until replacement water tests are equal chemically and bacteriologically to those of the permanent source of supply. Flush water shall be dechlorinated in accordance with applicable NPDES permit requirements.

Placing of HTH capsules or powder in pipe sections during the laying process will not be considered adequate disinfection.

The Contractor shall keep adequate chlorine residual testing and indicating apparatus available on site during the entire disinfection period. After final flushing, the Contractor shall plug flushing fittings with devices intended for this purpose at the pressure class of the pipe.

Where the water main is coated for disinfection, plugs and outlets shall be similarly coated.

The Contractor shall keep and provide to the Engineer accurate documentation of the dosing rate (ppm), time of dosing and duration. The dosing agent's name, contact information and signature shall be provided.

306-8.9.4.4 Recycled Water System Disinfection Procedures. Disinfection of recycled water system components shall conform to 306-8.9.4.3, except calcium hypochlorite tablets or granules may be used to disinfect recycled water mains and services.

306-8.9.4.5 Dechlorination and Flushing. The Contractor shall dechlorinate and remove pollutants from water flushed from water mains in accordance with AWWA C655 and the discharge requirements and locations specified in the Special Provisions.

306-8.9.4.6 Bacteriological Sampling and Testing. On 2 consecutive days, the Contractor shall take bacteriological samples and submit them to a laboratory approved by the Engineer. Passing bacteriological tests on 2 consecutive days shall be achieved prior to connecting the pipeline to the existing water system or placing the pipeline into service. If the initial chlorination fails to produce 2 consecutive days of passing bacteriological tests, chlorination shall be repeated until 2 consecutive days of passing bacteriological tests are achieved. Samples of water for the specified bacteriologic test shall be taken from each end of the disinfected main (located downstream of the point of introduction of the chlorine disinfectant). For mains over 2,400 feet (730 m) in length, additional samples shall be taken at intermediate points in such a manner that at least one sample is taken for every 1,200 feet (365 m) of main.

If trench water has entered the new main during construction, or if, in the Engineer's opinion, excessive dirt or debris have entered the new main, bacteriological samples shall be taken at intervals of approximately 200 feet (60 m) to the extent such sampling is possible.

Satisfactory bacteriological results shall conform to all of the following:

a) No total or fecal coliform.
b) A heterotrophic plate count less than 500 colony forming units (CFU) per mL
c) Presence of chlorine residual.

306-8.9.4.7 Laboratory Report. The laboratory report shall be on a chain of custody, lab work sheet, or summary letter imprinted with the laboratory's name, address, and phone number. The report shall describe the field tests, laboratory analysis and results, and shall be signed by the laboratory director.

The laboratory report shall be submitted to the Engineer for approval.

The Engineer may reject the report if any data is missing or suspect due to conflicting indications.

306-8.9.5 Pipeline Commissioning. Pipelines passing disinfection bacteriological testing shall be placed into service within 4 weeks from the date of sampling, or shall be resampled and tested prior to being placed into service.

306-8.9.6 Eleven-Month Anniversary Warranty Inspection. A warranty inspection shall be conducted during the 11th month following completion of the Work.

The Engineer will establish the date for the warranty inspection and will notify the Contractor at least 30 Days in advance. If notification of the inspection date does not occur within 12 months after completion of the Work, the first anniversary inspection shall be considered to be waived.

The following occurrences will be considered to be system failures:

a) Locations found where trench resurfacing has settled below matching grade.

b) Locations found where coatings or paint have peeled, bubbled or cracked, or locations where rust is evident.

c) Locations found where furnished manufactured products show visible leakage.

d) Locations found where piping, valves, appurtenances, or other pipeline equipment fail to perform as specified in applicable AWWA standards and to the level of performance described in the Contract Documents and applicable submittals.

The Contractor shall remove failed trench resurfacing, coating, or painting work identified during the warranty inspection and replace or reconstruct in conformance with the original requirements of the Contract Documents unless otherwise directed by the Engineer. Repaired painted areas shall be re-tested using spark testing or other methods described in the Special Provisions. If the area of failure exceeds 25 percent of the total trench resurfacing area or 25 percent of the coated or painted surface area on any structure or surface, the Contractor shall remove and replace the entire trench resurfacing, coating or paint system in conformance with the original requirements of the Contract Documents.

The Contractor shall repair or replace piping and appurtenances showing visible leakage or failing to perform as specified in applicable AWWA standards and to the level of performance described in the Contract Documents and applicable submittals.

If repairs are required under the 11-month anniversary warranty inspection, the warranty period shall be extended to the date repairs are complete as determined by the Engineer.

306-9 CAST-IN-PLACE NON-REINFORCED CONCRETE PIPE (CIPCP).

306-9.1 General. These specifications are for cast-in-place non-reinforced concrete pipe intended to be used for gravity and low head drains and irrigation systems.

306-9.2 Materials. Concrete, unless otherwise specified in the Special Provisions, shall be Class 560-C-3250 (Class 330-C-23) conforming to 201-1 except that:

a) The slump shall be 1 inch (25 mm) minimum and 3 inches (75 mm) maximum. No water shall be added after the slump test material has been sampled,

b) Batch proportions shall be designed by the Contractor and submitted to the Engineer in accordance with 2-5.3.

306-9.3 Trench Excavation.

306-9.3.1 General. Trenches shall conform to the alignment and grades shown on the Plans. The subgrade shall be fine graded to the tolerances specified in 306-9.5.2.5.

The bottom of the trench shall be shaped to serve as the outside form of the pipe. The "trench form" shall be defined as the portion of the trench over the bottom 210 degrees of the pipe. The trench form shall provide full, firm, and uniform support for the pipe.

306-9.3.2 Trench Width. Except for curves and structures, the trench width shall not exceed the outside diameter of the pipe plus 2 inches (50 mm) for a height of 1 foot (0.3 m) above the top of the pipe.

306-9.3.3 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, the portion of the rock within 6 inches (150 mm) of the lower 90 degrees of the trench form shall be removed. The void shall be filled with monolithically placed concrete prior to construction of the pipe or backfilled with soil compacted to a minimum relative compaction of 90 percent. The method shall be approved by the Engineer.

306-9.3.4 Extensive Rock. Where extensive rock is encountered, the bottom 90 degrees of soil and rock shall be overexcavated to a depth of 6 inches (150 mm) below the trench form and 12 inches (300 mm) along the remaining portions. The void shall be filled with monolithically placed concrete prior to construction of the pipe or backfilled with soil compacted to a minimum relative compaction of 90 percent. The method shall be approved by the Engineer.

306-9.4 Placement.

306-9.4.1 General. Concrete placement shall conform to 303-1.8 unless otherwise specified in the Special Provisions. Concrete shall not be placed when the temperature of the concrete exceeds 90°F (32°C) or is less than 50°F (10°C). The temperature of the soil adjacent to the trench shall be above 32°F (0°C).

306-9.4.2 Soil Moisture. At the time of concrete placement, soil which will be in contact with CIPCP shall be moistened, but shall not contain standing, seeping, or flowing water. The Contractor may place a layer of 1 inch (25 mm) maximum size rock 6 inches (150 mm) thick below the trench invert to assist in water control.

306-9.4.3 Concrete Forms. 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 the concrete, and prevent deformation during placement. Inflatable internal forms shall not be used. The concrete shall be vibrated, tamped, or worked with suitable devices until consolidated and the forms are completely filled.

306-9.4.4 Junction Structures. Where junction structures are to be constructed, CIPCP shall be constructed continuous through the structure locations. The pipe shall be cut away to the specified opening prior to the concrete setting. Alternate methods may be used as approved in writing by the Engineer.

306-9.4.5 Construction Joints. When placement is stopped for a period of time long enough that initial set may occur or for 20 minutes, whichever is less, a construction stoppage joint shall be constructed by sloping the end of the pipe at approximately 45 degrees and inserting 24-inch (600 mm) long No. 3 (No. 10M) dowels 12 inches (300 mm) into the center of the pipe wall at intervals of approximately 18 inches (450 mm) around the pipe circumference. The total exposed face shall be left in a roughened condition.

Before placement operations may resume, the concrete placed at the construction stoppage joint shall have attained 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 1-1/2 times the pipe wall thickness and a minimum length of 24 inches (600 mm). The joint shall be cleaned of laitance, foreign, and loose materials before resuming concrete placement.

306-9.4.6 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. During times of low temperatures or other adverse conditions the forms may be kept in place for longer periods of time.

306-9.4.7 Finishing. The interior shall be at least as smooth as a steel trowel finish except for the form lap ridges permitted in 306-9.8.2.4.

306-9.5 Curing. Immediately after placement, the exposed top portion of the pipe shall be cured by placing a polyethylene film at least 1.5 mils (38 μm) thick so as to completely cover the top surface. Each opening in the pipe shall be covered with polyethylene and loosely secured to prevent drafts 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.

306-9.6 Repairing. After the internal fixed forms have been removed, the inside of the pipe will be inspected by the Engineer. Rock pockets, blisters, voids, or similar defects not extending through the wall and less than 2 square feet (0.18 m^2) in area, shall be repaired immediately by removing the defective concrete and replacing it with bonded and cured mortar or other patching material approved by the Engineer.

Rock pockets, blisters, voids, or other defects greater than 2 square feet (0.18 m^2) or which extend through the pipe wall shall be repaired by removing the entire pipe for 1 foot (300 mm) on each side beyond the limits of the defect.

Cracks shall not be repaired until the backfill has been placed. However, the Contractor may remove and replace cracked pipe prior to placement of the backfill.

Subsequent to placement of the backfill, the Contractor shall notify the Engineer when the pipe is ready for reinspection. Cracks less than 10 mils (250 μm) in width or cracks greater than 10 mils (250 μm) in width but less than 12 inches (300 mm) long shall be painted with a cement paste. Longitudinal cracks exceeding 10 mils (250 μm) in width and 12 inches (300 mm) in length shall 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 shall be defined as any length between 2 structures.

Circumferential cracks exceeding 10 mils (250 μm) in width and 12 inches (300 mm) in length shall be repaired by removing at least 1 inch (25 mm) of concrete in width for a depth of at least 1/2 the wall thickness. After cleaning this area, it shall be filled with bonded mortar and cured.

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.

306-9.7 Sampling and Testing.

306-9.7.1 General. Sampling and testing shall be performed in the sequence described herein. Concrete will be tested during placement 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 the wall thickness and compressive strength. Strength test results shall be verified by a laboratory approved by the Engineer.

The Engineer will determine the number and location of the samples to be taken and tests to be performed by the Contractor. The location shall be identified by station, and where applicable, the angle from vertical measured clockwise facing up-station.

306-9.7.2 Wall Thickness. The Engineer will determine the wall thickness in accordance with the following:

a) The thickness at the invert and crown of the pipe will be measured by probing at approximately 25 foot (7.5 m) intervals during placement of the concrete. The probe will be forced through the concrete to make firm contact with the form at the crown and will 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 a 3/8 inch (9.5 mm) round bar, at least 2 inches (50 mm) longer than the wall thickness to be measured, rounded on one end with a tee handle on the other.

b) The thickness at the invert and springline will be measured through holes drilled by the Contractor. The holes shall be at least 3/4 inch (19 mm) 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 50 feet (15 m) at the invert and both springlines and shall be located as determined by the Engineer. The Engineer may require additional holes on curves.

After measurement, the Contractor shall fill all holes with Class "C" mortar conforming to 201-5.

306-9.7.3 Concrete Cores. Cores, when required by the Engineer, shall be obtained from CIPCP and tested in accordance ASTM C42. The Contractor shall obtain the cores. Testing shall be arranged by the Contractor and performed at a laboratory approved by the Engineer. The cores shall have a length-to-diameter ratio of not less than one. The diameter of cores shall be at least 3 times the maximum size of the aggregate used in the concrete, except where the wall thickness if such that the length-to-diameter will be less than one, in which case the core diameter may be reduced to 2-1/2 times the maximum aggregate size used.

At least 4 cores shall be taken for each 200 feet (60 m), 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 2 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 each core hole in such a manner that the patch will be permanent, not leak, and have a smooth finish flush with the interior surface.

306-9.7.4 Load Bearing Tests. Load bearing tests shall be performed by the Contractor every 1,000 feet (300 m) of pipe having the same size and wall thickness, with a minimum of 1 per size and 2 for the Work. The test locations will be determined by the Engineer. The tests shall be performed in the presence of the Engineer.

The method and apparatus requirements shall be as follows:

a) 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.

b) The test length shall be at least 4 feet (1.2 m) and not more than 5 feet (1.5 m). At the option of the Contractor, the test section may be isolated from the completed pipe.

c) 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 internal diameter of the pipe. The minimum thickness of the sand shall be 0.25 times the specified internal diameter.

d) The frame and bearing plate shall be sufficiently rigid such that the load is distributed uniformly and the frame and plate 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 346.

e) The frame shall be properly located on the pipe test section and filled with sand. The sand shall be clean and graded to pass a No. 4 (4.75 mm) 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.

f) 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.

g) The applied load, in pounds (N), shall equal the test load multiplied by the length of the test section, in feet (meters). The test load shall be calculated as follows:

U.S. Standard Measures:

Test Load = $(127.5H + 1.5LL + 5.56T)\ OD + 34.0(ID)^2$

SI Units:

Test Load = $(20030H + 1.5LL + 10.48T)\ OD + 5340\ (ID)^2$

Where:

ID = Specified inside diameter of the pipe in feet (meters).

T = Specified wall thickness of the pipe in inches (mm).

OD = ID + 2T/12 = Outside diameter of pipe in feet.

(SI Units: OD = ID + 2T/1000 = Outside diameter of pipe in meters.)

H = Depth of cover on pipe in feet (meters).

LL = Live load on pipe in pounds per square foot (kPa).

TABLE 306-9.7.4

Depth of Cover ft (m)	Live Load (LL) lbs/ft^2 (kPa)
3 (0.9)	489 (23.4)
4 (1.2)	314 (15.0)
5 (1.5)	234 (11.2)
6 (1.8)	182 (8.71)
7 (2.0)	145 (6.94)
8 (2.4)	119 (5.70)
9 (2.7)	120 (5.75)
10 (3.0)	90 (4.31)
Over 10 (3.0)	N/A

h) The total test load shall be supported by the test section without the development of any additional cracking.

i) 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 4 foot (1.2 m) section of pipe when approved in writing by the Engineer. The load applied shall be determined by the equation 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.

306-9.8 Dimensions and Tolerances.

306-9.8.1 General. The minimum nominal size of CIPCP shall be 24-inch (600 mm) inside diameter.

306-9.8.2 Diameter. The inside 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 4 measurements of the inside diameter made at 45-degree intervals shall not be less than the nominal diameter.

306-9.8.3 Wall Thickness. Unless otherwise shown on the Plans, the minimum wall thickness shall not be less than that shown in Table 306-9.8.3. The wall thickness shall be uniform around the circumference of the pipe.

TABLE 306-9.8.3

Inside Diameter inches (mm)	Minimum Wall Thickness inches (mm)
24 and 30 (600 and 750)	3 (76)
36 (900)	3-1/2 (89)
42 (1050)	4 (102)
48 (1200)	5 (127)
54 (1350)	5-1/2 (140)
60 (1500)	6 (153)
66 (1650)	6-1/2 (165)
72 (1800)	7 (178)
78 (1950)	7-1/2 (191)
84 (2100)	8 (203)
90 (2250)	8-1/2 (216)
96 (2400)	9 (229)
108 (2700)	10 (254)
120 (3000)	12 (305)
132 (3300)	14 (356)
144 (3600)	15 (381)

For an inside diameter not shown above or on the Plans, the minimum wall thickness shall be equal to the next size larger pipe.

306-9.8.4 Offsets and Indentations. Offsets and indentations, including transverse and longitudinal form offsets and construction stoppage joints, shall not exceed 1/4 inch (6 mm) in width for pipe with a specified inside diameter of 42 inches (1050 mm) or less, 3/8 inch (9.5 mm) for pipe with a specified inside diameter over 42 inches (1050 mm) and less than 72 inches (1800 mm), and 1/2 inch (12.5 mm) for pipe diameters equal to or greater than 72 inches (1800 mm).

Reaches having offsets or indentations in excess of these limits shall be repaired as approved by the Engineer.

306-9.8.5 Grade and Alignment. A laser grade control system shall be used during trench construction and placement.

Departure from and return to established grade shall not exceed 3/8 inch per foot (10 mm/m) and maximum departure shall not exceed 1 inch (25 mm). Maximum departure from established alignment shall not exceed 2 inches (50 mm) on tangents and 4 inches (100 mm) on curves. Departure from and return to established alignment shall not exceed 1/4 inch per foot (20 mm/m).

If the departure exceeds the maximum allowed, the work shall be stopped and the necessary adjustments made. The affected portions of the conduit with excessive departure shall be removed and replaced at the alignment and grades shown on the Plans.

306-9.9 Rejection. CIPCP will be rejected for any of the following reasons:

a) Longitudinal cracks exceeding 10 mils (250 μm) in width and 12 inches (300 mm) or greater in length unless repaired in conformance with 306-9.6. 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.

b) Circumferential cracks exceeding 10 mils (250 μm) in width and 12 inches (300 mm) or greater in length unless repaired in conformance with 306-9.6.

c) Longitudinal cracks exceeding 1/1000 the internal diameter or a maximum 1/16 inch (1.5 mm) in width.

d) Rock pockets, honeycombing, blisters, voids, or other defects that extend through the pipe wall.

e) A wall thickness less than the minimum shown in Table 306-9.8.3.

f) A diameter that does not conform to the requirements specified in 306-9.8.2.

g) Application of any wash coat of cement, grout, or other material prior to re-inspection after backfill has been placed.

h) Air bubble voids on the interior surface of the pipe exceeding 1/4 inch (6 mm) in depth unless pointed with mortar or other approved material.

i) Unpaired offsets or indentations, including transverse and longitudinal form offsets exceeding those allowed in 306-9.8.4.

j) Deviation or departure from true grade or alignment exceeding that allowed in 306-9.8.5.

k) Concrete used that has a slump of less than 1 inch (25 mm) or more than 3 inches (75 mm) as specified in 306-9.2. 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.

l) Concrete that has core strengths less than specified in 306-9.2.

m) The pipe does not pass the load test specified in 306-9.7.4.

n) The pipe has been damaged in any manner.

o) Concrete that was placed when the concrete temperature exceeded 90°F (32°C) or was less than 50°F (10°C), or when the soil adjacent to the trench was at or below 32°F (0°C).

p) The trench does not provide full, firm, and uniform support over the bottom 210 degrees of the pipe or the trench width exceeds the outside diameter by more than 2 inches (50 mm), except when meeting the requirements of 306-9.3.2, 9.3.3, and 9.3.4.

q) The interior of the pipe is not at least as smooth as a steel trowel finish except for the form lap ridges.

306-10 PRECAST REINFORCED CONCRETE BOX (PRCB).

306-10.1 General. These specifications cover the construction of single-cell PRCB sections intended to be used for the conveyance of stormwater. PRCB sections shall conform to 216.

306-10.2 Repairs. PRCB sections damaged due to imperfections in fabrication or handling shall be repaired by a method approved by the Engineer.

306-10.3 Subgrade. Unsuitable subgrade material shall be removed to the depth shown on the Plans or determined by the Engineer and replaced with leveling bed material. Voids below subgrade shall be filled with leveling bed material prior to densification. Subgrade material shall be compacted to a minimum of 90 percent relative compaction.

306-10.4 Leveling Bed Material. Leveling bed material shall conform to 216-2.4 and be compacted to a minimum of 90 percent relative compaction.

306-10.5 Installation. PRCB shall be laid up-grade with the groove ends up-grade unless otherwise approved by the Engineer. Connections shall be constructed as shown on the Plans.

At the close of work each day, or whenever the work ceases for any reason, each end shall be securely closed as approved by the Engineer.

306-10.6 Tongue-and-Groove Joints. Tongue and groove joints shall be constructed in accordance with 306-7.3.2.1 modified as follows:

a) Only one end shall be beveled for PRCB sections placed on curves.

b) Concrete used to fill clear spaces more than 1 inch (25 mm) and less than 3 inches (75 mm) shall be Class 560-C-3250 (330-C-23) conforming to 201-1 or Class "C "mortar conforming to 201-5 unless otherwise specified in the Special Provisions.

Preformed flexible joint sealant conforming to ASTM C990 or AASHTO M198 may be used. Preformed flexible joint sealant shall be installed in accordance with the manufacturer's specifications on the tongue and groove, in order to fill the joint annular space on the inside of the PRCB section. Flexible plastic gaskets shall not be used on PRCB pulled to provide a curve.

Preformed flexible joint sealant bands conforming to ASTM C877 may be used, in conjunction with mastic or mortar, when installed in accordance with the manufacturer's specifications.

306-10.7 Structure Backfill. Structure backfill material shall conform to 217-3. Structure backfill placement shall conform to 300-3.5.1. Structure backfill material shall be placed 12 inches (300 mm) from the top and 24 inches (600 mm) from each side.

306-11 Not Used.

306-12 BACKFILL.

306-12.1 General. Trench backfill material shall conform to 217-2. Backfill for prefabricated gravity and pressure pipe, cast-in-place non-reinforced concrete pipe, and prefabricated reinforced concrete box 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 shall be considered as starting at the subgrade for cast-in-place reinforced concrete box and structures.

Except where a pipe must remain exposed for a 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 conduit will not be damaged or displaced. If a pipe is supported by concrete bedding that does not cover the pipe, the remainder of any bedding material shall be placed to 1 foot (0.3 m) over the top of the pipe. Backfill above concrete bedding shall not be placed nor sheeting pulled until the concrete bedding has been cured per 201-1.

The Contractor may place backfill or structure backfill against or over the top of any cast-in-place structure in accordance with Table 306-12.1, unless otherwise specified in the Special Provisions.

TABLE 306-12.1

Operation	Location	
	Against Sides of Structures (Days)	Over Top of Structure (Days)
Placement of Loose Backfill	5	21
Densification of Backfill	7	28[1]

1. Or 100 percent of the specified compressive strength.

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 and compacted as approved by the Engineer.

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.

Compaction shall be performed immediately after each lift of backfill is placed.

When the depth of cover of the top pipe or cable is less than 30 inches (750 mm), the top 24 inches (600 mm) of backfill, measured from the surface, shall be compacted to 90 percent relative compaction.

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 will be required.

306-12.2 Backfill for Narrow Trenches. Narrow trenches are defined as 10 inches (250 mm) or less in width. Backfill for narrow trenches shall be placed in accordance with 306-1.12.1 except as modified herein. Narrow trenches shall be backfilled by the use of trench backfill slurry conforming to 201-1 or CLSM conforming to 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 top of the trench backfill slurry or CLSM shall be placed flush with the top of the pavement when steel plates are not placed. The trench backfill slurry or CLSM shall be cut back to a minimum of 1 inch (25 mm) but no greater than 8 inches (200 mm) below the existing pavement prior to placing permanent paving. For trenches 6 inches (150 mm) or less in width, the compacted thickness of asphalt concrete shall be 3 inches (75 mm).

Backfill to be mechanically compacted in narrow trenches shall be placed in accordance with 306-1.12.3, except as modified herein. Backfill shall not have any rocks greater in any dimension, than 1/4 the width of the trench. In-place density for narrow trenches will be determined in accordance with ASTM D2937 or by a method approved by Engineer.

306-12.3 Mechanically Compacted Trench Backfill.

306-12.3.1 General. Backfill shall be mechanically compacted by means of tamping, sheepsfoot, pneumatic tire, or vibrating rollers, or other mechanical tampers. Such equipment shall be of the size and type approved by the Engineer. Impact-type pavement breakers ("stompers") will not be permitted over or adjacent to pipe, duct, or cable, unless otherwise approved 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 constructed under the Contract. The Contractor shall make its own determination in this regard.

Each lift of backfill shall be uniformly spread, moistened (or dried, if necessary), and then compacted 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:

a) Impact, free fall, or "stomping" equipment- maximum lift thickness of 24 inches (600 mm)

b) Vibratory equipment, including vibratory plates on backhoe dipsticks, vibratory smooth-wheel rollers, and vibratory pneumatic-tired rollers - maximum lift thickness of 18 inches (150 mm).

c) Rolling equipment, including sheepsfoot (both vibratory and nonvibratory), grid, smooth-wheel (nonvibratory), grid, smooth wheel (nonvibratory), and segmented wheels - maximum lift thickness of 8 inches (200 mm).

d) Hand-directed mechanical compactors such as vibratory plates or tamper - maximum lift thickness of 4 inches (100 mm).

306-12.3.2 Compaction Requirements. Unless otherwise specified in the Special Provisions, mechanically compacted trench backfill shall be compacted to the following minimum relative compaction:

a) 85 percent relative compaction:
   1) In the bedding zone.
   2) Outside the traveled way and other paved areas (or areas to receive pavement).
   3) Under sidewalks.

b) 90 percent relative compaction:
   1) In the upper 3 feet (0.9 m) 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).
   2) Within engineered embankments.
   3) Where lateral support is required for existing or proposed structures.

c) 95 percent relative compaction where required by 301-1.3.

306-12.4 Jetted Trench Backfill.

306-12.4.1 General. Trench backfill to be compacted by water shall be jetted. Flooding will not be permitted. Jetting will be permitted only if so specified in the Special Provisions.

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:

a) The jet pipe shall consist of a minimum 1-1/2 inch (38 mm) diameter pipe to which a minimum 2-inch (50 mm) diameter hose is attached at the upper end. The jet shall be of sufficient length to project to within 2 feet (0.6 m) of the bottom of the lift being densified.

b) The Contractor shall jet to within 2 feet (0.6 m) 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.

c) The lift of backfill shall not exceed that which can be readily densified by jetting, but in no case shall the undensified lift exceed 15 feet (4.5 m).

d) 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.

e) The Contractor shall have available a continuous supply of water at a minimum pressure of 40 pounds per square inch (275 kPa) gage. If a water truck is used to supply water, it shall have a pump capable of supplying water at 40 pounds per square inch (275 kPa) gage and shall have the capacity to jet the trench without refill.

f) After jetting trench backfill, the Contractor shall prepare the top of the backfill to provide a firm and unyielding subgrade conforming to 301-1. Jetting maybe supplemented with mechanical methods.

306-12.4.2 Compaction Requirements. Unless otherwise specified in the Special Provisions, trench backfill compacted through jetting shall be densified to the following minimum relative compaction:

a) 85 percent relative compaction:

1) From the bottom of the trench to the beginning of the upper 3 feet (0.9 m), measured from the pavement surface (or finish grade where there is no pavement) within native material or unengineered embankments.

2) Outside the traveled way, shoulders, and under sidewalks, in the upper 3 feet (0.9 m), measured from the pavement surface (or finish grade where there is no pavement).

3) Under sidewalks.

b) 90 percent relative compaction:

1) In the upper 3 feet (0.9 m), 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).

2) Within engineered embankments.

3) Where lateral support is required for existing or proposed structures.

4) 95 percent relative compaction where required by 301-1.3.

306-12.5 Backfill for Cast-In-Place Non-Reinforced Concrete Pipe (CIPCP). Backfill for CIPCP shall be considered as starting at the top of the trench form. 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 CIPCP until the required 28-Day compressive strength has been attained. 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.

306-13 TRENCH RESURFACING.

306-13.1 Temporary Resurfacing. Unless permanent pavement is placed immediately, temporary resurfacing 2 inches (50 mm) thick shall be placed and maintained wherever excavation is made through

pavement, sidewalk or driveways. In sidewalk areas the temporary resurfacing shall be at least 1 inch (25 mm) thick; in all other areas it shall be at least 2 inches (50 mm) thick. 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 asphalt concrete mixture used for temporary trench resurfacing shall conform to Class D2 asphalt concrete conforming to 203-6.4.3; and liquid asphalt conforming to grade SC-800 shown in Table 203-2.4.

The mixture may be furnished from stockpiles or directly from the plant, and may be laid cold. 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 provide the full thickness of temporary resurfacing specified. The temporary resurfacing shall be placed, rolled, maintained, removed, and disposed of by the Contractor.

306-13.2 Permanent Resurfacing. Unless otherwise specified, 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. Trench and excavation resurfacing shall be 1 inch (25 mm) greater in thickness than existing pavement.

Subgrade for trench resurfacing shall conform to 301 and the pavement reconstruction shall comply with the applicable provisions of 302. Aggregate base, when encountered within the structural section area, shall be compacted to a minimum relative density of 95 percent and compacted in lifts in accordance with 301-2.2. The thickness of aggregate base shall be equal to that existing adjacent to the excavation.

306-13.3 Placement of Permanent Repair Hot Mixed Asphalt Concrete. The asphalt concrete shall be placed in compacted lifts as shown in Table 306-13.3.

TABLE 306-13.3

Compaction Equipment	Maximum Compacted Thickness, inches (mm)
Vibratory Plate	1-1/2 (38)
Pneumatic Plate	2 (50)
Vibratory Rammers	2 (50)
Steel Wheel Roller[1]	2-1/2 (63)
Vibratory Roller[1]	3 (75)
Pneumatic Tired Rollers	Not Permitted

1. 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. The tack coat when cured or cooled shall be of sufficient thickness to uniformly and completely cover the vertical surfaces of the existing asphalt concrete. 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 re-applied. The Contractor shall ensure that the tack coat is not damaged during the placement of the asphalt concrete.

306-13.4 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 3 feet (1 m) wide and individual excavations or bore holes having an area of less than 50 square feet (5 m^2), 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 1/4 inch (6 mm).

306-13.5 Finish Course for Asphalt Concrete Placement. The finish course shall be a C or D gradation. For trenches 8 feet (2.5 m) 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 is greater than 110 tons (100 tonnes), a paving machine shall be used.

For trench widths 3 feet (1 m) or greater and less than 8 feet (2.5 m), 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 is greater than 17 tons (15 tonnes).

For trenches less than 3 feet (1 m) wide and individual excavations or bore holes having an area of less than 50 square feet (5 m^2), the final lift shall be placed in such a manner as to obtain the specified density and smoothness.

306-13.6 Density and Smoothness. For trench widths of 3 feet (1 m) or greater, the Contractor shall compact each lift with a self-propelled steel wheeled roller conforming to the PLI (N/mm) requirement specified in 302-5.6.

For trench widths of less than 3 feet (1 m), the Contractor shall compact each lift by steel wheel rollers, vibratory plates, or rammers of such width to fit within the sides of the excavation. The PLI (N/mm) requirements of 302-5.6 shall not apply except for the final lift. The final lift shall be compacted using a steel wheel roller conforming to the PLI (N/mm) requirements of 302-5.6.

For individual excavations or bore holes having an area of less than 50 square feet (5 m^2), the Contractor shall compact each lift by steel wheel rollers, vibratory plates, or rammers of such width to fit within the sides of the excavation. The PLI (N/mm) requirements of 302-5.6 shall not apply.

Pneumatic tire rollers or truck tires shall not be used to compact 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 1 inch (25 mm), except for trenches specified in 306-12.4.

For trench widths 3 feet (1 m) or greater, the compaction temperatures shall conform to 302-5.6. For trench widths less than 3 feet (1 m), compaction shall be initiated before the asphalt concrete cools to less than 200°F (94°C).

The minimum compaction after rolling shall be 95 percent of the density obtained in accordance with 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 3 feet (1 m) and parallel to the centerline of the street shall conform to the smoothness requirements specified in 302-5.6.2. Trenches less than 3 feet (1 m) wide, individual excavations or bore holes having an area less than 50 square feet (5 m^2), and trenches of any width not parallel to the centerline of the street shall match the smoothness of the existing pavement, except the final pavement surface tolerances shall be 0 to plus 1/8 inch (3 mm) based on the existing pavement on either side of the excavation. Final pavement below the existing surface will not be accepted.

Finish courses with deviations exceeding the above requirements shall be removed and replaced. Removal shall be to a minimum depth of 1-1/2 inches (38 mm) for the full-width of the trench. The minimum length of removal along the trench shall extend 4 feet (1.2 m) beyond the ends of the deviations, but in no case exceed the limit of the original excavation.

306-13.7 Concrete Resurfacing. Replacement of PCC pavement for trench or individual excavations or bore holes shall be 1 inch (25 mm) greater in thickness than the existing pavement. The concrete shall conform to and be placed per 302-6.

306-14 MEASUREMENT.

306-14.1 Shoring and Bracing. Shoring and bracing will be measured as specified in the Special Provisions or shown in the Bid.

306-14.2 Pressure Pipe. Pressure pipe will be measured in a horizontal plane along the pipe centerline between the ends as laid and shall include the length of the actual pipe in-place, including the lay-lengths of in-line tees, fittings, valves, meters and appurtenances.

306-14.3 Gravity Pipe. Gravity pipe will be measured along the longitudinal axis between the ends as laid and shall include the length of 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.

306-14.4 Precast Reinforced Concrete Box (PRCB). PRCB will be measured along the longitudinal axis between the ends laid for each size. The length shall include the actual length of the PRCB in place but it shall not include the inside dimensions of structures.

306-14.5 Valves, Hydrants, Buried Structures, and Pipeline Appurtenances. Pipeline appurtenances shall include backflow prevention devices, meters, water service laterals, expansion joints, and other devices specified as appurtenance Bid items in the Special Provisions or the Bid. Valves, hydrants, buried structures, and appurtenances will be measured by "each" unless otherwise specified in the Special Provisions..

306-14.6 Temporary Resurfacing. Temporary resurfacing will be measured by the ton (tonne).

306-14.7 Permanent Resurfacing. Unless otherwise specified, permanent resurfacing will not be measured separately for payment.

306-15 PAYMENT.

306-15.1 General. Payment for pipe and conduit will be made at the Contract Unit Price per linear foot (m). The Contract Unit Price shall include payment for

a) all wyes, tees, bends, monolithic catch basin connections, and specials shown on the Plans;
b) the removal of interfering portions of existing pipelines, sewers, storm drains, and improvements;
c) the closing or removing of abandoned conduit and structures;
d) the excavations of the trench;
e) the control of surface waters;
f) the preparation of subgrade;
g) placing and joining pipe;
h) pressure testing;

i) video inspection;

j) disinfection sample collection and delivery;

k) backfilling the trench;

l) permanent resurfacing; and

m) all other work (excluding temporary resurfacing) necessary to install the pipe or conduit, complete in-place.

No separate or additional payment will be made for additional bedding or a higher strength of pipe necessitated by the Contractor exceeding the maximum trench width.

306-15.2 Shoring and Bracing. Payment for shoring and bracing will be made as specified in the Special Provisions.

306-15.3 Dewatering. Payment for dewatering will be made as specified in the Special Provisions.

306-15.4 Valves, Hydrants, Buried Structures, and Pipeline Appurtenances. Payment for valves, hydrants, buried structures, and pipeline appurtenances will be made at the Contract Unit Price for each item and shall include testing and disinfection.

306-15.5 Valves. Payment for valves will be made at the Contract Unit Price for each valve assembly of the size, class, and type shown on the Plans. The Contract Unit Price shall include excavation, valve, actuator, thrust restraint, valve supports, gaskets and fasteners, valve cans, risers, extensions, and lids, backfill, restoration of the street surface, and all other work, excluding temporary resurfacing, necessary to construct the valve complete in-place.

For air valve assemblies, the Contract Unit Price shall also include payment for concrete pads, enclosures, laterals, risers, and isolation valves shown on the Plans or specified in the Special Provisions.

306-15.6 Hydrants Payment for hydrants will be made at the Contract Unit Price for each hydrant assembly of the size, and type shown on the Plans. The Contract Unit Price shall include excavation, the hydrant, hydrant lateral, hydrant shutoff valve and actuator, thrust restraint, gaskets and fasteners, valve cans, risers, extensions, and lid, backfill, restoration of the street surface, and all other work, excluding temporary resurfacing, necessary to construct the hydrant assembly complete in-place.

306-15.7 Buried Structures. Buried structures shall include manholes, cleanouts, junction structures, lamp holes, catch basins and other structures specified as buried structures in the Special Provisions. Payment for buried structures will be made at the Contract Unit Price for each type or size of structure shown on the Plans. The Contract Unit Price shall include excavation, backfill, constructing inverts, furnishing and installing castings, restoration of the street surface, and all other work, excluding temporary resurfacing, necessary to construct the buried structure, complete in-place.

306-15.8 Pipeline Appurtenances. Payment for pipeline appurtenances will be made at the Contract Unit Price for each appurtenance of the size and type shown on the Plans, complete in-place.

Payment for backflow prevention devices will be made at the Contract Unit Price for each backflow prevention assembly. The Contract Unit Price shall include payment for excavation, backflow prevention assembly, isolation valves and actuators, thrust restraint, gaskets and fasteners, backfill, concrete pads and enclosure, restoration of the street surface, and all other work, excluding temporary resurfacing, necessary to construct the backflow prevention assembly, complete in-place.

Payment for water service laterals will be made at the Contract Unit Price for each water service lateral or meter assembly, including service tap, corporation stop, lateral, riser, angle meter valve, service saddle, meter installation, meter box or vault, meter box lid, and all other service material shown on the Plans or specified in the Special Provisions.

Payment for meters will be made at the Contact Unit Price for each meter. The Contract Unit Price shall include payment for the meter (unless furnished by the Agency) and any appurtenant couplings, meter boxes or vaults, or meter box lid for which payment is not made under another Bid item.

Payment for expansion joints will be made at the Contract Unit Price for each expansion joint. The Contract Unit Price shall include payment for each expansion joint and appurtenant thrust restraint system.

Payment for other pipeline appurtenances will be made as specified in the Special Provisions.

306-15.9 Temporary Resurfacing. Payment for temporary resurfacing will be made at the Contract Unit Price per ton (tonne). The Contract Unit Price per ton (tonne) shall include 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. No separate or additional payment will be made for material placed by the Contractor for its convenience.

SECTION 307 – JACKING AND TUNNELING

307-1 JACKING OPERATIONS.

307-1.1 General. Before starting excavation, the Contractor shall, in accordance with 2-5.3, submit Working Drawings of the jacking pit bracing, casing (or conduit), jacking head, methods, equipment, and grouting pressure proposed to be used.

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, of adequate strength to carry the loads imposed upon it.

Excavation shall not be made in excess of the outer dimensions of the conduit being jacked unless otherwise approved by the Engineer. Any loss of earth outside the jacking head shall be avoided. Excavated material shall be removed from the conduit as excavation progresses. No accumulation of such material within the conduit will be permitted.

Once commenced, jacking shall be performed continuously and uninterrupted until the conduit has been jacked between the limits shown on the Plans. This requirement may be modified if the Contractor submits to the Engineer for prior approval methods and details that will prevent "freezing" of the conduit and ensure that the heading is stable at all times.

Upon completion of the jacking operations, voids around the outside face of the conduit shall be completely filled by grouting.

Grouting equipment and material shall be on the Work site before the jacking operations and drilling of grout holes are completed.

Should loss of ground occur during the jacking operation, the voids shall be backpacked promptly with soil-cement consisting of 1 part cement to 5 parts granular material. Where the soil is not suitable for this purpose, the Contractor shall import granular material. The soil-cement shall be thoroughly mixed and rammed into place promptly after the loss of ground.

307-1.2 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 60 inches (1500 mm) or greater in nominal inside diameter is to be jacked for a distance greater than 32 feet (10 m), a pilot tunnel shall first be constructed. Unless otherwise specified, the dimension and support of the pilot tunnel shall be optional with the Contractor and subject to approval by the Engineer.

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 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 2 inches (50 mm) and shall extend to within 1 inch (25 mm) of the edge of the cradle.

In lieu of the concrete cradle specified above, the Contractor may, subject to approval 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 5 feet (1.5 m) 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.

307-1.3 Jacking Steel Casing. Unless otherwise shown on the Plans, the size and wall thickness of the casing to be jacked shall be at the Contractor's option, except that the casing thickness shall be not less than 3/8 inch (9.5 mm), 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.

Clay pipe installed in a jacked casing shall have mechanical compression joints and be braced or filled to prevent shifting or flotation during backfilling operations.

Backfill shall be gunite sand, gunite concrete, or pressure concrete unless otherwise shown on the Plans or specified in the Special Provisions. 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.

Gunite sand backfill placement shall conform to 307-2.7. Where gunite 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 gunite concrete or pressure concrete backfill is to be used, the pipe shall be laid on a subbase of pipe bedding concrete conforming to 201-1 at least 5 inches (125 mm) thick at the centerline.

The pipe barrels shall rest upon concrete support blocks with the pipe sockets clearing the concrete subbase by at least 1/2 inch (12.5 mm).

In addition to submitting details of the jacking pit bracing, casing, and jacking head required in 307-1.1, the Contractor shall submit in accordance with 2-5.3 details of the following: concrete support blocks, bracing to prevent pipe shifting or flotation, and pressure concrete mix design, placement method, and equipment.

307-1.4 Jacking Corrugated Steel Pipe. The thickness of the pipe shown on the Plans shall 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.

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 1 inch per 100 feet (8 mm per 10 m).

The diameter of the excavated hole shall not be more than 0.1 foot (30 mm) 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 1-1/2 feet (0.5 m), unless approved by the Engineer.

307-1.5 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 specified in the Special Provisions, when a pilot tunnel is required to be constructed, the Contractor will be permitted a tolerance from exact grade or alignment of 1 inch per 100 feet (8 mm per 10 m).

307-1.6 Measurement. Jacking will be measured by the linear foot (m) for each size and type of conduit to be jacked.

307-1.7 Payment. The Contract Unit Price per linear foot (m) of jacked conduit shall include excavation; constructing, supporting, and removing pilot tunnels; constructing reinforced concrete cradles where required; providing grout holes, grout, and grouting where necessary; importing soil for soil-cement; and work appurtenant to jacking conduit within the limits shown on the Plans.

For corrugated steel pipe, the Contract Unit Price shall include a heavier thickness of pipe than that shown on the Plans, if necessary.

Except when a Bid item is provided for jacked casing, payment for furnishing and jacking casing in place shall be included in the Contract Unit Price per linear foot (m) 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.

307-2 TUNNELING OPERATIONS.

307-2.1 General. Tunneling is a manned-entry method used to construct underground conduits by hand-digging or the in-place operation of a tunnel boring machine. Microtunneling shall conform to 308.

Required pipe tunnel locations and lengths shall be as shown on the Plans. The Contractor shall, in accordance with 2-5.3, submit Working Drawings showing details of the following:

a) Tunnel shaft bracing and dimensions.

b) Tunnel supports.

c) Method of backpacking tunnel supports.

d) Method of transporting pipe in tunnel.

e) Bracing to prevent pipe shifting and flotation.

f) Pressure concrete mix design, placement method and equipment.

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.

307-2.2 Excavations. Access shafts or portals shall be located where shown on the Plans. Where no such locations are given, the Contractor shall have the option of determining such locations subject to approval by the Engineer. Access shafts or portals will not be permitted within street intersections unless otherwise shown on the Plans or approved by the Engineer.

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 completely fill the 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 3 inches (75 mm) for any tunnel to be constructed on a curve with a centerline radius of less than 300 feet (90 m).

Drilling and blasting shall be performed in such a manner to avoid undue shattering or loosening of material.

Loose material in the invert shall be removed to a clean rock surface or undisturbed foundation prior to placing pipe bedding and installing pipe. Deep depressions shall 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 over-excavating shall be considered a part of tunnel excavation and no additional compensation will be allowed therefore.

307-2.3 Dewatering. Dewatering shall conform to 7-8.6.4. The Contractor shall furnish, install, and operate pumps, pipes, appliances, and equipment of sufficient capacity to keep tunnel excavations and accesses free from water until the tunnel is backfilled, unless otherwise approved by the Engineer. The Contractor shall provide the means or facilities necessary to convey water to the pumps.

307-2.4 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. 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 Working Drawings of the tunnel supports proposed to be used. Such Working 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 4 inches (100 mm), 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.

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 12 inches (300 mm), and to intermittent sets or ribs shall be 10 inches (250 mm). The minimum overhead clearance from pipe sockets to nearest inside face of any steel or timber member shall be 10 inches (250 mm).

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 18 inches (450 mm).

The minimum side and top clearances prescribed herein shall be increased by 3 inches (75 mm) for pipe without projecting sockets or collars and shall apply to the barrel of the pipe.

The minimum side and top clearances prescribed herein shall be increased by 3 inches (75 mm) 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:

a) Socket and spigot pipe with rubber gasket or mechanical compression joints.
b) Pipe 24 inches (600 mm) or larger in internal diameter.
c) 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 4 inches (100 mm) on each side of the joint in fresh mortar at least 3 inches (75 mm) thick and extending 2 inches (50 mm) above the top of the granular bedding material.

The Contractor shall reconstruct tunnel supports as necessary to conform to the aforementioned requirements.

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 material not suitable for backfill.

307-2.5 Subgrade and Bedding. Pipe shall be placed and bedded as shown on the Plans or Working Drawings specifying the methods of laying and bedding pipe in trenches.

If an invert slab is required or otherwise placed separately, it shall be 5 inches (125 mm) minimum thickness, the full width of the tunnel, and the concrete shall be tunnel backfill concrete conforming to 201-1. Concrete shall not be placed until the 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.

307-2.6 Backpacking Tunnel Supports. Voids behind temporary or permanent tunnel support systems, including over-break, cave-ins, and chimneys, shall be backpacked. 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 1 cubic foot (0.03 m^3) 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 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 shall import granular material for backpacking.

Soil-cement for backpacking lagged or fully lined tunnels shall consist of a 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. The soil-cement shall be thoroughly mixed and rammed into place immediately following placement of tunnel supports. The placement interval shall not exceed 3 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.

307-2.7 Tunnel Backfill. Pipe laying operations in tunnels shall not precede tunnel backfill by more than 150 feet (45 m) 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. 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 pressure concrete or gunite concrete.

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 303-2 except that no Portland cement need be added. The Contractor may add up to 100 pounds of cement per cubic yard (60 kg/m^3) 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 nozzle person shall operate in the immediate vicinity of the backfill face to ensure compaction and complete filling of voids.

The Contractor shall submit in accordance with 2-5.3, a proposed mix design and method of placing concrete, including placing equipment. No pressure concrete backfill shall be placed until the 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.

Pressure concrete shall be placed by methods capable of forcing it into crevices and filling all void spaces in the tunnel. Unless otherwise shown 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, 150 feet (45 m). The discharge end of the slick line shall be rigid conduit with a minimum length of 10 feet (3 m). It shall be kept buried in at least 5 feet (1.5 m) of fresh concrete during concrete placement. Concrete shall be pumped continuously during withdrawal of the slick line to eliminate voids.

307-2.8 Pressure Grouting of Voids. Where the tunnel void spaces are not completely filled, the Contractor shall pressure grout such locations through grout pipes installed either from the ground surface or from within the conduit. At least 2 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 10 pounds per square inch (70 kPa)). 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 100 pounds per square inch (700 kPa) 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 10 pounds per square inch (70 kPa) except in cases where large cave-ins or other adverse conditions may require higher pressures.

307-2.9 Measurement. Tunneling will be measured by the linear foot (m) for each size of tunnel to be constructed.

307-2.10 Payment. Unless the Bid specifies Contract Unit Prices for individual work items, the Contract Unit Price per linear foot (m) shall include 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 all other work appurtenant to tunnel construction within the limits shown on the Plans. Unless otherwise specified, payment for tunnel excavation shall include the excavation 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.

For pipe laid through tunnel access shafts, payment will be made in accordance with 306-15.

No separate or additional payment will be made for:

a) additional excavation required to remove material which may fall or appears to endanger workers,
b) increasing the tunnel dimensions where necessary to provide adequate room for workers and equipment,
c) reconstruction of tunnel supports,
d) rock required to fill voids caused by overexcavation, or necessary to maintain the tunnel bottom for support of construction equipment and tunnel supporting members, or to control water during tunnel excavation, and
e) imported granular material for backpacking.

SECTION 308 – MICROTUNNELING

308-1 GENERAL. 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.

308-2 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.

308-3 SUBMITTALS. The Contractor shall submit the following items for review and approval by the Engineer in accordance with 2-5.3. Approval of the submittal by the Engineer shall be obtained prior to ordering pipe materials and/or the start of the microtunneling operations.

a) Manufacturers' data sheets and specifications describing in detail the microtunneling system to be used.

b) Description of similar projects with references on which the proposed system was successfully used by the Contractor/operator.

c) Description of method to remove and dispose of spoil.

d) Maximum anticipated jacking loads and supporting calculations.

e) 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.

f) Shaft dimensions, locations, surface construction profile, depth, method of excavation, shoring, bracing, and thrust block design.

g) Pipe design data and specifications.

h) A description of the grade and alignment control system.

i) Intermediate jacking station locations and design.

j) Description of lubrication and/or grouting system.

k) Layout plans and descriptions of operational sequence.

l) 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 25 feet (8 m) on both sides of all microtunneling pipelines at a maximum spacing of 100 feet (30 m) along the pipeline route, or as required by the Engineer.

m) 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.

n) 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, the Contractor shall provide the following:

1) Protection against soil instability and ground-water inflow.
2) Safety for shaft access and exit, including ladders, stairs, walkways, and hoists.
3) Protection against mechanical and hydraulic equipment operations, and for lifting and hoisting equipment and material.
4) Ventilation and lighting.
5) Monitoring for hazardous gases.
6) Protection against flooding and means for emergency evacuation.
7) Protection of shaft, including traffic barriers, accidental or unauthorized entry, and falling objects.
8) Emergency protection equipment.
9) Safety supervising responsibilities.

o) Annular space grouting plan if required by the Contract Documents.

308-4 MINIMUM SOIL COVER. The minimum depth of cover to the top of the installed pipe using this process shall be 1-1/2 to 3 times the outside diameter of the pipe being installed, or 6 feet (2 m), whichever is greater depending on the soil conditions. With prior approval of the Engineer, the minimum depth of cover may be reduced.

308-5 SURFACE DESCRIPTION. Unless otherwise specified in the Contract Documents, settlement of heave at the ground surface during and after construction shall not exceed 1/2 inch (12.5 mm) 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.

308-6 SUBSURFACE CONDITIONS.

308-6.1 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 308-6.3. All subsurface investigations deemed necessary by the Contractor to complete the work shall be included. Copies of all reports and information obtained by the Contractor shall be provided to the Agency.

308-6.2 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 copies of the information and reports listed in 2-7 and 308-6.3 and submit in accordance with 2-5.3. Microtunneling operations must be approved by the Engineer prior to the start of microtunneling work.

308-6.3 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 work and soil conditions encountered and may include but not be limited to the following:

Particle-size analysis: ASTM D422

Soil Classification: ASTM D2487

Plastic limit: ASTM D4318

Liquid limits: ASTM D4318

Plasticity index: ASTM D4318

Expansion index: ASTM D4829

Density: ASTM D1556, D2037, D5195, D4564

Water (Moisture) content: ASTM D4959, D2216, D5220, D3017, D4643, D4944

Shear strength:

Direct: ASTM D3080

Triaxial, C.U: ASTM D4767

Unconfined compressive strength: ASTM D2166

Permeability: ASTM D2434

Apparent or unconfined soil cohesion.

Standard penetration test (SPT): ASTM D1586.

Water table depth

Nature of fill material

Nature of pollutants

Rock type and color

Fracture index

Rock quality designation (RQD)

Core recovery, TCR.

Reasonable attempts will be made to collect subsurface test samples within 20 feet (6 m) horizontally of the centerline of the proposed conduit location. Subsurface test samples will be collected to a minimum depth of one pipe diameter below conduit invert. The test samples will typically be collected at 200-foot (60 m) intervals or at manhole locations.

308-7 PIPE. Pipe 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 1/16 inch per foot (5 mm/m) of pipe diameter, with a maximum of 1/4 inch (6 mm), 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 Special Provisions or shown on the Plans.

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.

308-8 MICROTUNNELING SYSTEM COMPONENTS.

308-8.1 Microtunneling Tunnel Boring Machine (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 1 inch (25 mm), unless otherwise specified.

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.

308-8.2 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 betonite 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.

308-8.3 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.

308-8.4 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.

308-8.5 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.

308-8.6 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 ± 1 inch (25 mm) on grade and 1-1/2 inches (38 mm) in line between shafts, unless otherwise specified or approved by the Engineer.

The rate of return to line and grade shall not exceed 1 inch in 25 feet (1:300), unless otherwise specified.

308-9 METHODS.

308-9.1 General. Prior to pipe installation, the Contractor shall implement the approved submittals to monitor ground movement.

308-9.2 Intermediate Shafts. If an intermediate shaft is requested, the Contractor shall obtain written approval from the Engineer. The Contractor's request shall include all necessary permits and approvals, minimize public inconvenience and minimize impacting existing facilities.

308-9.3 Annular Space Grouting. The annular space created by the overcut of the MTBM in excess of 3/4 inch (19 mm) shall be filled with a material approved by the Engineer unless otherwise specified.

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.

308-9.4 Work Hours. Work hours are not restricted unless otherwise specified in the Special Provisions. Multiple shifts may be used if noise levels do not exceed local ordinances unless otherwise specified in the Special Provisions. Continuous microtunneling will be permitted where:

a) Expansive soils are encountered; or

b) The actual jacking forces required approach either the capacity of the jacking system or the designed jacking capacity of the pipe.

308-9.5 Construction Zones. Microtunneling construction zones in the public right-of-way shall be limited to one lane of 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.

308-9.6 Shafts. Shafts shall be of a size commensurate with safe working practices and located as shown on the Plans or Working Drawings. 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.

Shafts shall be backfilled per 306-12. Shoring materials, bracing, temporary supports, rubbish, and construction materials shall be removed from the Work site and disposed of by the Contractor.

308-9.7 Testing. Installed pipe shall be tested in accordance with 306-7.8.

308-10 RESTORATION OF SURFACE IMPROVEMENTS. Unless otherwise specified in the Special Provisions or shown on the Plans, existing surface improvements damaged or removed as a result of microtunneling operations shall be restored to their original condition.

308-11 MEASUREMENT. Tunneling will be measured by the linear foot (m). The limits of measurement for payment shall be as specified in the Special Provisions or shown on the Plans.

308-12 PAYMENT. Unless the Bid lists Contract Unit Prices for individual work items, the Contract Unit Price per linear foot (m) shall include 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 shown on the Plans.

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 Special Provisions, or as directed by the Engineer.

309-2 MATERIALS. The concrete portion of monuments shall be constructed in accordance with 201-1 and 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 1 inch (25 mm) circle in the center of the plate.

Monuments shall be set firmly and vertically in the ground to a depth of at least 3 feet (0.9 m).

The tops of survey monument covers shall be set flush with the groundline or pavement surface, whichever applies.

309-4 PAYMENT. The Contract Unit Price for each survey monument shall include full compensation for doing all the work involved in constructing the survey monument, 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 35°F (2°C), 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 35°F (2°C) 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.

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*.

* Portions reproduced courtesy of Steel Structures Painting Council.

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 specified in 310-2.3. Other detrimental foreign matter shall be removed by the following operations:

a) Stratified rust (rust scale) shall be removed by hand hammering, hand chipping, other hand impact tools, or a combination thereof.

b) 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 2 square feet (0.2 m^2) 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:

a) 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.

b) Spraying of the surface with solvent. The final spraying shall be done with clean solvent.

c) 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 specified 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 specified 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:

a) 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.

b) 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.

c) 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 6-inch (150 mm) 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 16 pounds (71 N), and the rate of cleaning shall be 2 square feet (0.2 m^2) 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 specified 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 2/3 of each square inch (645 mm^2) 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:

a) Dry sandblasting using compressed air blast nozzles and dry sand of a maximum particle size no larger than that passing through a No. 16 (1.18 mm) mesh screen, U.S. sieve series.

b) 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 No. 16 (1.18 mm) mesh screen, U.S. sieve series.

c) 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.

d) 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.

e) Closed, re-circulating nozzle blasting using compressed air, vacuum, and any of the preceding abrasives.

f) 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 No. 30 mesh (600 µm). 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 2 coats), a pre-treatment, and 2 finish coats. The total dry film thickness of the primer shall not be less than 3 mils (80 µm), and the total dry film thickness of the 2 finish coats shall be not less than 2 mils (50

μm). 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 0.25 pounds per gallon (30 g/L) 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 specified 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 No. 30 to 60 (600 μm to 250 μm) 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 2

inches (50 mm) 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. No separate or additional payment will be made for furnishing and maintaining enclosures to permit painting during inclement weather.

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 with one coat of zinc dust-zinc oxide primer conforming to 210-1. 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 Contract Unit Price 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 Contract Unit Price 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 2 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 Bid prices for the various Contract items of work involving lumber and no separate payment for such work will be made.

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 Engineer and shall consist of the following:

a) Two pieces of liner at least 15 inches (380 mm) long and 9 inches (230 mm) wide, shall be lapped 1-1/2 inches (38 mm) and held in a vertical position.

b) 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 2 inches (50 mm) beyond the liner to provide tabs.

The weld specimen will be tested by the Engineer as follows:

a) Each welding strip tab, tested separately, shall be subjected to a 10-pound (45 N) 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.

b) Three test specimens shall be cut from the welded sample and tested in tension across the welds.

   1) If none of these specimens fails when tested as indicated in 210-2.3.5, the weld will be considered as satisfactory.

   2) If one specimen fails to pass the tension test, a retest will be permitted. The retest shall consist of testing 3 additional specimens cut from the original welded sample. If all 3 of the retest specimens pass the test, the weld will be considered satisfactory.

   3) If 2 of 3 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 Plans 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 1-1/2 inches (38 mm). 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 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 1/2 inch (12.5 mm) 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 4 inches (100 mm). Where sheets are cut and joined for the purpose of fitting irregular surfaces, this space shall not exceed 2 inches (50 mm).

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 2 inches (50 mm) nor greater than 4 inches (100 mm) 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 32 mils (800 μm).

Intermediate weep channels shall be provided as required by the Plans or Special Provisions. Intermediate weep channels shall not be less than 2.5 inches (63 mm) nor greater than 4 inches (100 mm) in width. If locking extensions are removed to provide intermediate weep channels, the base of the extension left on the sheet shall not exceed 63 mils (1.6 μm). 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 2 inches (50 mm) 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 12 inches (300 mm) 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 Special Provisions, a 12-inch (300 mm) long weld strip, 1 inch (25 mm) 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 Special Provisions, or the Standard Plans showing liner installation methods, returns shall be made as follows:

a) Each liner return shall be a separate strip of liner at least 3 inches (75 mm) wide joined at right angles to the main liner by means of approved corner strips.

b) 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 2 inches (50 mm) of densely caulked cement mortar, lead wool, or other caulking material approved by the Engineer, and finish coated with a minimum of 1 inch (25 mm) of an approved corrosion-resistant material.

311-1.4 Concrete Casting Operations.

311-1.4.1 Concrete Placement. During placement, concrete shall be continuously vibrated to avoid damage to the liner and securely anchor the locking extensions into the concrete.

311-1.4.2 Removing Forms. When removing forms, care shall be taken to protect the 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:

a) Flexible liner Type P-1 joint shall consist of a 4-inch (100 mm) joint strip, centered over the mortared pipe joint and secured along each edge to adjacent liner by means of a welding strip.

b) 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 3 inches (75 mm) 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.

c) Rigid liner Type CJ-1 shall consist of a co-extruded 7-1/4 inch (185 mm) 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.

d) Field joints in rigid liner at manhole joints shall use and shall consist of a 1-1/2 inch (38 mm) by 1-1/2 inch (38 mm) 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 in 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 in 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 1/2 inch (13 mm). 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 1-1/2 inches (38 mm) 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 4 inches (100 mm).

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 1/8 inch (3 mm).

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 500°F and 600°F (260°C and 315°C).

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 1/8 inch (3 mm) 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 12-inch (300 mm) 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:

a) 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.
b) 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:

a) The liner shall be cleaned, dried, and sprayed with an adhesive coating recommended by the manufacturer of the liner plate.

b) Immediately after the adhesive is applied to the liner, the surface shall then be liberally sprinkled with clean, dry, well-graded sand, passing a No. 30 (600 μm) sieve but be retained on a No. 70 (212 μm) 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.

c) 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 1/16 inch (1.5 mm) above the pipe surface. In the event that field welding is required, the plastic liner shall not be installed closer than 12 inches (300 mm) 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 4 inches (100 mm).

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 3 standard sizes: 2-inch (50 mm), 3-inch (75 mm), and 4-inch (100 mm) diameter disks with a thickness of 78 mils (1.98 μm). 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 Contract Unit Price or lump sum price in the Bid for the pipe or structure to which they are applied.

SECTION 314 - TRAFFIC STRIPING, CURB AND PAVEMENT MARKINGS, AND PAVEMENT MARKERS

314-1 GENERAL. The work shall consist of the removal and application of traffic striping (striping), curb and pavement markings (markings), and pavement markers at the locations shown on the Plans.

For the purposes of these Specifications, traffic striping shall be defined as longitudinal centerlines and lane lines that separate traffic lanes in the same or opposing direction of travel, and longitudinal edge lines that mark the edge of the traveled way or the edge of the lanes. Curb markings shall be defined as colored markings on the curb that denote parking restrictions. Pavement markings shall be defined as transverse markings which include, but are not limited to, word and symbol markings, limit lines (stop lines), crosswalks, shoulder markings, parking stall markings and railroad crossing markings.

The type of material, paint or thermoplastic, to be applied shall be as specified in the Special Provisions or as shown on the Plans.

314-2 REMOVAL OF TRAFFIC STRIPING AND CURB AND PAVEMENT MARKINGS.

314-2.1 General. The Contractor shall remove existing traffic striping and pavement markings by wet or dry sandblasting, high velocity water jet, grinding, or other methods as specified in the Special Provisions. Obliteration with black paint or emulsified asphalt will not be allowed.

Curb markings shall be painted over as specified in the Special Provisions or shown on the Plans.

Conflicting striping and pavement markings shall be removed before the application of new temporary or permanent traffic striping, and curb or pavement markings.

314-2.2 Measurement. Removal of traffic striping and curb and pavement markings will be measured as follows:

a) Traffic striping and curb markings will be measured by the linear foot (m) for each width and type of traffic stripe or curb marking.
b) Pavement markings will be measured by the square foot (m^2). The space between the stripes or letters will be included in the overall measurement.

314-2.3 Payment. Payment for removal of traffic striping and curb markings will be made at the Contract Unit Price per linear foot for each width and type of traffic stripe or curb marking. Payment for removal of pavement markings will be made at the Contract Unit Price per square foot.

314-3 REMOVAL OF PAVEMENT MARKERS.

314-3.1 General. Removal of existing pavement markers shall be performed in such a manner as to leave the existing pavement undamaged.

Asphalt concrete pavement shall be considered damaged when a depression of more than 1/4 inch (6 mm) results. Damaged asphalt concrete pavement shall be patched with E-PG 64-10 asphalt concrete pavement conforming to 203-6 and 302-5.

314-3.2 Measurement. Removal of pavement markers will be measured by each pavement marker removed.

314-3.3 Payment. Payment for removal of pavement markers will be made at the Contract Unit Price for each pavement marker to be removed.

314-4 APPLICATION OF TRAFFIC STRIPING AND CURB AND PAVEMENT MARKINGS.

314-4.1 General. Traffic striping and curb and pavement markings shall conform to the dimensions and details shown on the Plans.

314-4.2 Control of Alignment and Layout.

314-4.2.1 General. When necessary, the Engineer will furnish the necessary control points. The Contractor shall establish traffic striping between these points by string line or other method approved by the Engineer.

Traffic lines shall be spotted in advance of application by using a rope as a guide for marking spots every 5 feet (1.5 m), by using a marking wheel mounted on a vehicle, or by another method approved by the Engineer.

314-4.3 Painted Traffic Striping and Curb and Pavement Markings.

314-4.3.1 General. The work shall consist of applying painted (including glass beads) traffic stripes and curb and pavement markings at the locations shown on the Plans. Glass beads shall conform to 214-3. Paint shall conform to 214-4.

Paint shall be applied only when:

a) the pavement surface is dry and clean,
b) the atmospheric temperature is above 40°F (1°C) when using acetone-based paint and 50° F (10°C) when using waterborne paint,
c) the weather is not windy, foggy, or humid,
d) the forecast atmospheric temperature will not drop below the aforementioned 40°F (1°C) or 50° F (10°C) temperatures during the drying period, and
e) the forecast temperature is within the paint manufacturer's recommended range.

314-4.3.2 Surface Preparation. Before applying paint, the existing pavement surface shall be cleaned. Areas which cannot be satisfactorily cleaned shall be scrubbed with a water solution of tri-sodium phosphate (10 percent Na_3PO_4) or other cleaning solution approved by the Engineer. After cleaning, the surface shall be rinsed with water and dried before painting. The cleaning solution and rinse water shall not be allowed to enter any storm drain or natural water course.

314-4.3.3 Mixing. Mechanical mixers shall be used to mix paint. Prior to application, paint shall be mixed a sufficient length of time to thoroughly mix the pigment and vehicle together, and shall be kept thoroughly agitated during application.

314-4.3.4 Application Equipment.

314-4.3.4.1 General. Application equipment shall be approved by the Engineer prior to use. Application equipment shall include brushes, brooms, compressors, air blowers, mechanical marking machines, heating devices, bead dispensing devices, auxiliary hand spray painting equipment, stencils, paint rollers, and other equipment necessary to complete the work.

314-4.3.4.2 Striping Machines. Striping machines shall:

a) be a spray-type, rubber tired vehicle suitable for applying traffic paint;
b) have sufficient paint capacity for each color with adequate air pressure to perform the Work satisfactorily without excessive stopping;
c) be capable of producing a uniform film thickness without running or spattering;
d) be capable of being guided within the straightness tolerances set forth in these Specifications;
e) have suitable adjustments for painting the line width specified and when required, be equipped with an automatic cycling device to produce intermittent (skip) lines in accordance with 314-4.2.1;
f) 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;
g) be capable of accurately superimposing succeeding coats of traffic paint upon the first coat and upon existing stripes at a minimum speed of 5 mph (8 km/h);
h) be capable of 2-gun, or 3-gun (1 black and 2 yellow spray guns operating simultaneously or individually) applications;
i) have a wheel base of sufficient length to produce a straight line to meet the straightness tolerance specified in 314-4.2.4; and
j) be capable of producing curved lines without abrupt breaks.

Striping machines shall be equipped with the following:

k) a pointer or sighting device not less than 5 feet (1.5 m) long extending from the front of the machine;
l) a pointer or sighting device extending from the side of the machine to gauge the distance from the centerline for painting shoulder stripes;
m) shields or an adjustable air curtain for line control;
n) pressure regulators and gages (if pneumatically operated) that are in within full view of the operator;
o) a paint strainer in the paint supply line;
p) a paint storage tank with a mechanical agitator that operates continuously during painting operations;
q) a glass bead dispenser located behind the paint applicator nozzle which is controlled simultaneously with the paint applicator nozzle; and
r) calibrated rods for measuring the volumes of paint and glass beads in the paint and glass bead tanks.

Where the configuration or location of a traffic stripe is such that the use of striping machines is unsuitable, traffic paint and glass beads may be applied by other methods and equipment approved by the Engineer. The Engineer will determine if the striping machine is unsuitable for a particular use.

Stencils and hand spray equipment shall be used to paint curb and pavement markings. Stencils shall conform to the dimensions shown on the Standard Plans.

314-4.3.5 Application. Each coat of paint for any traffic stripe, including glass beads, shall be applied in one pass of the striping machine, regardless of the number, widths and patterns of individual stripes involved.

On 2-lane streets, when the first coat of the centerline stripe is applied in the same direction as the stationing increases, the right-hand spray gun of the 3 spray guns used to apply a double yellow stripe shall be used to apply a single yellow stripe. When the first coat of the centerline stripe is applied in the direction as the stationing decreases, the left-hand gun of the 3 spray gun used to apply double yellow stripe shall be used to apply a single yellow stripe. The second coat of centerline striping shall be applied in the opposite direction that the first coat was applied.

A 1-coat, 3-inch (75 mm) wide black stripe shall be painted between the 2, 4-inch (100 mm) wide yellow stripes of a double traffic stripe. If the 2, 4-inch (100 mm) wide yellow stripes are to be applied in 2 coats, the black stripe shall be applied concurrently with the second yellow stripe.

On existing pavement surfaces, traffic striping and pavement markings shall be applied in 1 coat. Paint to be applied in 1 coat shall be applied at an initial rate of 1 gallon per 107 square feet (1 L/2.6 m^2) unless otherwise specified in the Special Provisions. The final rate shall be approved by the Engineer.

On new pavement surfaces, traffic striping (except the black stripe between the yellow stripes of a double traffic stripe) and pavement markings shall be applied in 2 coats unless otherwise shown on the Plans or specified in the Special Provisions. If the paint is applied in 2 coats, the first coat shall be thoroughly dry before the second coat is applied.

Paint to be applied in 2 coats shall be applied at the initial rates shown in Table 314-4.3.5 unless otherwise specified in the Special Provisions.

TABLE 314-4.3.5

Paint Type	Square Foot Coverage Per Gallon	
	First Coat	Second Coat
Waterborne Paint	215	215
Acetone-Based Paint	360	150

The final application rates shall be approved by the Engineer. The volume of paint applied shall be measured by inserting a calibrated rod into the paint tank. At the option of the Engineer, if the striping machine is equipped with paint gauges, the volume of paint may be determined by using the gauges.

Glass beads shall be mechanically applied to the surface of each coat of paint, except black paint, prior to the paint setting. Glass beads shall be embedded to a depth of one-half of their diameter. Glass beads shall be applied at a rate of 5 pounds per gallon (2 kg/L) of paint unless otherwise specified in the Special Provisions or directed by the Engineer. The amount of glass beads applied shall be measured by inserting a calibrated rod into the glass bead tank of the striping machine.

314-4.3.6 Measurement. Painted traffic stripes will be measured by the linear foot along the line of the traffic stripes, without deductions for gaps in broken traffic stripes. A double traffic stripe, consisting of 2, 4-inch (100 mm) wide yellow stripes separated by a 3-inch (75 mm) wide black stripe, will be measured as 1 traffic stripe.

Painted curb markings will be measured by the linear foot (m).

Painted pavement markings will be measured by the square foot (m^2) for the actual area painted or by lump sum.

314-4.3.7 Payment. Payment for painted traffic stripes and painted curb markings will be made at the Contract Unit Price per linear foot (m) for the number of coats of paint required, as specified in the Proposal, regardless of the number, widths, and pattern of individual stripes composing each traffic stripe.

Payment for painted pavement markings will be made at the Contract Unit Price per square foot (m^2) or lump sum Bid price for the number of coats of paint required, as specified in the Proposal.

No separate payment will be made for establishing alignment for stripes and layout work.

314-4.4 Thermoplastic Traffic Striping and Pavement Markings.

314-4.4.1 General. The work shall consist of applying thermoplastic traffic striping and pavement markings at the locations shown on the Plans and Standard Plans. Glass beads shall conform to 214-3. Thermoplastic material shall conform to 214-5.

Thermoplastic traffic striping and pavement markings shall only be applied to dry pavement surfaces with a surface temperature above 50° F (10° C) unless otherwise specified in the Special Provisions. The wind shall be calm enough that no blowing dirt is deposited on the pavement surface.

314-4.4.2 Surface Preparation. Before applying thermoplastic material, the existing pavement surface shall be mechanically wire brushed to remove all dirt and contaminants. New Portland cement concrete pavement shall be mechanically wire brushed or abrasive blast-cleaned to remove all laitance and curing compound.

314-4.4.3 Application Equipment. Application equipment shall be approved by the Engineer prior to use. Pre-heaters with mixers having a 360-degree rotation shall be used to preheat thermoplastic material before it is applied.

Application equipment shall be capable of:

a) utilizing either the spray or extrusion methods;
b) applications that dry to "no pick up" in accordance with ASTM D711; and
c) producing smooth, continuous lines having sharp dimensions.

Thermoplastic pavement markings shall be applied with equipment and stencils specifically designed and constructed for that purpose.

314-4.4.4 Application. A primer, of the type recommended by the manufacturer of the thermoplastic material, shall be applied to asphalt concrete surfaces over 6 months old and to all Portland cement concrete surfaces. The primer shall be applied immediately in advance of, but concurrent with, the application of thermoplastic material. The primer shall be applied at the rate recommended by the manufacturer and shall not be thinned.

Thermoplastic material shall be applied at a temperature between 400°F and 425°F (200° C and 218° C), unless a different temperature is recommended by the manufacturer. Thermoplastic material shall be applied in a single layer. The pavement surface to which the thermoplastic material is applied shall be completely coated by the material and the voids in the pavement surface shall be filled.

Unless otherwise specified in the Special Provisions, thermoplastic material for traffic striping shall be applied at a minimum thickness of 60 mils (1,500 µm). Thermoplastic material for pavement markings shall be applied at a thickness of 100 to 150 mils (2,500 µm to 3,800 µm).

Glass beads conforming to 214-3 shall be mechanically applied to the surface of the molten thermoplastic material at a rate of not less than 8 pounds per 100 square feet (0.39 kg/m^2). The amount of glass beads applied shall be measured by inserting a calibrated rod into the glass bead tank.

314-4.4.5 Measurement. Thermoplastic traffic striping will be measured by the linear foot (m) along the line of the traffic stripes, without deductions for gaps in broken traffic stripes. A double traffic stripe, consisting of 2, 4-inch (100 mm) wide, yellow stripes, will be measured as 2 traffic stripes.

Thermoplastic pavement markings will be measured by the square foot (m^2) for the actual area covered or by the lump sum.

314-4.4.6 Payment. Payment for thermoplastic traffic striping will be made at the Contract Unit Price per linear foot (m) for each width and pattern, as specified in the Proposal.

Payment for thermoplastic pavement markings will be made at the Contract Unit Price per square foot (m^2).

No separate payment will be made for establishing alignment for stripes and layout work.

314-4.5 Tolerances and Appearance. Traffic striping shall not vary more than 1/2 inch in 50 feet (80 mm/100 m) from the specified alignment.

Straight stripes deviating more than 1/2 inch in 50 feet (80 mm/100 m) shall be obliterated by sandblasting and the markings corrected. When existing traffic striping and pavement markings are to be repainted, they shall be repainted to completely cover the old markings within 1/4 inch (6 mm). Stripe repainting shall be retraced within a longitudinal tolerance of 6 inches (150 mm) 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.

Drips, overspray, improper markings, paint and thermoplastic material tracked by traffic shall be immediately removed, at the Contractor's expense, from the pavement surface by methods approved by the Engineer.

Completed traffic stripes shall have clean and well-defined edges without running or deformation, be uniform, be straight on tangent alignments and be a true arc on curved alignments. The widths of completed traffic stripes shall not deviate more than 1/4 inch (6 mm) on tangent nor more than 1/2 inch (12.5 mm) on curves from the width shown on the Standard Plans. Broken traffic stripes shall also conform to the following:

a) The lengths of the gaps and individual stripes that form broken traffic stripes shall not deviate more than 2 inches (50 mm) from the lengths shown on the Standard Plans.
b) The lengths of the gaps and individual stripes shall be of such uniformity throughout the entire length of the broken traffic stripes that a striping machine will be able to repeat the pattern and superimpose additional stripes upon the traffic stripe being applied.

Completed curb and pavement markings shall have clean and well-defined edges without running or deformation and conform to the dimensions shown on the Standard Plans, except that minor variations may be accepted by the Engineer.

314-4.6 Protection from Damage. Newly placed traffic stripes and curb and pavement markings shall be protected from damage by public traffic or other causes until the paint is thoroughly dry or the thermoplastic material has sufficiently hardened. All adjacent surfaces shall be protected from disfiguration by spatter, splashes, spillage, and dripping of paint or other material.

314-5 PAVEMENT MARKERS.

314-5.1 General. The work shall consist of applying pavement markers conforming to 214-7 to the existing pavement surface at the locations shown on the Plans.

314-5.2 Adhesives.

314-5.2.1 General. Pavement markers shall be cemented to the pavement with rapid-set epoxy adhesive conforming to 214-7.2.2 or hot-melt bituminous adhesive conforming to 214-7.3 unless otherwise specified in the Special Provisions.

In areas of new construction where the pavement markers are protected from traffic, including the Contractor's vehicles, standard-set epoxy adhesive conforming to 215-5.2.5 may be used. Pavement markers applied with standard-set epoxy adhesive shall be protected from traffic for at least 3 hours after placement when the pavement surface temperature is 55°F (13° C) or above, for at least 24 hours when the pavement surface temperature is between 40°F and 55°F (4°C and 13° C), and for at least 48 hours when the pavement surface temperature is 40°F (4°C) or below. The Engineer will determine when the adhesive has set sufficiently to bear traffic.

Regardless of the type of adhesive used, pavement markers shall not be placed when the pavement is not surface dry.

314-5.2.2 Epoxy Adhesives.

314-5.2.2.1 General. Pavement markers shall not be placed using epoxy adhesives when either the pavement or the atmospheric temperature is 32°F (0°C) or less. Epoxy adhesives shall not be used to apply non-reflective plastic pavement markers.

314- 5.2.2.2 Mixing.

a) **General.** Automatic mixing equipment shall use positive displacement pumps capable of metering the 2 components in the specified ratio to within ± 5 percent by volume of either component. At the beginning of each working day when directed by the Engineer, the ratio of the 2 components 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 2 suitable containers with the unmixed components. The mixing equipment shall mix the 2 components until there is no trace of black or white streaks in the mixed epoxy adhesive. Voids in a cured, undisturbed sample of the mixed epoxy adhesive obtained from the extrusion nozzle shall not exceed 4 percent.

b) **Rapid-Set Epoxy Adhesives.** Rapid-set type epoxy adhesives shall not be mixed by hand. Rapid-set epoxy adhesives shall be mixed by a 2-component-type automatic mixing and extrusion apparatus. When machine mixing standard-set epoxy adhesive or rapid-set epoxy adhesive, pavement markers shall be placed within 60 seconds after the epoxy adhesive has been mixed and extruded and no further movement of the marker will be allowed. In addition, the time between when the components are pumped into the mixing head and when the mixed epoxy adhesive is in place on the pavement, and not subject to further movement, shall not exceed 90 seconds. Mixed epoxy adhesives shall not remain in the mixing head for more than 45 seconds. Epoxy adhesive remaining in the mixing head longer than this period shall be disposed of.

c) **Standard-Set Epoxy Adhesives.** When hand mixing standard-set epoxy adhesives, not more than 1 quart shall be mixed at a time, and the pavement markers shall be aligned and pressed into place within 5 minutes after beginning mixing operations. A mixed batch which becomes so viscous that the adhesive cannot be readily extruded from under the marker upon application of slight pressure shall not be used.

314-5.2.3 Hot-Melt Bituminous Adhesives. Pavement markers shall not be placed using hot-melt bituminous adhesives when the pavement surface or atmospheric temperature is 50°F (10°C) or less.

Hot-melt bituminous adhesives shall be heated indirectly in an applicator with continuous agitation or recirculation. Hot-melt bituminous adhesives shall not be heated above the maximum safe heating temperature recommended by the manufacturer and shall not be applied at temperatures greater than 425°F (210°C) nor less than 375°F (190°C).

314-5.3 Surface Preparation. The existing pavement surface shall be free from dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material that would adversely affect the bond of the adhesive. Cleaning shall be done by blast cleaning on all surfaces regardless of age or type, except that blast cleaning of clean, new asphalt concrete and clean, new seal coat surfaces will not be required when hot-melt bituminous adhesives are used.

314-5.4 Placement. Reflective markers shall be placed in such a manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. Pavement markers shall not be placed over longitudinal or transverse joints of the pavement surface. Pavement markers shall not be placed on new asphalt concrete pavement or seal coats until they have been open to public traffic for a period of not less than 7 Days when hot-melt bituminous adhesive is used, or not less than 14 Days when epoxy adhesive is used.

Adhesives shall be placed uniformly on the pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact with the pavement marker with no voids present and with a slight excess after the marker has been pressed in place. Pavement markers shall be placed in position and pressure applied until firm contact is made with the pavement. When hot-melt bituminous adhesive is used, the markers shall be placed immediately after application of the adhesive. 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. Markers shall be protected against impact until the adhesive has hardened to the degree designated by the Engineer.

314-5.5 Pavement Recesses. Pavement recesses shall be located along the line or lines of new or existing stripes.

Pavement recesses shall be constructed in new or existing pavement. The method of recess construction shall be selected by the Contractor. Equipment for recess construction shall be power-operated, mechanical and capable of removing the pavement to the dimensions shown on the Plans or Standard Plans without damaging the underlying pavement.

Residue shall be removed from the roadbed by use of vacuum equipment. Residue from the removal operations shall neither flow across the pavement nor into gutters or other drainage facilities. Residue shall be removed from the pavement surface before the residue is blown by action of traffic or wind.

Pavement recesses shall not be constructed on existing structures.

314-5.6 Measurement. Retroreflective and non-reflective pavement markers will be measured by the number of each type of pavement marker placed on the pavement surface. Retroreflective pavement markers placed in a pavement recess will be measured by the number of each type of pavement marker.

314-5.7 Payment. Payment for retroreflective and non-reflective pavement markers placed on the pavement surface will be made at the Contract Unit Price for each type of pavement marker placed on the pavement surface.

Payment for retroreflective pavement markers placed in pavement recesses will be made at the Contract Unit Price for each pavement marker placed in a pavement recess.

PART 4
ALTERNATE MATERIALS

SECTION 400 - ALTERNATE ROCK PRODUCTS, UNTREATED BASE MATERIALS AND PORTLAND CEMENT CONCRETE

400-1 ROCK PRODUCTS.

400-1.1 General. This subsection shall apply only when Alternate Rock Material-Type S is specified.

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 C131, 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 No. 4 (4.75 mm) sieve and fine aggregate is material passing the No. 4 (4.75 mm) sieve.

Materials may be sampled at any time until final formal acceptance of the Work.

400-1.2 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, 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.

400-1.3 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 any 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 in accordance with 211-5.

400-2 UNTREATED BASE MATERIALS.

400-2.1 General. 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.

400-3.1 General. The provisions of 201-1 shall apply except that gradings A, B, and C may be used interchangeably. When no class is specified, Class 560-C-3250 (330-C-23) 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.

400-3.2 Coarse Aggregate. Coarse aggregate shall meet the requirements of 200-1.4 with the following modifications:

a) The soundness loss, when tested by California Test 214 shall not exceed 10 percent.

b) The minimum specific gravity of the No. 4 (4.75 mm) material shall be 2.56.

c) 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 400-3.2 for each aggregate size.

TABLE 400-3.2: PERCENTAGE PASSING

Sieve Sizes	Number 2		Number 3		Number 4
	Individual Test Results	Moving Average	Individual Test Results	Moving Average	Combined Average
2" (50 mm)	100	100	-	-	-
1-1/2" (37.5 mm)	89-100	91-100	100	100	-
1" (25 mm)	X ± 18	X ± 12	89-100	91-100	-
3/4" (19 mm)	0-16	0-14	X ± 18	X ± 12	100
3/8" (9.5 mm)	0-5	0-4	X ± 18	X ± 12	90-100
No. 4 (4.73 mm)	-	-	0-16	0-14	0-30
No. 8 (2.36 mm)	-	-	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).

400-3.3 Fine Aggregate. 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 400-3.3: PERCENTAGE PASSING

Sieve Sizes	Individual Test Results	Moving Average
3/8" (9.5 mm)	100	100
No. 4 (4.75 mm)	95 - 100	96 - 100
No. 8 (2.36 mm)	61 - 99	66 - 94
No. 16 (1.18 mm)	X ± 11	X ± 8
No. 30 (600 µm)	X ± 8	X ± 7
No.50 (300 µm)	X ± 6	X ± 4
No. 100 (150 µm)	1 - 11	3 - 9
No. 200 (75 µm)	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.

PART 5
PIPELINE SYSTEM REHABILITATION

SECTION 500 – PIPELINE, MANHOLE AND STRUCTURE REHABILITATION

500-1 PIPELINE REHABILITATION.

500-1.1 Requirements.

500-1.1.1 General. 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 Contract will be designated on the Plans and in the Specifications. Unless otherwise specified 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 commencement of the Work to verify manufacturing compliance with required quality control standards and that no damage occurred to the materials during shipment to the Work site. At the time of installation, materials shall not be more than 6 months old from the date of manufacture. Safety data sheets shall be available at the Work site.

500-1.1.2 Submittals. Prior to rehabilitation, the Contractor shall submit Working Drawings of construction details and all other submittals per 2-5.3. The Working 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.

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.

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 specified in the Special Provisions. Pipeline debris shall be considered as, but not limited to, sludge, dirt, sand, rocks, grease, roots, and other solid or semisolid materials.

Some pipeline cleaning methods available are listed herein. When utilizing high-velocity hydraulic cleaning equipment independently or in combination with other cleaning methods, a minimum of 2 passes with the hydraulic nozzle shall be done unless otherwise approved by the Engineer. Root cutters and porcupines shall be attached to the winches if so specified in the Special Provisions or directed by the Engineer. 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 accordance 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.** 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 2 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 750 feet (230 m) of rod. The machine shall be fully enclosed and have an automatic safety clutch or relief valve.

For segmented liner systems 27 inches (675 mm) 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 1/2 inch (12.5 mm) 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 baffle plate shall be attached to the test section with adequate height to remove 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 Contract shall be considered as a changed condition in accordance with 3-4.

TABLE 500-1.1.4

Nominal ID of Liner Pipe, inches (mm)	Minimum Equipment Insertion Force, Tons (kN) [1]
27 (675) to and including 60 (1500)	25 (220)
Over 60 (1500) to and including 84 (2100)	32.5 (290)
Over 84 (2100)	50 (440)

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 is 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 in conformance with the Contract Documents and that all active service connections have been re-instated, as required. Video inspections shall be recorded on a digital storage device. All original digital recordings, log sheets, and reports shall be submitted to the Engineer and will become the 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 6 inches (150 mm) 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 shall be measured from the centerline of the manhole to the centerline of the next manhole. The camera and television monitor shall produce a minimum 350 lines per inch (14 lines/mm) 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 shall be approved by the Engineer prior to the work being performed. CCTV inspection for re-instating service connections shall be performed utilizing system b) or c).

CCTV inspection shall be performed utilizing one of the following video camera systems:

a) remote-focus stationary lens cameras;

b) rotating-lens cameras; or

c) pan-and-tilt cameras.

The CCTV inspection camera utilized shall be specifically designed and constructed for sewer inspection. The CCTV inspection 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 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 CCTV inspection 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 it be moved through the pipe at a speed greater than 30 feet per minute (9 m/min.). A clear picture shall be provided looking into each service connection for both the pre-installation and post-installation digital recording. During the pre-installation CCTV inspection, if the CCTV inspection 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 CCTV inspection, the Contractor shall remove the obstruction by excavation, repair, or other means approved by the Engineer, in order that CCTV inspection may continue.

Documentation shall consist of a color, digital recording, log sheets, and a written report detailing the post-rehabilitation condition of the pipeline and lateral connections/openings. The report shall note the time and date of CCTV 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, digital recording number, counter number, and a detailed logging of defects encountered. Any rejected work shall be repaired, then inspected by CCTV. If the quality of the digital recording is deemed to be unacceptable by the Engineer, the pipeline shall be re-televised.

Additional requirements for performing CCTV inspection will be shown on the Plans or specified in the Special Provisions.

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 requirements 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.

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 Special Provisions. 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 specified 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 2 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 segmented liner pipe 27 inches (675 mm) 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 Working 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.

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 accordance 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 1 inch (25 mm) and a maximum of 2 inches (50 mm) 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.

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 Engineer shall be promptly removed from the Work 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 per linear foot (m). If a separate Bid item is not included, payment 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 Contract Unit Price per linear foot (m) or lump sum for pipeline point repair/replacement and rehabilitation shall include furnishing and installing all fittings, connections, seals, and special work shown on the Plans and in the Specifications. Additionally, the Contract Unit Price shall include chemical and physical testing; 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.

No separate or additional payment will be made for removal of obstructions encountered during post-installation CCTV inspection, nor for re-televising necessary due to the digital recording being unacceptable to the Engineer.

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 Special Provisions 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 specified, and shall conform to 207 for the type and class required.

500-1.2.3 Excavation. Trenching and excavation shall conform to 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, in accordance with 7-8.5 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 scheduled 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 306. The Contractor shall submit the post-cleaning digital video(s) to the Engineer prior to demobilizing open trench operations. The results of the post-cleaning digital video(s) may indicate the need for additional excavation and repair prior to lining. The Contractor shall review all the post-cleaning digital video(s) and identify any additional point repair, which impact(s) 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 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 D3350 and ASTM F714. Fittings shall comply with ASTM D2683 or D3261. 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 to ASTM D3350, 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. The entire annular space shall be fully grouted. The maximum safe annular grouting pressure for single-stage or multi-stage grouting shall not exceed the values shown in Table 500-1.3.7.

TABLE 500-1.3.7
DIFFERENTIAL-PRESSURE (VACUUM OR EXTERNAL FLUID) CAPABILITY FOR UNSUPPORTED PIPE AT 73.4°F (23°C)[1]

SDR	psi (kPa)
32.5	4 (30)
26	8 (55)
21	16 (110)
19	21 (145)
17	28 (195)
15.5	36 (250)

1. Safety factor not included.

500-1.3.8 Service Connections and End Seals. 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.

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 8 feet (2.4 m) 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.

500-1.4 Cured-In-Place Pipe Liner.

500-1.4.1 General. CIPP liner for the rehabilitation of pipelines shall be either the Type A - inversion process conforming to ASTM F1216 or the Type B - pull-in-place process in compliance with ASTM F1743 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 shall be 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 D5813 and shall have, as a minimum, the initial structural properties per Table 500-1.4.2.

TABLE 500-1.4.2

Epoxy Resin Properties	ASTM Test Method	Initial Values psi (MPa)
Flexural Strength	D790	5,000 (34.5)
Flexural Modulus	D790	300,000 (2050)
Tensile Strength	D638	4,000 (27.5)
Tensile Modulus	D638	250,000 (1710)
Epoxy-Vinyl-Ester Resin Properties	**ASTM Test Method**	**Initial Values psi (MPa)**
Flexural Strength	D790	4,500 (31)
Flexural Modulus	D790	250,000 (1710)
Tensile Strength	D638	3,000 (20.5)
Tensile Modulus	D638	250,000 (1710)

The Contractor shall provide field-cured samples as directed by the Engineer and as specified in the Special Provisions. The physical properties of the finished CIPP shall be verified through a field-sampling procedure in accordance with ASTM F1216 or ASTM F1743 and in accordance with ASTM D5813.

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 shall conform to 211-2 and to the weight change requirement of Table 210-2.4.1.

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 F1216 or ASTM F1743 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 Work 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 100°F (38°C) before discharge.

500-1.4.7 Service Connections and End Seals. 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.

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.

500-1.5 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 (36 inches (900 mm) 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 D1784.

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 specified in the Special Provisions. There are 2 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 as shown in Table 500-1.5.3 (A).

TABLE 500-1.5.3 (A)

Nominal ID of Original Pipe inches (mm)	Minimum Thickness		Minimum Profile Height mils (µm)
	Former Strip mils (µm)	Joiner Strip mils (µm)	
8 to 12 (200 to 300)	25 (635)	25 (635)	192 (4880)
15 to 18 (375 to 400)	30 (760)	31 (790)	242 (6150)
24 to 36 (600 to 900)	45 (1140)	58 (1470)	480 (12200)
30 to 72 (750 to 1800) [1]	60 (1520)	–	488 (12400)

1. In some lining applications for pipes and conduits 30 to 36 inches (750 to 900 mm) 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[1] inches (mm)	Stiffness Factor (EI)[2] in^3 - lbf/in^2 ($Pa \cdot m^3$)
8 (200)	120 (14)
10 (250)	120 (14)
10 (250)	240 (27)
12 (300)	240 (27)
15 (375)	240 (27)
15 (375)	600 (68)
18 (450)	600 (68)
24 (600)	600 (68)
24 (600)	1600 (181)
30 (750)	1600 (181)
36 (900)	1600 (181)

1. For ID's larger than 36 inches (900 mm), see Plans or Special Provisions.
2. Stiffness factors shall be determined in accordance with ASTM D2412. $EI = 0.149R^3$ (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 200 linear feet (60 linear meters) of PVC product. Testing shall be performed every 2 hours and records kept on file in conformance with 500-1.5.4.

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 5 feet (1.5 m), 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.

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 joins shall be made with the plasticized end section, which shall overlap the joint by not less than 4 inches (100 mm). End joins 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 and End Seals. Service lateral connections shall be re-established with the liner in accordance with manufacturer's recommendations as approved by the Engineer.

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.

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 D3350 and ASTM F714. This method applies to the rehabilitation of 4 through 18-inch (100 through 450 mm) diameter pipe. Unless otherwise specified, 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.

TABLE 500-1.7.1[1]

Pipe Size Inches (mm)	Pipe Stiffness[2], psi(kPa)		
	SDR 21	SDR 26	SDR 32.5
4 (100)	61	31	16
6 (150)	61	31	16
8 (200)	61	31	16
10 (250)	61	31	16
12 (300)	61	31	16
15 (375)	61	31	16
18 (450)	61	31	16

1. Minimum pipe stiffness (PS) when tested in accordance with ASTM D2412.
2. PS values are from ASTM F174 Table X1.1

500-1.7.2 Material Composition. Pipe shall be made from HDPE compound complying with ASTM D3350, 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 Acceptance. Material 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 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:

a) 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.

b) 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 (1,500 pounds per square inch (10.3 MPa) 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.

c) 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.

d) After the deformed HDPE liner is outfitted with temperature and pressure instruments, steam shall be introduced into the system until a minimum temperature of 226°F (108°C) to a maximum temperature of 244°F (118°C) is reached and shall not exceed the melting temperature of 260°F (127°C). The minimum outside pipe temperature at the terminating end of the pipe shall be 185°F (85°C). This temperature shall be held for a minimum of 20 minutes. The deformed pipe shall be pressurized up to 14.5 pounds per square inch gage (100 kPa gage), 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 26 pounds per square inch gage (180 kPa gage).

e) The Contractor shall cool the re-formed pipe according to the approved manufacturer recommendations. When the temperature reduces to 100°F (38°C), the Contractor shall then slowly raise the pressure to approximately 33 pounds per square inch gage (230 kPa gage), while applying air or water for continued cooling. The equipment shall be disconnected after ambient temperature is attained.

f) 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.

g) If the testing of the installed HDPE liner pipe is required in the Special Provisions, 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 Special Provisions 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 D638 and ASTM D790 to confirm that the liner pipe conforms to the minimum tensile and elongation requirements specified in 500-1.7.2. All costs incurred for this testing shall be borne by the Contractor.

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.

500-1.7.8 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 Work site prior to installation will be rejected and shall be immediately removed from the Work site.

500-1.8 CCFRPM Liner Pipe.

500-1.8.1 General. CCFRPM liner for use in lining sanitary sewers shall comply with ASTM D3262. Unless otherwise specified, the minimum pipe stiffness shall be 18 pounds per square inch (125 kPa), or greater, as tested in accordance with ASTM D2412.

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 D3262 shall be Type 1, Liner 2, Grade 3, and a minimum pipe stiffness of 18 pounds per square inch (125 kPa), unless a higher value is shown on the Plans or specified in the Special Provisions. Elastomeric sealing gaskets shall conform to the requirements of ASTM F477.

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 D3262.

500-1.8.4 Marking. Each pipe section shall be marked on the inside and every 5 feet (1.5 m) on the outside, to show the manufacturer's name, manufacturing number (identifies factory location, date, shift, and sequence), nominal diameter, pipe stiffness, ASTM D3262 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 conforms to ASTM D3262 (qualification test only) and ASTM D2412.

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).

Installation shall conform to 500-1.1.7 b). The pushing force shall be applied to the pipe wall end inside of the bell. Maximum jacking loads shall not exceed the values shown in Table 500-1.8.6.

TABLE 500-1.8.6

Nominal Diameter inches (mm)	SAFE AXIAL COMPRESSIVE LOAD[1], Tons (kN)	
	18 psi (125 kPa) Pipe Stiffness Tons (kN)	36 psi (250 kPa) Pipe Stiffness Tons (kN)
18 (450)	—	17 (151)
20 (500)	—	19 (169)
24 (600)	23 (205)	31 (276)
30 (750)	36 (320)	52 (463)
36 (900)	52 (463)	66 (587)
42 (1050)	71 (632)	95 (845)
48 (1200)	93 (827)	130 (1157)
54 (1350)	123 (1094)	171 (1521)
60 (1500)	155 (1379)	212 (1886)
66 (1650)	175 (1557)	240 (2135)
72 (1800)	209 (1859)	292 (2598)
78 (1950)	252 (2242)	351 (3123)
84 (2100)	307 (2731)	422 (3754)
90 (2250)	357 (3176)	485 (4315)
96 (2400)	411 (3656)	560 (4982)
102 (2550)	470 (4181)	640 (5694)

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 1 inch (25 mm) 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 shall be equal to the pipe stiffness divided by 3.

500-1.8.8 Service Connections and End Seals. Service connections and end seals shall conform to 500-1.1.7.

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 specified in the Special Provisions. 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 shown on the Plans or specified in the Special Provisions.

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 Working 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 4 inches (100 mm).

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 and as approved by the Engineer.

Liner shall be bonded to the existing pipe a minimum of 6 inches (150 mm) 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 2-inch (50 mm) wide weld strip, centered over the 1 inch (25 mm) 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 1-1/2 inches ± 1/4 inch (38 mm ± 6 mm) beyond the end of the sheet. The sheet shall be overlapped not less than 1/2 inch (12.5 mm) and the overlap secured to the adjacent liner by means of a 1 inch (25 mm) welding strip. The downstream sheet shall overlap the upstream sheet.

3) Type R-3 joint shall consist of a 1 inch (25 mm) wide weld strip centered over a 1/4 inch (6 mm) maximum gap between sheets and secured along each edge of adjacent liner by means of a 1 inch (25 mm) 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.

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) **Scope.** This method applies to the rehabilitation of 4 through 15 inches (100 through 375 mm) diameter pipe. The standard dimension ratio shall be SDR 35, 41, or 50 as specified in the Special Provisions. 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)[2]

Nominal ID of Original Pipe inches (mm)	SDR	Stiffness Factor (EI)[1] in^3- lbf/in^2 ($Pa \cdot m^3$)
4 (100)	35	40 (4.5)
6 (150)	35	133 (15)
8 (200)	50	109 (12)
	41	198 (22)
	35	320 (36)
10 (250)	50	213 (24)
	41	388 (44)
	35	624 (70)
12 (300)	50	369 (42)
	41	671 (76)
	35	1076 (122)
15 (375)	50	720 (81)
	41	1307 (148)
	35	2105 (238)

1. Pipe Stiffness (PS) shall be determined in accordance with ASTM D2412. 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 D1784.

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 F1504, to show compliance with 500-1.10.2 b), or as specified in the Special Provisions. Testing shall be performed once per shift, change in material batch or coil. A Certificate of Compliance 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.

d) **Marking.** Marking shall conform to 207-17.2.1, except that under Item 3, there is no ASTM standard 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 psi (MPa)	D638	5,000 (34.5) min.	5,000 (34.5) min.
Impact Strength, ft-lbs/inch (J/m)	D256 Method A Size 1/2 x 1/8 x 2-1/2 inches (12.7 x 3.175 x 63.5 mm)	1.5 (80) of notch, min.	1.5 (80) of notch, min.
Weight Change % Unconditioned Conditioned	D543		 + 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 2,000 pounds (8.9 kN).

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 150°F (66°C) is attained at the terminating end. This temperature shall be held for a minimum of 5 minutes and shall not exceed 240°F (115°C).

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 5 feet per second (1.5 m/s) using steam at 5 to 8 pounds per square inch gage (35 to 55 kPa gage). 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 5 to 12 pounds per square inch gage (35 to 84 kPa gage). After the conversion to air pressure, water may be introduced until the system is completely filled. A minimum of 8 pounds per square inch gage (55 kPa gage) air or water pressure shall be maintained until the system is cooled to at least 120°F (49°C) 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 D638 for tensile strength, ASTM D790 for flexural modulus, and ASTM D2444 for impact resistance to confirm that the liner pipe conforms to the minimum requirements per 500-1.10.2 b).

500-1.10.3 Type B Folded and Re-formed PVC Pipe Liner.

a) Scope. This method applies to rehabilitation of 4 through 18-inch (100 through 450 mm) diameter pipe. The standard dimension ratio may be SDR 26, 32.5, or 41 as specified in the Special Provisions. This rehabilitation system may be capable of expanding up to 10 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 inch (mm)	**SDR**	**Stiffness Factor (EI)[1, 2] in^3 - lbf/in^2 (Pa - m^3)**
4 (100)	32.5	23 (2.7)
	26	47 (5.3)
6 (150)	32.5	79 (9.0)
	26	153 (17)
8 (200)	32.5	187 (21)
	26	365 (42)
10 (250)	32.5	364 (42)
	26	711 (81)
12 (300)	32.5	630 (72)
	26	1228 (140)
15 (375)	32.5	1226 (140)
	26	2397 (274)
18 (450)	41	1057 (121)

1. Pipe Stiffness (PS) shall be determined in accordance with ASTM D2412. 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 PVC compounds having a cell classification of 12111, as defined in ASTM D1784.

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 D7901, D2122, D2152, D2412, and F1057 to show compliance with 500-1.10.3 b) or as specified in the Special Provisions. Testing shall be performed once per shift, change in material batch, or coil. A Certificate of Compliance 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 standard 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) 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, psi (MPa) min.	D638	3,500 (24.1) min.	3,500 (24.1) min.
Impact Strength, Foot-lbs/inch (J/m) min.	D256 Method A Size 1/2 x 1/8 x 2-1/2 inches (12.7 x 3.75 x 63.5 mm)	1.2 (64) of notch, min.	1.2 (64) of notch, min.
Weight Change (%)	D543		
Unconditioned			± 1.5% max.
Conditioned			± 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 2,000 pounds (8.9 kN).

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 200°F (93°C) 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 240°F (115°C).

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 5 feet (1.5 m) per second using steam at a maximum of 10 pounds per square inch gage (70 kPa) gage. 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 10 pounds per square inch gage (70 kPa) gage. 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 100°F (38°C), the water valve on the upstream manifold shall be gradually opened to allow incoming air/water mixture to reach 80°F (27°C). 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 D638 for tensile strength, ASTM D790 for flexural modulus, ASTM D2444 for impact resistance to confirm that the liner pipe conforms to the minimum requirements per 500-1.10.3 b).

500-1.10.4 Service Connections and End Seals. Service connections and end seals shall conform to 500-1.1.7.

500-1.10.5 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 Work site.

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 F894.

Unless otherwise specified the minimum pipe stiffness shall be 22.5 pounds per square inch (155 kPa). 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 D2412 and ASTM F894. The profile configuration shall be either external or internal unless otherwise shown on the Plans or specified 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 F894 or more frequently as required by the Engineer.

TABLE 500-1.11.3

Nominal Diameter inches (mm)	RSC (Min.)	Pipe Stiffness (PS) (Min.) psi (kPa)
18 (450)	64	22.5 (155)
21 (525)	74	22.5 (155)
24 (600)	84	22.5 (155)
27 (675)	95	22.5 (155)
30 (750)	106	22.5 (155)
33 (825)	116	22.5 (155)
36 (900)	127	22.5 (155)
42 (1050)	148	22.5 (155)
48 (1200)	169	22.5 (155)
54 (1350)	191	22.5 (155)
60 (1500)	212	22.5 (155)
66 (1650)	233	22.5 (155)
72 (1800)	255	22.5 (155)

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 F894 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. Installation shall conform to 500-1.1. Maximum jacking loads shall not exceed the values shown in Tables 500-1.11.6 (A) and (B).

TABLE 500-1.11.6 (A) – EXTERIOR PROFILE

Nominal Inside Diameter inches (mm)	Safe Axial Compressive Loads*	
	RSC 100 Tons (kN)	RSC 160 Tons (kN)
18 (450)	2.3 (20.4)	3.3 (29.3)
21 (525)	2.3 (20.4)	3.8 (33.8)
24 (600)	3.3 (29.3)	3.8 (33.8)
27 (675)	3.9 (34.6)	3.8 (33.8)
30 (750)	3.9 (34.6)	4.0 (35.5)
33 (825)	N/A.	5.8 (51.6)
36 (900)	N/A.	5.8 (51.6)
42 (1050)	N/A.	9.4 (83.6)
48 (1200)	N/A.	9.8 (87.1)
54 (1350)	N/A.	17.9 (159.2)

* Includes a Safety Factor of 2:1.

TABLE 500-1.11.6 (B) – INTERIOR PROFILE

Nominal Inside Diameter inches (mm)	Safe Axial Compressive Loads*	
	RSC	Tons (kN)
18 (450)	64	9.5 (84.5)
21 (525)	74	11.0 (97.8)
24 (600)	84	12.5 (111.2)
27 (675)	95	14.0 (124.5)
30 (750)	106	15.5 (137.8)
33 (825)	116	18.5 (164.5)
36 (900)	127	20.0 (177.9)
42 (1050)	148	25.0 (222.4)
48 (1200)	169	30.0 (266.9)
54 (1350)	191	45.0 (400.3)
60 (1500)	212	58.0 (515.0)
66 (1650)	233	72.0 (640.5)
72 (1800)	255	117.0 (1040)

* 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 8 feet (2.4 m) 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 and End Seals. Service connections shall be exposed and connected to the liner pipe by use of a saddle approved by the Engineer. Service connections and end seals shall conform to 500-1.1.7.

500-1.12 PVC Closed Profile Liner Pipe.

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 F1803. Unless otherwise specified, the minimum pipe stiffness shall be 46 pounds per square inch (318 kPa), as tested in accordance with ASM D2412.

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 D1784. 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 21 through 30 inches (525 through 750 mm) or 2 shifts of production for sizes 36 through 48 inches (925 through 1200 mm). 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 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 5 feet (1.5 m) on the outside showing the manufacturers name, manufacturing number (identifies production plant, date, shift), cell classification, lot number, nominal diameter, pipe stiffness and ASTM F794. 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 shown in Table 500-1.12.5 and 208-4 respectively.

TABLE 500-1.12.5

Property	ASTM Test Method	Value (Initial and After 112-Day Exposure) Cell Class 12364
Tensile Strength (Yield), psi (MPa), min.	D638	6000 (41.5)
Impact Strength, Ft-lbs/inch (J/m) of notch, min.	D256 Method A Size 1/2 x 1/8 x 2-1/2 inches (12.7 x 3.17 x 63.5 mm)	0.65 (34.7)
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 (qualification test only) and ASM D2412.

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 shown in Table 500-1.12.6.

TABLE 500-1.12.6

Nominal Pipe Diameter in (mm)	46 psi (318 kPa) Pipe Stiffness Maximum Pushing Load – Tons (kN) [1]
21 (525)	12.5 (111)
24 (600)	12.5 (111)
27 (700)	12.5 (111)
30 (750)	12.5 (111)
36 (925)	12.5 (111)
42 (1050)	12.5 (111)
48 (1200)	12.5 (111)

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 shall be 10 pounds per square inch (70 kPa).

500-1.12.8 Service Connections and End Seals. Service connections and end seals shall conform to 500-1.1.7.

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 percent 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.

500-1.13 Spiral Wound Polyvinyl Chloride (PVC) Pipe Liner.

500-1.13.1 General. Spiral wound PVC pipe liner for use in the rehabilitation of circular and non-circular pipelines shall be a PVC profiled strip with a continuously sealed spiral joint. The profile may include steel reinforcing if shown on the Plans or specified in the Special Provisions. The profiled strip is wound into the liner shape shown on the Plans to a size ranging from 6 inches through 15 feet (150 mm through 4.6 m). The profile may be designated as "Type 1" or "Type 2" on the Plans or in the Special Provisions. Type 1 is expandable to fit against the host pipe wall. Type 2 is installed with a fixed dimension, requiring annular space grouting between the liner and the existing host pipe. An end seal shall be provided at each manhole. Installation shall be in accordance with ASTM F1741 as modified herein.

500-1.13.2 Material Composition. The profiled strip shall be made from PVC compounds conforming to ASTM F1697, Section 5. The gasket and/or sealing material shall be as recommended by the manufacturer and shall be submitted in accordance with 2-5.3. When so specified in the Special Provisions, the steel reinforcing strip shall be fabricated from steel conforming to ASTM F1697, Section 5.2. When so specified in the Special Provisions, annular space grout shall be self leveling and consolidating. Structural grout shall be of sufficient strength to support all required loads.

500-1.13.3 Material Acceptance. The material shall consist of a ribbed PVC profiled strip with interlocking, sealed edges, gasket material and steel reinforcing strip, if required. The edges lock together as the strip is wound into a pipe. The profiled strip shall have shaped ribs which vary in height and width as specified in ASTM F1697. The Contractor shall submit, in accordance with 2-5.3, a Certificate of Compliance that states that the PVC profiled strip material, gasket material, and the steel reinforcing strip conforms to ASTM F1697 and the requirements shown on the Plans and specified in the Special Provisions. The grout shall conform to ASTM F1741, and the requirements shown on the Plans and in the Special Provisions.

500-1.13.4 Marking. Each PVC profiled strip shall be distinctively marked on its inside surface at intervals not to exceed 30 feet (9 m) measured longitudinally along the profiled strip 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 profiled strip, gasket, end seals, sealants, and other material exposed to the sewer environment, as determined by the Engineer, shall be tested in accordance with 211-2 and, conform to the weight change requirements of Table 207-17.5.

500-1.13.6 Installation and Field Inspection. The existing pipeline shall be cleaned and televised in accordance with 500-1.1.4 and 500-1.1.5. When so specified in the Special Provisions, the existing pipeline may be inspected and televised by the man-entry method. The condition of the cleaned pipeline shall be approved by the Engineer prior to the installation 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 installation of the liner pipe.

At the time of installation, the profiled strip material shall be homogeneous and free of defects, cracks, holes, blisters, or foreign materials.

The installed spiral wound PVC pipe liner shall be inspected and televised in accordance with 500-1.1.4 and 500-1.1.5 or by the man-entry method if so specified in the Special Provisions.

Spiral wound PVC pipe liner shall be of uniform appearance, undamaged, free of cracks, holes, unsealed joints, and shall be installed according to the manufacturer's recommendations and in accordance with ASTM F1741. End seals shall conform to 500-1.1.7, subparagraph "e".

500-1.13.7 Connections. Connections for Type 1 liners shall be re-established in accordance with 500-1.1.7, subparagraph "a".

The Contractor shall submit the data listed in 500-3.1.10, subparagraphs "a" through "i", for the structural grout in accordance with 2-5.3.

The procedure for re-establishing service lateral connections for Type 2 liners shall be submitted to the Engineer in accordance with 2-5.3. This procedure shall include the method of blocking the service connections during grouting and the sleeving system to be used between the liner and the host pipe. The sleeving system shall conform to 500-3 and be submitted to the Engineer in accordance with 2-5.3.

500-1.13.8 Annular Space Grouting. Annular space grouting shall conform to ASTM F1741, Section 6.5. The utilization of structural or non-structural grout shall be as specified in the Special Provisions.

A structural grout mix design shall be submitted to the Engineer in accordance with 2-5.3 and shall have a minimum compressive strength of 5,000 pounds per square inch (34.5 MPa) in 28 Days when tested in accordance with ASTM C39. The submittal shall include the data listed in 500-3.1.10, subparagraphs "a" through "j", "l", and "o", for structural grout.

Non-structural grout material shall conform to 500-3.

The entire annular space shall be grouted. Grout penetration shall be verified by the Contractor. The method of verifying the penetration of the grout shall be submitted to the Engineer in accordance with 2-5.3.

500-1.13.9 Repair. The Contractor shall submit a repair method to the Engineer in accordance with 2-5.3 for any profile strips or liner pipe found to be damaged during or after installation, or if grouting deficiencies are encountered.

500-2 MANHOLE AND STRUCTURE REHABILITATION.

500-2.1 General. This subsection specifies various lining systems for manholes and structures. The types of rehabilitation materials and methods shall be as shown on the Plans and specified in the Special Provisions. Flow control, if required shall also be as shown on the Plans or as specified in the Special Provisions. Unless otherwise specified in the Special Provisions, proof of meeting the Chemical Resistance test per 211-2 shall be submitted to the Engineer per 2-5.3.

As used in this subsection "holiday" shall be defined as any discontinuity, bare or thin section in a lined or coated area.