DIVISION 25. MISCELLANEOUS CONSTRUCTION

This work consists of various types according to the requirements of the sections listed below. Comply with the lines, grades, and dimensions shown in the contract documents or established by the Engineer.

2501. Piles and Pile Driving.
2502. Subdrains.
2503. Storm Sewers.
2504. Sanitary Sewers.
2505. Guardrail Construction and Removal.
2506. Flowable Mortar.
2507. Concrete and Stone Revetment.
2508. Removal of Paint and Painting Steel Bridge Structures.
2509. Cleaning, Surface Preparation, and Painting of Galvanized Surfaces.
2510. Removal of Pavement.
2511. Removal and Construction of Sidewalks and Recreational Trails.
2512. Portland Cement Concrete Curb and Gutter.
2513. Concrete Barrier.
2514. Curb Removal.
2515. Removal and Construction of Paved Driveways.
2516. Removal and Construction of Retaining Walls and Steps.
2517. Railroad Approach Sections.
2518. Safety Closure.
2519. Fence Construction.
2520. Field Laboratory and Field Office.
2521. Certified Plant Inspection.
2522. Tower Lighting.
2523. Highway Lighting.
2524. Highway Signing.
2525. Traffic Signalization.
2526. Construction Survey.
2527. Pavement Marking.
2528. Traffic Control.
2529. Full Depth Finish Patches.
2530. Partial Depth Finish Patches.
2531. Pavement Surface Repair (Milling).
2532. Pavement Surface Repair (Diamond Grinding).
2533. Mobilization.
2534. Delivery of Samples.
2535. Bin Type Crib Walls.
2536. Asbestos Removal.
2537. Underground Tank System Removal and Petroleum Contaminated Soil Remediation.
2538. Salvage, Removal, and Disposal of Obstructions.
2539. Concrete Pavement Undersealing by Pressure Grouting.
2540. Longitudinal Joint Repair.
2541. Crack and Joint Cleaning and Sealing (HMA Surfaces).
2542. Crack and Joint Cleaning and Sealing (Portland Cement Concrete Pavement).
2543. Transverse Joint Repair for HMA Pavements.
2544. Cleaning and Filling Cracks for HMA Surfaces.

2545. Overlay of Type "B" Guide Signs.
2546. Gabions and Revet Mattresses.
2547. Temporary Stream Access.
2548. Milled Shoulder Rumble Strips - HMA or PCC Surface.
2549. Pipe and Manhole Rehabilitation.
2550. Night Work Lighting.
2551. Crash Cushions.
2552. Trench Excavation and Backfill.
2553. Trenchless Construction.
2554. Water Mains, Valves, Fire Hydrants, and Appurtenances.

Section 2501. Piles and Pile Driving

2501.01 DESCRIPTION.

A. Furnish and place piles for foundations, trestles, and other exposed work.

B. Furnish and place piling for falsework according to Article 2403.03, L.

2501.02 MATERIALS.

Use piles that comply with the following requirements for the class of pile specified:

A. Untreated Timber Piles: apply Article 4165.03.

B. Treated Timber Foundation Piles: apply Article 4165.04.

C. Treated Timber Trestle Piles: apply Article 4165.05.

D. Concrete Piles: apply Section 4166.

E. Steel Pipe Piles: apply Section 4167.

F. Steel H-Piles: apply Section 4167.

G. Concrete Sheet Piles: apply Section 4166.

H. Steel Sheet Piles: apply Section 4167.

2501.03 CONSTRUCTION.

A. Pile Driving Equipment.
The hammer used for driving piles may be of gravity, steam, air, or diesel type. Use pile driving equipment that complies with the following provisions:

1. Gravity Hammers.

a. When gravity hammers are permitted, use a ram that weighs (has a mass) between 3000 pounds (1350 kg) and 6000 pounds (2750 kg) with a height of drop not exceeding 10 feet (3 m).

b. Equip gravity hammers with hammer guides to ensure concentric impact on the pile cap. Use hammer guides that have some method for visually determining the drop height during driving.

c. For all gravity hammers, apply Article 2501.03, A, 10, of this article.

2. Single or Double Acting Air and Steam Hammers.

a. Use equipment with sufficient capacity to maintain the hammer operation under working conditions as recommended by the manufacturer.

b. Use equipment with accurate pressure gages which are easily accessible to the Engineer.

c. Steam hammers may be air operated if the capacity and pressure of the compressor comply with recommendations of the hammer manufacturer.

d. Ensure the weight (mass) of the striking parts of air and steam hammers is no less than 33% of the combined weight (mass) of the pile cap and pile being driven. In no case allow the striking parts to have a weight (mass) less than 2750 pounds (1250 kg).

3. Diesel Hammers.

For all diesel hammers, apply Article 2501.03, A, 10, of this article.

a. Open End (Single Acting) Diesel Hammers.

1) Equip with a method to visually determine drop height during driving. Examples of measurement devices are as follows:

- A graduated scale (jump stick) extending above the ram cylinder.
- Graduated rings or grooves on the ram.
- An electronic, sound activated, remote measuring instrument.

2) Provide the Engineer with the manufacturer's chart equating stroke to blows per minute for the open end diesel hammer used.

b. Closed End (Double Acting) Diesel Hammers.

1) Equip with an accurate bounce chamber pressure gage mounted in a manner to enable easy access for the Engineer.

2) Provide the Engineer with a current, calibrated chart equating bounce chamber pressure and gage hose length to either equivalent energy or stroke for the hammer being used.

4. Driving Aids.

a. Do not use vibratory hammers, hydraulic hammers, or driving aids such as jets, followers, and prebored holes unless stated in the contract documents or authorized in writing by the Engineer. When permitted, vibratory hammers and hydraulic hammers may be used for installing production piles only after the pile tip elevation is established by load test or by test piles driven with an approved hammer. As condition for approval, perform (at no additional cost to the Contracting Authority) load tests and extra work required to drive test piles as determined by the Engineer.

b. Control production pile installation with vibratory hammers according to power consumption, rate of penetration, specified tip elevation, or other means acceptable to the Engineer. Assure the pile capacity equals or exceeds the design bearing. Use an approved hammer to retap piles driven to full penetration with a

vibratory hammer. Bearing will be determined by an applicable wave equation analysis.

5. **Hammer Cushion.**
   a. Equip all impact pile driving equipment with suitable thickness hammer cushion material to prevent damage to the hammer or pile. In the Engineer's presence, inspect the hammer cushion for condition, composition, and thickness before beginning pile driving at each structure, and regularly during driving.
   b. For hammers with internal cushions, check the cushion regularly at 100 hour intervals during driving. Use the hammer manufacturer's recommended beginning cushion thickness and composition. Report this information to the Engineer prior to driving. Replace the hammer cushion when it has less than 70% of the recommended thickness, has burned, or has been broomed.

6. **Pile Cushion.**
   a. Protect the head of all concrete piling with a suitable pile cushion. When requested, provide the pile cushion composition and thickness to the Engineer. Determine the minimum thickness by the wave equation.
   b. If alternate pile driving control methods are used, use a minimum thickness of 6 inches (150 mm) of suitable wood.
   c. In the Engineer's presence, inspect the pile cushion for condition, composition, and thickness before beginning pile driving at each structure, and regularly during driving. Replace any pile cushion when it has less than 70% of the original reported thickness, has burned, or has been broomed.

7. **Pile Driving Cap.**
   a. Piles driven with impact hammers require an adequate cap to distribute the hammer blow evenly to the top of the pile. Align the cap axially with the hammer and the pile. Guide with leads. Use an appropriate cap for the type and size of pile. Ensure it fits around the top of the pile so that the driving unit is centered during driving.
   b. For special types of piles, provide appropriate driving caps, mandrels, or other devices according to the manufacturer's recommendations so that the piles may be driven without damage.
   c. Cut all pile tops squarely to ensure proper fit of the driving cap.

8. **Followers.**
   Use followers only with the Engineer's authorization.

9. **Water Jets.**
   Use water jets only with the Engineer's authorization. When jets are used, ensure the size, number, and location of jets, as well as the volume and pressure of water at the jet nozzles, is sufficient to freely erode material from under and adjacent to the pile.

10. **Approval of Pile Driving Equipment.**
    a. On each project, the Engineer's approval is required for all pile driving equipment. Size all pile driving equipment so that the piles

can be driven with reasonable effort to the required lengths without damage.

b. Pile driving equipment approval on Interstate and Primary projects will be based on the wave equation analysis. For other projects, the alternate approval method will be used unless specified otherwise.

1) Wave Equation Analysis.

a) For wave equation approval, submit to the Engineer the required data forms detailing equipment to be used on the project. Submit this information to the Engineer at least 20 calendar days prior to driving piles.

b) The Contractor will be notified of the acceptance or rejection of the driving system within 12 calendar days of the Engineer's receipt of the data forms. Modify or replace the proposed methods or equipment (at no additional cost to the Contracting Authority) if the wave equation analysis:

- Indicates pile damage could occur, or
- The pile could not be driven to the required bearing.

c) Ensure the subsequent driving system results in wave equation analysis indicating the piles can be reasonably driven to the desired capacity without damage. The Engineer will notify the Contractor of the acceptance or rejection of the revised driving system within 9 calendar days of receipt of a revised data form or method plan.

d) Equipment meeting the values in Tables 2501.03-1 and 2501.03-2 below will be acceptable for wave equation analysis.

2) Alternate Approval Method.

Use the tabulated energy values in Tables 2501.03-1 and 2501.03-2, in the Appendix, as a basis for approval of pile driving equipment for the alternate approval method. Approval will be based on meeting all requirements of this article. This approval does not relieve the Contractor of the basic obligation to provide equipment suitable for driving the specified pile to the required bearing without damage.

11. Pile Driving Equipment.

a. Use an approved system or placement method. Variations in the driving system will not be permitted without the Engineer's approval. If the hammer performance deviates from the manufacturer's recommended specifications, take immediate corrective action. The Engineer will not allow driving to continue until the system is performing to the manufacturer’s specifications.

b. Changes in the driving system will be considered after the Contractor has submitted the required data for review. The Contractor will be notified of the acceptance or rejection of the driving system changes within 9 calendar days of the Engineer's receipt of the requested change. Time required for submission, review, and approval of a revised driving system does not constitute the basis for a contract time extension.

B. Determination of Pile Lengths.

1. When pile length is not specified, the Engineer will determine the length from the results obtained under the procedure specified in the contract documents. Wood pile lengths will be in multiples of:
   - 2 feet (0.5 m) for lengths of 20 feet (6 m) and less, and
   - 5 feet (1.5 m) for lengths over 20 feet (6 m).

2. Steel H-piles and steel pipe piles will be in multiples of 5 feet (1.5 m). Precast concrete piles may be specified in any length of whole feet (to the nearest 0.5 m).

C. Test Piles.

1. When the contract documents specify that the lengths of piles are to be determined from results of driving test piles, furnish and drive piles:
   - Of lengths designated in the contract documents or by the Engineer, and
   - In locations designated in the contract documents or by the Engineer.

2. Determine the load carrying capacity of test piles as provided in Article 2501.03, M. Drive these test piles with the same or comparable type of equipment as that which is to be used for driving other piles for the structure. The Contractor may be required to excavate the test pile area to the proposed footing elevation before driving the test pile. Within 10 calendar days, the Engineer will determine the length of piles to be furnished by considering the results of the test pile.

D. Concrete Piles.

1. Use concrete bearing piles of the form and dimensions specified in the contract documents. Place as indicated in the contract documents.

2. Piles may be driven when the concrete compressive strength has reached a minimum of 5,000 psi (35 MPa), but no less than 7 calendar days after casting.

E. Steel Pipe Piles.

Construct steel pipe piles by first driving steel pipe of the specified type and size in the locations specified in the contract documents, and then filling the pipe with concrete. Construct the piles according to the following additional requirements:

1. **Inspection.**
   - **a.** Furnish a light suitable for visual interior inspection of driven pipe piles. This inspection will be conducted before cut off and filling is allowed.
   - **b.** Remove and replace, or otherwise correct as directed by the Engineer, all piles which have been improperly driven, broken, or are otherwise defective.

c. Ensure the interior of the pile is clean and free of water at the time of inspection.

2. Cut Off.
Upon completion of driving, inspection, and approval, neatly cut the pile on a horizontal plane at the elevation specified in the contract documents.

3. Filling.
a. After the piles have been cut off, remove water piles.
b. After reinforcement has been accurately placed, fill pile completely with Class C structural concrete meeting requirements of Section 2403. Ensure pile is free of accumulated water at the time concrete is placed.
c. In order to avoid formation of air pockets, place the concrete:
- Using vibratory methods as specified in Article 2403.03, D or
- In small charges of not over 2 cubic feet (0.05 m^3) each.

4. Painting.
After the piles have been filled with concrete, clean the exposed sections using hand methods. Paint with three coats of paint from the cap to the low water elevation or 2 feet (0.5 m) below finished ground line according to the provisions of Section 2508. Apply all three coats of paint in the field.

F. Steel H-Piles.

1. Use steel H-piles of the cross section, size, and weight per foot (mass per meter) specified in the contract documents. The contract documents may allow an option of pipe piles in place of steel H-piles. Pipe piles are also described in Section 4167.

2. When driving is complete, cut the pile off neatly at the elevation specified. The contract documents may require encasement of steel H-piles. The Contractor may increase the diameter of encasements with no additional payment. Limit the increase to 4 inches (100 mm) or less. For a structure, use encasements all of the same diameter. Clean steel H-piles that are exposed to the atmosphere in the finished structure. Paint these piles with three coats of paint as specified in Section 2508.

3. Limit the number of permitted welds used to develop plan specified lengths of steel H-piles to those in Table 2501.03-3:

Table 2501.03-3: Number of Permitted Welds.

Plan Pile Length, feet (m)	Number of Permitted Welds (splices)
0 - 50 (0-15.0)	0
51-100 (15.1-30)	1
101-150 (30.1-45.0)	2

4. Welds (splices) in excess of the number specified above will not be permitted unless required for a pile extension. When steel H-piles are to be spliced, make the last added length the shortest pile length.

G. Steel Sheet Piles.

1. For steel sheet piles that will become a part of a finished structure, use an interlocking type with a:
   - Web thickness no less than 3/8 inch (9 mm),
   - Section modulus no less than that specified in the contract document.

2. Use an interlock approved by the Engineer.

3. Put used sheet piles in proper condition before redriving.

4. Where steel sheet piles will receive a concrete cap, cut them off neatly in straight lines at the required elevations after driving. Adapt the details at angles in sheet pile walls to the type of pile used. Obtain the Engineer's approval.

5. Steel sheet piles need not be painted unless specified.

H. Foundation Piles.

1. The term "foundation piles" means all piles, whether of wood, concrete, or steel, which support superimposed loads and have no part of their length exposed above ground line.

2. Except as provided otherwise in the contract documents, complete excavation before driving foundation piles. After driving is completed, remove all loose and displaced material forced up during driving from around the piles, leaving a firm surface to receive the footing concrete.

3. After piles have been driven, cut the tops to the plane indicated at the required elevation. Remove all crushed or broomed wood, broken concrete, or deformed steel. Paint the tops of treated wood piles with two coats of treatment material meeting the requirements of Section 4160. Inspect steel pipe piles for damage according to Article 2501.03, E.

I. Trestle Piles.

1. The term "trestle piles" means all piles, whether of wood, steel, or concrete, which support superimposed loads, but will be exposed above the ground level for a part of their length. Bents around which fills may later be constructed are considered trestle piles.

2. Drive wood and steel piles with an accuracy that will permit them to be capped as shown in the contract documents, with only such springing and bending that will not damage the pile. If, in the Engineer's judgment,

a pile has been deformed or cracked by springing after being driven, replace it. Perform all springing prior to placing the cap.

3. Drive concrete piles to stand without springing within 4 inches (100 mm) of the intended location, and in no case closer than 3 inches (75 mm), to the faces of the caps as shown in the contract documents. In case it is necessary to move a concrete pile after driving to secure the above accuracy, move it by loosening the soil surrounding the pile with jets until it can be moved and can stand without strain in the correct position. After being moved, drive the pile a sufficient amount to assure the specified minimum bearing value.

4. Cut trestle piles off to be level or at the designed slope at the elevation of cut-off shown in the contract documents. Ensure the length of pile above this elevation is sufficient to permit complete removal of all material damaged by driving.

5. In treated wood piles, apply two coats of an approved treatment material meeting requirements of Section 4160 to all bolt holes, cuts, daps, or chamfers made subsequent to treatment, as well as all abrasions of the surface and the tops of piles after cut-offs. When the tops of treated piles are not to be encased in concrete, protect them as specified in Article 2409.03, D.

J. Preparation of Wood Piles for Driving.
Prepare all wood piles for driving according to the following:

1. Preparation of Pile Heads.
Trim the pile head accurately to make a driving fit into the driving cap. If the head of the pile becomes broomed or crushed before driving is completed, trim off the broomed fibers to provide sound wood accurately fitting the driving cap.

2. Preparation of Pile Points.
Cut the lower end of a pile square. If directed by the Engineer, shape it to a point no less than 4 inches by 4 inches (100 mm by 100 mm). Form the tapered point concentric to the center line of the pile.

K. Protection of Concrete Piles during Driving.
Protect the tops of all concrete bearing and sheet piles from damage by the impact of the hammer. Design, maintain, and use this protection to cause the minimum absorption of energy consistent with adequate protection of the top of the pile.

L. Accuracy in Placing and Driving Piles.

1. In spotting the points of piles in preparation for driving, use care to locate them as shown in the contract documents or as directed by the Engineer. Limit the deviation from such designated locations to 3 inches (75 mm) or less at the time driving is begun, except as may be made necessary by the presence of unavoidable obstructions.

2. While being driven, hold piles so they deviate the minimum possible amount from the vertical or batter line shown in the contract documents. Firmly and securely hold in place in proper position the leads used in driving piles to assure driving the pile in the line required.

3. Suspend pile driving during and for 12 hours following concrete placement that is within 50 feet (15 m) of the pile driving operation.

M. Determination of Bearing Value of Piles.
When load tests are not specified in the contract documents or are not directed by the Engineer, determine the bearing value of piles determined using one of the following methods:

1. Wave Equation Analysis.

a. Wave equation analysis will be used on all Interstate and Primary projects, on other projects when specified in the contract documents, or as directed by the Engineer.

b. Drive piles to full penetration using approved driving equipment.

c. Retaps or pile extensions may be necessary to obtain the required pile bearing capacity, including potential adjustments for scour or downdrag conditions.

d. Do not continue driving beyond a depth at which acceptable pile stress is exceeded. With the Engineer's approval, driving may be stopped when the rate of driving exceeds 160 blows per foot (0.3 m).

2. Bearing Determinations by Formula.

a. When wave equation analysis is not required, compute the bearing value of piles using the following formulas:

For Gravity Hammers with Wood, Steel H, or Steel Pipe Piles:

English

$$P = \frac{3WH}{S+0.35} \times \frac{W}{W+M}$$

Metric

$$P = \frac{2.5WH}{S+8.9} \times \frac{W}{W+M}$$

For Gravity Hammers with Concrete Piles:

English

$$P = \frac{4.5WH}{S+0.2} \times \frac{W}{W+M}$$

Metric

$$P = \frac{3.7WH}{S+5.1} \times \frac{W}{W+M}$$

Set the height of fall to no less than 5 feet (1.5 m) or more than 8 feet (3 m), and the rate of driving to no less than 8 blows per minute.

Diesel Hammers with Wood, Steel H, or Steel Pipe Piles and (Construction) Steam Hammers for all Piles:

English

$$P = \frac{3E}{S+0.1} \times \frac{W}{W+M}$$

Metric

$$P = \frac{0.25E}{S+2.5} \times \frac{W}{W+M}$$

Diesel Hammers with Concrete Piles:

English

$$P = \frac{7E}{S+0.1} \times \frac{W}{W+M}$$

Metric

$$P = \frac{0.58E}{S+2.5} \times \frac{W}{W+M}$$

Where, for the above equations:

P = The bearing value in tons (kN),

W = The weight (mass) of the gravity hammer, or the ram of an air hammer or diesel hammer in tons (kilograms),

H = The height of free fall of the hammer or ram in feet (meters),

M = The weight (mass) in tons (kilograms) of the pile plus the weight (mass) in tons (kilograms) of the cap plus (for diesel hammers) the weight (mass) of the anvil in tons (kilograms),

E = The energy per blow in foot-tons (joules) (for single acting steam hammers E = W x H (E = 9.81 x W x H)),

S = The average penetration in inches (millimeters) of the pile per blow for the last 5 blows for gravity hammers and the last 10 blows for air or diesel hammers.

b. Apply the following conditions in the use of the above formulas:

1) Unless the hammer has free fall, substitute a value for "W" that is less than the weight (mass) of the hammer by an amount sufficient to compensate for all friction and drag tending to retard its fall.

2) With approval from the Engineer, driving may be stopped when the rate of driving exceeds 160 blows per foot (0.3 m).

3) There is no excessive bounce to the hammer after the blow.

4) For the computation of the bearing value for battered piles driven with gravity hammers, multiply the value obtained from the formulas by the following factor:

(Cosine a) minus (f sine a), where "a" equals the angle the leads make with the vertical and "f" equals the coefficient of friction between the hammer or ram and the surface on which it slides. For gravity hammers sliding on greased steel surfaced leads, assume the value of "f" to be 0.1.

c. The Engineer may modify the above formulas on the basis of load tests. At the Engineer's discretion, the Wave Equation Analysis may be used to evaluate the driving system, as well as determine pile bearing.

3. Static Load Test.

a. When directed by the Engineer, bearing value of piles will be determined by actual load test in which the entire load is applied concentric with the pile.

b. Careful measurements will be made to determine the amount and rate of settlement.

c. Gages reading in thousandths of an inch (0.001 µm) will be used to determine the settlement.

d. The designated test pile(s) shall stand, after being driven, at least 40 hours before the test load may be applied.

e. This method is outlined in Section 5.6 and 6.4 of ASTM D 1143. The procedure in ASTM D 1143 will be followed except as modified below:

1) Apply the test load in increments of 10% of the proposed design load.

2) Apply the load at 2.5 minute intervals. Record readings of time, load, and settlement immediately before and after the application of each load. The test is to continue by adding load increments until continuous jacking is required to maintain the test load (i.e., failure by settlement), or the load limit of the jacking equipment is reached.

3) When the maximum load has been applied, take pile settlement readings immediately, and at 2.5 minutes and 5 minutes, after jacking has ceased. Remove the test load and immediately record pile rebound readings. Take additional rebound readings 2.5 minutes and 5 minutes later.

4) Use the data obtained to plot a load (tons (kilonewtons) versus settlement in inches (millimeters)) curve.

f. The failure load is defined as the intersection between the tangent of the linear portion of the load settlement curve and a line with a slope of 0.05 inches per ton (0.14 mm/kN) from the yield point.

g. The yield point is defined as the intersection between the load settlement curve and a line which is parallel to the linear portion of the load settlement curve at 0.25 inches (6 mm) of settlement.

h. The safe bearing value will be 50% of the load at the failure point.

4. Dynamic Pile Analyzer Tests.

a. The Engineer will take dynamic measurements during the driving of piles designated as dynamic load test piles, or as directed by the Engineer. Instruments for dynamic analysis will be:

- Attached near the top of the pile with bolts placed in approved masonry anchors, or
- Bolted through drilled holes in the web of steel piles, or
- Bolted with wood lag screws for timber piles.

b. The Engineer will furnish the instruments, material, and labor necessary for drilling the holes and mounting the instruments.

c. When specified in the contract documents, or ordered by the Engineer, furnish a shelter to protect the dynamic test equipment from the elements. Maintain the inside temperature of the shelter above 45°F (7°C). Locate the shelter within 100 feet (30 m) of the test location.

d. Pretest, Pile Calibration.

1) Predriving wave speed measurements will be required for concrete or wood piles. Make each designated pile available for this measurement prior to placement of the pile in the leads.

2) When predriving wave speed measurements are required, block the piling up off the ground in a horizontal position and locate it to not contact other piling. Predriving wave speed measurements will not be required for steel piles.

e. Prior to Driving.

1) Prior to placing the designated pile in the leads, provide access to the pile and allow the Engineer time to predrill instrument mounting holes or conduct predriving wave speed measurements, or both, if required.

2) When the designated test pile is placed in the leads and is ready to drive, provide the Engineer reasonable access to the pile for testing purposes.

3) Attach the instruments and associated test cables to the top of the pile as directed by the Engineer, unless there is an acceptable personnel platform (minimum size of 4 feet x 4 feet (1.2 m x 1.2 m) designed to be raised to the top of the pile) provided for the Engineer.

4) Allow time to attach or reattach and check the instruments as needed before beginning to drive.

f. Driving.

1) Drive the designated pile to at least the depth at which the dynamic test equipment indicates that the capacity shown in the contract documents has been achieved, unless the Engineer directs otherwise. The stresses in the pile will be monitored during driving with the dynamic test equipment to ensure that damage, as determined by the Engineer, does not occur.

2) If an over-stress condition is indicated, the Engineer will suspend driving and determine if plan capacity has been achieved. If necessary, in order to maintain monitored stresses below the accepted values, reduce the driving energy transmitted to the pile by:

- Using additional cushion thickness,
- Reducing the energy output of the hammer, or
- Changing hammers.

3) If nonaxial driving is indicated by the dynamic test equipment measurements, immediately realign the driving system.

4) When the Engineer orders, wait a minimum of 24 hours and retap the dynamic load test pile after the instruments are reattached. Do not use a cold hammer for the retap. Warm up the hammer before the retap by applying at least 20 blows to another pile. The maximum amount of penetration required during a retap is 6 inches (150 mm). After retapping, the Engineer will determine if desired bearing has been achieved or if additional pile penetration is required.

5. **Retaps.**
   - **a.** When piles do not achieve the specified driving resistance during driving, the Engineer may require one retap per 10 piles or a minimum of 2 piles in each foundation at no additional cost to the Contracting Authority. Only piles with the lowest driving resistance will be considered for retap.
   - **b.** Perform the retap by allowing the pile to set up for 24 hours, or as directed by the Engineer.
   - **c.** Warm up hammers (other than gravity) by applying a minimum of 20 blows to another pile before the retap driving begins. Take the bearing for the retap within the first 6 inches (150 mm) of penetration.
   - **d.** The first two blows of a retap are for seating the cap and assuring proper operation of the hammer. Do not use the first two blows as part of bearing evaluation.
   - **e.** Measure the penetration of the next ten blows, or record the number of blows it takes to drive the pile 6 inches (150 mm). Correct to the appropriate measurement and check for bearing.
     - **1)** If bearing is achieved, driving may be halted. However, if the Engineer approves, driving may be continued to cut-off as long as acceptable pile stress is not exceeded.
     - **2)** If penetration is less than 1 inch (25 mm) for the first ten blows, discontinue driving. Record the bearing as refusal.
   - **f.** Have the Engineer evaluate piles not achieving the specified driven resistance after a retap and, if so ordered, extend as required following the procedures of Article 2501.03, P.

N. Bearing Required.

Unless modified by the Engineer, drive all piles to the design bearing specified in the contract documents. Ensure the specified design bearing is obtained below scour elevation for substructure subject to scour.

O. Penetration.

1. Unless provided otherwise in the contract documents, drive all piles until the design bearing, determined as provided in Article 2501.03, M, is at least equal to that specified in Article 2501.03, N.

2. Drive all piling for piers and abutments of stream crossings, and the piling for piers and abutments of other structures, when ordered by the Engineer, until the following requirements for penetration have been met:
   - **a.** The length of all piles specified in the contract documents, or ordered by the Engineer, for any specific structure is to be construed as indicating the desired penetration. Continue the effort to secure this penetration as long as the pile can be driven without damage to the pile.
   - **b.** When the pile can not be driven to the required length without damage, the Engineer will determine if additional penetration is required. If full penetration is required, advance the pile by jetting, preboring to a maximum depth of 20 feet (6 m), or other approved

methods which will secure the required penetration and bearing without damage to the pile.

c. The driving of wood piling in excess of 40 ton (350 kN) bearing will not be permitted.

d. If soil conditions permit auguring, perform the auguring according to Article 2501.03, Q, except drill the holes to the approximate size of the pile measured at mid length. Do not use Bentonite slurry in prebored holes to gain additional penetration.

e. Drive piles which do not carry superimposed vertical loads, such as wingwall piles, fender piles, wing dam piles, and revetment piles, to the penetration shown in the contract documents without regard to bearing values.

P. Extensions and Splices.

Follow Article 2501.03, M, 5, when piles driven to the specified depth fail to develop the required design bearing. If the Engineer orders pile extensions, driving will continue as long as practical, then the piles will be extended in the manner specified below:

1. Concrete Piles.

a. When a concrete pile is to be extended and the pile does not require further driving, cut away the concrete at the end to expose 24 inches (600 mm) of the existing extension bars cast in the upper end of the pile, as well as 24 inches (600 mm) of the prestressing tendons. To the exposed steel, properly lap and securely wire reinforcing equivalent in cross sectional area to the exposed extension bars.

b. If for any reason extension bars do not exist at the splice, cut the concrete off squarely with at least 24 inches (600 mm) of the prestressing tendons exposed. Use eight No. 7 (No. 25) reinforcing bars, from full lap with the tendons to within 3 inches (75 mm) of the extension top.

c. In the concrete pile extension, use 5 gage (No. W 3.5) spiral reinforcing placed at a 3 inch (75 mm) pitch, and ending with six close turns at the top.

d. After the extension reinforcement is in place, place the necessary forms. Do not allow leakage along the face of the pile.

e. Use the same quality concrete for the extension used to cast the original pile.

f. Just prior to placing concrete for the extension, prepare the joint according to Article 2403.03, I. Coat with a creamy mixture composed of 1 part of water and 1.5 parts of dry cement. The grout may be poured in at the top of the form, depositing it as nearly as possible in the center of the pile.

g. After placement, the forms may be removed after 24 hours, and the extension cured by wrapping with two thicknesses of burlap kept wet for 4 calendar days. Finish the entire surface of the exposed pile to present a uniform color and texture. Splice piles that require further driving as specified in the contract documents or as directed by the Engineer.

2. **Steel Piles.**
   a. For extensions of steel H-piles and steel pipe piles, neatly weld the entire cross section after removing all damaged metal. Ensure the axis of the extension coincides with the axis of the original pile. Perform welding of all steel piles according to Article 2408.03, B.
   b. Allow only welders qualified according to Material I.M. 560 to make field extensions of steel piles. Ensure they use an approved welding procedure involving the use of backing plates according to Article 2408.03, B.
   c. When designated in the contract documents, the Contractor has the option of extending steel piles by means of mechanical splices approved by the Engineer.

3. **Wood Piles.**
   Splice wood piles as directed by the Engineer.

Q. Prebored Holes as per Plan.

1. When required by the contract documents, bore holes greater than the maximum cross sectional dimension of the pile. Bore holes to the elevations shown and to a minimum diameter 4 inches (100 mm) greater than the maximum cross sectional dimension of the pile 3 feet (1 m) from the butt. Drive piles through the holes to at least the specified design bearing.

2. Use natural bentonite slurry when piling is to be advanced in prebored holes. For holes drilled in noncollapsing soils, the bentonite slurry may be placed after piles are driven. In collapsing soils, place the bentonite slurry at the time the hole is drilled. Cover holes to prevent footing concrete from entering the holes.

3. Use prebored hole filling materials consisting of polymer free sodium bentonite designed for sealing wells and bored holes. Materials may consist of American Petroleum Institute Specification 13A, sodium bentonites, high solids bentonite grout mixes, or granular bentonites composed of approximately 1/4 inch (6 mm) or larger particles.

4. For collapsing soils, make a slurry by thoroughly mixing the bentonite with water according to the manufacturer's recommendation for the product used. In no case use more than 100 gallons (500 L) of water per 80 pounds (50 kg) of bentonite. Place slurry materials by pumping or other applicable methods that assure the hole is filled from the bottom up.

5. For noncollapsing dry holes, coarse 1/4 inch (6 mm) or larger bentonite particles may be poured directly into the hole and hydrated with water after placement.

6. Completely stabilize the hole and fill with bentonite prior to placing footing concrete.

2501.04 METHOD OF MEASUREMENT.

Measurement for the quantities of Wood Piles, Steel HP-Piles (either encased or not), Steel Pipe Piles, Concrete Piles, and Steel Sheet Piles, will be the plan length. The quantity may be modified by Article 2501.04, D or F.

A. Wood Piles.
When a wood pile is broken in driving, through no fault of the Contractor, the length measured for payment will be the plan length.

B. Sheet Piles.
The area of walls of sheet piles will be determined from the plan length and the horizontal center line length measured to the nearest 0.1 foot (0.1 m) of wall.

C. Concrete Encasement.
The length of concrete encasement of steel HP-piles constructed will be measured to the nearest 0.1 foot (0.1 m).

D. Extension and Splices.

1. For wood, steel HP (either encased or not), or steel pipe piles that are extended, the length measured for payment will be the length of the extension specified by the Engineer. Portions of pile cut-offs used as extensions on the same contract will not be remeasured as additional plan quantity.

2. For concrete piles that are extended, the length measured for payment will be the length of the extension specified by the Engineer, plus the additional length required to be removed for splicing the reinforcement.

E. Prebored Holes.

1. The length of prebored holes will be calculated in linear feet (meters) from elevations as shown in the contract documents to the nearest 0.1 foot (0.1 m).

2. Preboring required by Article 2501.03, O, will be measured for payment to the nearest 0.1 foot (0.1 m).

F. Extra Pile.
Extra piles ordered, in addition to the plan quantities, will be measured for payment.

2501.05 BASIS OF PAYMENT.

Payment will be the contract unit price for the quantities of Wood Piles, Steel HP-Piles (either encased or not), Steel Sheet Piles, Steel Pipe Piles, and Concrete Piles measured as provided above. The price bid for piles is full compensation for delivering piles to the site, preparing, driving, cutting, and filling (steel pipe piles only) piles, except as modified in this article.

A. Increased or Decreased Length or Size of Piles.

1. Return unused piling (either ordered as directed by the Engineer, or specified in the contract documents and delivered to the job site without having been placed in the leads) to the supplier. Payment will be made for freight, restocking, and handling charges.

2. When the plans designate steel HP-piles 60 feet (18 m) or shorter and the Engineer subsequently orders steel H-piles longer than 60 feet (18 m), the adjusted price for such piles will, when required, will also include payment for one extension splice for each pile at the rate specified in Paragraph C below.

B. Extension of Concrete Piles.
Payment for the extension will be twice the contract unit price per linear foot (meter) of pile. The length of extension is to be as directed by the Engineer.

C. Extension of Steel H-piles or Pipe Piles.
Payment will be at ten times the contract unit price per linear foot (three times the contract unit price per meter) for splices (welded or mechanical) for steel HP-piles or pipe piles required to be spliced to obtain lengths greater than specified in the contract. Payment includes all equipment, labor, and materials necessary to complete the splice.

D. Splicing of Wood Piles.
Payment will be according to Article 1109.03, B.

E. Pile Cut-Offs.

1. Pile cut-offs not used as extensions on the same contract become the property of the Contractor. Steel pile cut-offs used as extensions on the same contract will not be paid for as additional plan quantity.

2. All piles, or portions thereof, which become the property of the Contractor shall be removed from the project site by the Contractor.

F. Encasement.
Payment will be the contract unit price per linear foot (meter).

G. Test Piles.
The contract may provide a lump sum item for Test Piles. If an item is not provided, Test Piles ordered by the Engineer and driven under the Engineer's supervision will be considered as extra work and will be paid for as provided in Article 1109.03, B.

H. Pile Points.
When the contract documents require that points of piles be protected with metal points, furnish these points without extra compensation. When metal points are not specified in the contract documents, furnish them only upon direction of the Engineer, in which case payment will be made as provided in Article 1109.03, B.

I. Sheet Piles.
When specified to become a part of the permanent structure, payment will be at the contract unit price per square foot (square meter) for steel sheet piles of the specified weight (mass) and cross section for the area of the wall or walls placed.

J. Pile Loading Tests.

1. When required, payment will be the contract lump sum price. Payment is full compensation for all labor, material, and equipment required to comply with the procedure shown in the contract documents, including the test and anchor piles, welding, and placing and removing the test beam.

2. For pile loading tests ordered by the Engineer, payment will be a lump sum price of $3000. When this test is performed within a cofferdam, the lump sum price will be $6000. Payment is full compensation for all labor, material, welding, and equipment, for placing and removing the test beam, and loss of time.

K. Prebored Holes.

1. When required by the contract documents, payment will be the contract unit price per linear foot (meter).

2. Payment is full compensation for all labor, equipment, and materials including bentonite slurry.

3. Prebored holes required by Article 2501.03, O, will be paid for according to Article 1109.03, B.

L. Dynamic Pile Test.

1. When required by the contract documents, or ordered as directed by the Engineer, payment will be a lump sum price of $250 per test pile.

2. Payment is full compensation for all labor, materials, equipment, and time associated with this test as outlined in Article 2501.03, M.

M. Jetting.
When required by Article 2501.03, O, payment will be according to Article 1109.03, B.

Section 2502. Subdrains

2502.01 DESCRIPTION.
Furnish and install subdrains. Construct trench drains.

2502.02 MATERIALS.

A. Pipe: Meet the requirements of Section 4143.

B. Engineering Fabric: Meet the requirements of Article 4196.01, B, 2.

C. Porous Backfill Material: Meet the requirements of Section 4131.

D. Corrugated Metal Pipe Subdrain Outlet: Meet the requirements of Section 4141.

2502.03 CONSTRUCTION.

Install the size and type of subdrains shown in the contract documents. Install them at the locations and to the grades and elevations shown in the contract documents. Apply the provisions of Section 2403.

A. Standard Subdrains.

1. Unless the Engineer grants permission to construct the drain in sections, begin at the outlet and proceed continuously upgrade. The Engineer will furnish stakes and figures for the grade of the flow line.
- **a.** Accurately place the pipe to line and grade.
- **b.** Lay drain tile ends, when used, as closely together as possible.
- **c.** Use special tile connections for junctions in tile lines.
- **d.** Use a special connection when a pipe diameter change is more than 2 inches (50 mm).
- **e.** Use properly fitting connectors for joints in metal and plastic pipes.
- **f.** Use properly designed fittings for junctions of pipe lines.
- **g.** Take necessary precautions to avoid damaging existing tile lines.
- **h.** Connect such tile lines to the subdrain being installed.

2. Construct inlets to subdrains by filling the full width and depth of the trench with porous backfill material for the length specified.

3. Construct intakes according to design and locations specified. Intake construction includes placing pipe through the intake wall.

4. Allow the Engineer to inspect pipes before covering.

5. Unless porous backfill material is specified, carefully cover (blind) the pipe with soil or other approved material to a depth of approximately 6 inches (150 mm). Do not place sand or boulders directly against pipe. After the drain has been blinded, place backfill in the remainder of the trench using methods and materials approved by the Engineer.

6. When subdrains are placed beneath a highway or driveway or are placed within 5 feet (1.5 m) of the edge of an existing or proposed pavement of base course, place backfill material in layers no thicker than 6 inches (150 mm). Thoroughly tamp each layer with mechanical tampers.

7. The contract documents may also require construction of a granular blanket in connection with subdrains. Construct the granular blanket according to Article 2107.03, K. When installation of a granular blanket is required, place porous backfill material for subdrains prior to construction of the granular blanket.

8. Mark subdrain outlets with steel posts. Use steel posts meeting the requirements of Article 4154.09. Drive the posts 3 feet (1 m) into the ground and install 4 foot (1.1 m) plastic sleeves over the posts. If the Contracting Authority furnishes sleeves, install the sleeves they furnish. Use only one post to mark the location of a double outlet.

9. Use or remove excess excavated project material as directed by the Engineer.

B. Trench Drains.

1. Construct trench drains at locations, depth, and grade shown in the contract documents or as directed by the Engineer.

2. Fill the trench with uncompacted porous backfill material.

C. Longitudinal Subdrains.

1. Place continuous longitudinal subdrains as indicated.

2. Install outlets as shown in the contract documents at approximately 500 foot (150 m) intervals. Provide additional outlets at the low points of vertical sag curves. The Engineer may adjust outlet location. Cover the outlet end of each sudrain with the specific outlet covering. Cap the blind end with a fitting recommended by the manufacturer.

3. Place Class A crushed stone over porous backfill material at piers and at subdrain outlets as shown in the contract documents.

4. Compact material by tamping or vibration.

5. Other outlets may be by special connections which will be shown in the contract documents.

6. Ensure polyethylene tubing elongation does not exceed 5%.

7. Construct longitudinal and lateral shoulder subdrains as shown in the contract documents. Wet the aggregate backfill material prior to installation. The Engineer may require surface application of water. Place the subdrain aggregate backfill material as follows:

a. 24 inch (0.6 m) Depth Subdrain Trench.

1) Place aggregate backfill material in one lift above the sudrain pipe.

2) Compact the lift to maximum consolidation using a vibratory compactor narrower than the trench.

b. 36 inch (0.9 m) Depth Subdrain Trench.

1) Place aggregate backfill material in one lift above the sudrain pipe.

2) Compact the lift to maximum consolidation using a vibratory compactor and an approved trench roller, both narrower than the trench.

c. 42 inch (1.1 m) or Greater Depth Subdrain Trench.

1) Place aggregate backfill material in two lifts of approximately equal thickness above the subdrain pipe.

2) Compact the first lift with a vibratory compactor narrower than the trench.

3) Compact the second lift to maximum consolidation using a vibratory compactor and an approved trench roller, both narrower than the trench.

4) Do not allow compaction to damage the subdrain pipe.

5) When porous backfill material thickness immediately above the pipe is less than 1 foot (0.9 m), place aggregate backfill material in one lift and compact with a vibratory compactor.

8. Maximum consolidation will be determined by an initial trial section approximately 100 feet (30 m) long. Continue compaction on this section until maximum consolidation is achieved.

9. To prevent intrusion of porous backfill material, keep backfill material and engineering fabric (if included in the design) protected during subsequent pavement removal, concrete placement, or other work.

10. Use trench rollers with a maximum trench wheel weight (mass) of 6000 pounds (2700 kg).

11. Restore the shoulder and foreslope area as part of shoulder subdrain work.

a. Unpaved shoulders.

1) Finish unpaved shoulders with a minimum depth of 4 inches (100 mm) of granular shoulder material.

2) Compact granular shoulder material or earth with a minimum of three passes using a single vehicle tire loaded to 6000 pounds (2700 kg).

b. HMA Paved shoulders.

1) Finish HMA paved shoulders and other designated locations with a minimum depth of 6 inches (150 mm) of HMA base.

a) Tack the edges.

b) Place and compact the HMA base mixture in an initial 4 inch (100 mm) lift and a final lift which restores the surface flush with, and no more than 1/4 inch (5 mm) above the adjacent pavement surface.

c) Thoroughly compact each lift with a minimum of three passes using a single vehicle tire that is loaded to 6000 pounds (2700 kg) and is no wider than the trench, or equally compact using an approved trench roller.

2) Proof roll areas that show evidence of paved shoulder settlement before completion of the project. Use a single vehicle tire no wider than the subdrain trench and loaded to 6000 pounds (2700 kg).

3) Correct settlements greater than 1/4 inch (5 mm). Use a 3/8 inch (9.5 mm) mixture described in Section 2203, or a similar commercial mixture approved by the Engineer.

4) Tack the surface, and spread and compact the mixture.

5) Compaction may be accomplished with loaded truck tires.
6) Obtain the Engineer's approval for compaction.

12. If a large boulder or obstruction other than a culvert is encountered, construct the subdrain as shown on the detail for trench repair at culverts, except the engineering fabric and 1 foot (0.3 m) of compacted earth are not necessary. An additional subgrade outlet will be necessary for the interrupted drainage.

13. If culverts and other facilities the Contracting Authority owns are damaged by trenching equipment, repair them as directed by the Engineer.

14. Load excavated material directly onto the transporting vehicle when subdrains are constructed on existing roads and removal of the excavated material is required. The contract documents may designate an area to place this material. If an area is not designated, and the Engineer does not designate one, remove the excavated material from the project according to Article 1104.08.

15. Construct backslope drains as shown in the contract documents. The aggregate may be placed in one lift and with no compaction. Fill and mound the remaining trench in one lift. Compact the earth in place. Level the earth to match the adjacent area.

16. Cover subdrains at piers with granular material described in Article 2502.02, as shown in the contract documents, after the porous backfill material is placed and compacted. Compact the granular material in the same manner as the porous backfill material.

17. Cover subdrain outlets with a rodent guard described in Article 4143.01, B.

18. Mark subdrain outlets, except for medians, with steel posts. Use steel posts meeting the requirements of Article 4154.09. Drive the posts 3 feet (1 m) into the ground and install 4 foot (1.1 m) plastic sleeves over the posts. If the Contracting Authority furnishes sleeves, install the sleeves they furnish.

19. Use only one metal fence post to mark the location of a double outlet.

D. Limitations.

1. When the work is complete, ensure subdrain outlets are open and free of debris.

2. When the road is open to public traffic during construction, work or uncompleted work must be within the limits of a traffic control zone.

2502.04 METHOD OF MEASUREMENT.

Measurement for subdrain construction will be as follows:

A. Standard Subdrain.
To the nearest foot (meter) along the center line of the subdrain.

B. Longitudinal Subdrain.
Computed to the nearest foot (meter) from the following:

1. Longitudinal Subdrain (Backslope).
Lengths of backslope subdrains of each size, including subdrain placed in laterals and outlets, and the extension into the outlet pipe.

2. Longitudinal Subdrain (Shoulders).
Lengths of shoulder subdrains, calculated from centerline stationing for each size of shoulder subdrains and subdrains at piers, including lengths of perforated subdrains in laterals and outlets, and the extension into the corrugated pipe.

C. Subdrain Outlet.
By count of the size specified.

D. Intakes.
By count the number of the size and type specified.

E. Trench Drain.
To the nearest foot (meter).

2502.05 BASIS OF PAYMENT.

Payment for subdrain construction will be the contract unit price as follows:

A. Standard Subdrain.

1. Per foot (meter).

2. Payment will be full compensation for:
- Trenching,
- Removal of excess excavated material from the project,
- Furnishing and placing end caps, elbows, tees, and other necessary connections,
- Furnishing and placing porous backfill material where specified,
- Placing backfill in the trench and finishing the surface as directed by the Engineer, and
- All tools and labor necessary to construct the subdrain.

3. For subdrains built according to the contract documents, no extra compensation will be allowed for overdepth, rock excavation, tamping backfill material, and removal of surplus material from the project.

4. When the contract documents do not indicate the depth of excavation, the first 6 feet (1.8 m) of excavation will be included in the contract unit price. Payment will be made for overdepth excavation according to Article 2503.05.

B. Longitudinal Subdrain.

1. Longitudinal Subdrain (Backslope).
Per foot (meter) of each size placed.

2. Longitudinal Subdrain (Shoulders).
Per foot (meter) of each size placed.

3. Payment for longitudinal subdrains will be full compensation for the following:
- Excavation of the trench and removal of excess trench material from the project,
- Furnishing and placing subdrain pipe, laterals, elbows, tees, special connections, couplings, and adaptors according to the manufacturer's recommendations,
- Furnishing and placing porous backfill material,
- Furnishing and placing engineering fabric as required,
- Restoring the shoulder of shoulder subdrains and covering backslope subdrains with earth, including shoulder outlet locations, and
- Proof rolling as specified.

4. When boulders result from excavation for longitudinal subdrains, the Engineer may order boulder pickup and removal from the project. When ordered, payment for this work will be at 10 (4) times the contract unit price for placing the longitudinal drains on the backslope or shoulder as appropriate, per cubic yard (cubic meter) of boulders.

C. Subdrain Outlet.

1. Each.

2. Payment is full compensation for the following:
- Furnishing and installing corrugated metal pipe, double walled PE, or PVC pipe including the outlet coverings, grouted joints and special connections,
- Drilling or forming into an existing drainage facility,
- Associated excavation,
- Placing specified backfill material,
- Furnishing and installing steel posts and concrete patio block and installing plastic sleeves, and
- Restoration of the site.

D. Intakes.

1. Each.

2. Payment is full compensation for all materials, labor, and equipment necessary for construction of the intakes, as specified, including excavation and removal of excess material from the project.

E. Trench Drain.

1. Per foot (meter).

2. Payment is full compensation for trenching, removal of excess excavated material from the project and furnishing and placing porous backfill material.

Section 2503. Storm Sewers

2503.01 DESCRIPTION.
This section was developed in conjunction with Section 4020 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct storm sewers.

B. Abandon storm sewer.

C. Cleaning, inspecting, and testing storm sewers.

D. Cleaning and inspecting pipe culverts.

E. Cleaning, inspecting, and testing rehabilitated pipe.

2503.02 MATERIALS.
Apply Article 4149.03.

2503.03 CONSTRUCTION.

A. Examination.

1. Verify measurements at site. Make necessary field measurements to accurately determine pipe makeup lengths or closures.

2. Examine site conditions to ensure construction operations do not pose hazards to adjacent structures or facilities.

B. Pipe Installation.

1. General.
- **a.** Provide proper facilities for lowering the sections into place without damaging the pipe.
- **b.** Inspect pipe for defects before carefully lowering into trench. Do not install damaged or defective pipe.
- **c.** Clean pipe interior and joints prior to lowering into trench. Keep pipe clean during construction.
- **d.** Begin at the lowest point in line. Lay groove or bell end pointing upstream unless specifically noted otherwise.
- **e.** Place pipe with lifting holes at the top of the pipe and fill lift hole with non-shrink grout or manufactured plugs.

f. Assemble joints as specified by the pipe manufacturer. When specified, wrap exterior of storm sewer pipe joints with engineering fabric.

g. Cut ends of pipe at manholes, intakes, and structures. Do not hammer cut or break pipe.

h. Provide manholes and intakes as specified in the contract documents.

i. Use watertight stopper, plug, or other approved means to protect the exposed upstream ends of the pipe and prevent soil sediment from entering the storm sewer system.

2. Trenched.

a. Excavate trench and provide bedding and backfill material as specified in Section 2552. If reinforced concrete elliptical pipe is used, provide pipe bedding as specified.

b. Prepare trench bottom to design line and grade so that only minor movement of pipe is necessary after installation.

c. Lay pipe to design line and grade:

1) Install pipe to line and grade specified in the contract documents. Set field grades to invert of pipe.

2) Correct misalignment, displacement, or otherwise defective pipe by removing, relaying, or replacing pipe, at no additional cost to the Contracting Authority

d. Provide uniform bearing for full pipe barrel length. Excavate bell holes as necessary for uniform support of pipe barrel on bedding material.

e. Do not lay pipe in water or on saturated soil or bedding, or allow water to rise in trench around pipe prior to placing backfill material.

f. Do not disturb installed pipe and bedding when using movable trench boxes and shields. Block or anchor pipe as necessary to prevent joint displacement.

3. Trenchless.

Apply Section 2553.

C. Storm Sewer Pipe Installed within a Casing Pipe.

Apply Article 2553.03, D, for installation of storm sewer pipe within a casing pipe.

D. Pipe Jointing.

1. General.

a. Clean joint surfaces to remove soil or foreign material prior to jointing pipe.

b. Assemble joints according to the pipe manufacturer's recommendations. Use equipment that does not apply damaging forces to pipe joints.

2. Reinforced Concrete Pipe, Reinforced Concrete Arch Pipe, and Reinforced Concrete Elliptical Pipe.

a. Use cold applied bituminous or rubber rope gasket jointing materials unless specified otherwise.

1) Apply joint material to entire tongue, or to top half of tongue and bottom half of groove, in sufficient quantity to fill the joint. Close the joint between pipes.
2) Fill remaining voids in the joint, both inside and outside of pipe, with joint material. Smooth the joint material on the inside of pipes 24 inches (600 mm) and larger.

b. If a rubber O-ring or profile gasket is specified for RCP, coat the rubber gasket and joint with soap based lubricant immediately prior to closing the joint.

c. If wrapped pipe joint is specified, comply with the contract documents. Secure engineering fabric in place to prevent displacement while placing backfill material.

d. Place pipe such that joint openings on the outside or inside of the pipe do not exceed 1/8 inch (3 mm) at the bottom and 5/8 inch (15 mm) at the top.

3. Reinforced Concrete Low Head Pressure Pipe, Polyvinyl Chloride Pipe and Corrugated PVC Pipe, and High Density Polyethylene Pipe.
Coat gasket and joint with soap based lubricant immediately prior to closing the joint.

4. Corrugated Metal Pipe and Corrugated Metal Arch Pipe.
Lap coupling bands to form a tightly closed joint upon installation.

5. Connections between Dissimilar Pipes.

a. Use manufactured adapters or couplings approved by the Engineer.

b. Where adapters or couplings are not available, the Engineer may authorize use of concrete collar as shown in the contract documents.

E. Tolerances.
The following tolerances apply to utilities installed by open trench construction. For trenchless construction, apply Section 2553.

1. Ensure horizontal and vertical alignment of gravity sewer lines does not vary from design line and grade at any point along the pipe by more than 1% of the inside diameter of the pipe or 1/4 inch (6 mm), whichever is larger.

2. Tolerance is allowed only if design line and grade is sufficient to prevent backslope when tolerance limits are reached.

3. Reverse slope on pipe is prohibited. Remove and reinstall to proper grade.

F. Conflicts.

1. Provide temporary support for existing water, gas, telephone, power, and other utilities or services that cross trench.

2. Compact backfill material under existing utility crossing as specified in Section 2552, or construct utility line supports where specified in the contract documents or as directed by the Engineer.

G. Storm Sewer Abandonment.

1. Prior to placing the sewer plug, the Engineer will verify the sewer line is not in use.

2. Construct sewer plug by completely filling the end of the pipe with concrete. Force concrete into the end of the pipe for a distance of 16 inches (400 mm), or one-half the pipe diameter, whichever is greater.

3. If noted in the plans, fill the line to be abandoned with flowable mortar or CLSM (comply with Section 2552) by gravity flow or pumping.

H. Connection to Existing Manhole or Intake.
Apply Article 2435.03, E.

I. Cleaning, Inspection, and Testing.
Apply Articles 2504.03, L, 1, 2, and 5.

2503.04 METHOD OF MEASUREMENT.

A. Storm Sewer.

1. **Trenched.**
Measurement for each type and size of pipe installed in a trench will be in linear feet (meters) along the centerline of the pipe from center of intake or manhole to center of intake or manhole. Where the end of the pipe discharges to a ditch or waterway, measurement will be to the end of the pipe, exclusive of aprons. Lengths of elbows and tees will be included in the length of pipe measured.

2. **Trenchless.**
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along the centerline of the pipe.

B. Storm Sewer with Casing Pipe.

1. **Trenched.**
Measurement for each type and size of pipe installed with a casing pipe in a trench will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

2. **Trenchless.**
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

C. Removal of Storm Sewer.
Measurement for each type and size of pipe removed will be in linear feet (meters) from end to end.

D. Cleaning, Inspecting, and Testing.
None.

2503.05 BASIS OF PAYMENT.

A. Storm Sewer.

1. Trenched.
a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe.
b. Payment is full compensation for:
- Trench excavation,
- Dewatering,
- Furnishing bedding material,
- Placing bedding and backfill material,
- Joint wrapping,
- Connectors, and
- Testing, and inspection.

2. Trenchless.
a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe.
b. Payment is full compensation for:
- Furnishing and installing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Pipe connections, and
- Testing, and inspection.

B. Storm Sewer with Casing Pipe.

1. Trenched.
a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe.
b. Payment is full compensation for:
- Furnishing and installing both carrier pipe and casing pipe,
- Trench excavation,
- Dewatering,
- Furnishing bedding material,
- Placing bedding and backfill material,
- Furnishing and installing annular space fill material,
- Casing spacers,
- Pipe connections, and
- Testing and inspection.

2. **Trenchless.**
   a. Payment will be made at the contract unit price per linear foot (meter) for each type and size of carrier pipe.
   b. Payment is full compensation for:
      - Furnishing and installing both storm sewer pipe and casing pipe,
      - Trenchless installation materials and equipment,
      - Pit excavation, dewatering, and placing backfill material,
      - Casing spacers,
      - Furnishing and installing annular space fill material,
      - Pipe connections,
      - Testing, and inspection.

C. Removal of Storm Sewer.

1. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe removed.

2. Payment is full compensation for removal, disposal, and capping (if specified) of pipe.

D. Cleaning, Inspecting, and Testing.
Cleaning, inspecting, and testing storm sewers and pipe culverts is incidental to other project costs and will not be paid for separately.

Section 2504. Sanitary Sewers

2504.01 DESCRIPTION.

This section was developed in conjunction with Sections 4010 and 4060 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct sanitary sewer gravity and force mains.

B. Construct or relocate building sanitary sewer services, stubs, and connections.

C. Clean, inspect, and test sanitary sewer gravity mains, sanitary sewer force mains, and sanitary sewer service stubs.

D. Clean, inspect, and test rehabilitated pipe.

2504.02 MATERIALS.

A. Sanitary Sewer.
Apply Article 4149.02

B. Testing Equipment for Cleaning, Inspection, and Testing Sewers and Drains.

1. **General.**
   Comply with applicable sections of ASTM and other applicable industry standards and codes.

2. **Video Inspection.**
   a. Video Camera:
      1) High-resolution color with adjustable iris focus.
      2) Pan and tilt capabilities.
      3) Integral lighting suitable to provide proper illumination and a clear video image of the entire periphery of the pipe.
      4) Capable of operating in 100% humidity conditions.
      5) Produce a high quality video image.
   b. Provide closed circuit video inspection equipment capable of displaying on-screen footage of distance measured to within 1% of actual distance.

C. **Inspection Reporting.**
   Record the inspection in color in the recording media specified by the Engineer. Forward the recording to the Engineer.

2504.03 CONSTRUCTION.

A. **Examination.**

1. Verify measurements at site. Make necessary field measurements to accurately determine pipe makeup lengths or closures.

2. Examine site conditions to ensure construction operations do not pose hazards to adjacent structures or facilities.

B. **Gravity Sewer Installation.**

1. **General.**
   a. Install watertight plug to prevent water from entering the existing sewer system.
   b. Inspect pipe for defects before installation. Do not install damaged or defective pipe.
   c. Clean pipe interior and joints prior to installation. Keep pipe clean during construction.
   d. Begin at the lowest point in the line. Lay groove or bell end pointing upstream unless specifically noted otherwise.
   e. Assemble joints according to Article 2504.03, D.
   f. Cut ends of pipe at manholes and structures with a saw. Do not hammer cut or break pipe.
   g. Provide manholes as specified in the contract documents.
   h. Install cap, plug, or bulkhead at exposed ends of pipe upon completion of construction or whenever pipe installation is not in progress.

2. **Trenched.**
   a. Excavate trench and provide pipe bedding and backfill material as specified in Section 2552.

b. Prepare trench bottom to design line and grade so that only minor movement of the pipe is necessary after installation.

c. Lay pipe to design line and grade:

1) Install pipe to line and grade specified in the contract documents. Set field grades to invert of pipes.

2) At no additional cost to the Contracting Authority, correct misalignment, displacement, or otherwise defective pipe by removing, relaying, or replacing pipe.

d. Provide uniform bearing for full pipe barrel length. Excavate bell holes as necessary for uniform support of pipe barrel on bedding material.

e. Do not lay pipe in water or on saturated soil or bedding, or allow water to rise in trench around pipe prior to placing backfill material.

f. Do not disturb installed pipe and bedding when using movable trench boxes and shields. Block or anchor pipe as necessary to prevent joint displacement.

g. Install preformed wye or tee service fitting at each location as specified in the contract documents.

3. Trenchless.
Apply Section 2553.

C. Carrier Pipe Installed within a Casing Pipe.
Apply Article 2553.03, D, for installation of carrier pipe within casing pipe.

D. Gravity Main Pipe Jointing.

1. General.

a. Clean joint surfaces to remove soil or foreign material prior to jointing pipe.

b. Assemble joints according to the pipe manufacturer's recommendations. Use equipment that does not apply damaging forces to pipe joints.

2. Polyvinyl Chloride Pipe and Polyvinyl Chloride Composite Pipe (truss-type).

a. Coat rubber gasket and joint with soap-based lubricant immediately prior to closing joint.

b. Seal ends of PVC composite and closed profile pipe at manholes with the coating recommended by the manufacturer.

3. Reinforced Concrete Pipe.
Coat rubber gasket and joint with soap-based lubricant immediately prior to closing joint.

4. Ductile Iron Pipe.

a. Push-on Joint: Coat gasket and joint with soap-based lubricant immediately prior to closing joint.

b. Mechanical Joint: Wash plain end, bell socket, and gasket with soap solution. Press gasket into socket, set gland, and tighten bolts uniformly.

5. **Connections between Dissimilar Pipes.**
   a. Use manufactured adapters or couplings approved by the Engineer.
   b. Where adapters or couplings are not available, the Engineer may authorize use of a Type PC-2 concrete collar as shown in the contract documents.

E. Force Main Installation.

1. **General.**
   Install according to Section 2554.

2. **Tracer Wire.**
   a. Required for all force main installations. Apply Section 2554.
   b. Install tracer wire station at each end of the force main and at additional locations specified in the contract documents.
   c. Bury end of tracer wire station 2 feet (0.6 m) and compact.

F. Sanitary Sewer Service Stubs.

1. Provide sanitary sewer service stubs at locations specified in the contract documents.

2. Install wye or tee for each service connection.
   a. Connection of sanitary service to new sewer main, except RCP:
      1) Use only factory wye or tees.
      2) Install according to the manufacturer's requirements and Articles 4149.02, D, and 2504.03, D, for joints.
   b. Connection to existing sewer main and new RCP:
      1) Cut sewer main for service tap with hole saw or sewer tap drill.
      2) Use preformed saddle wye or saddle tee for service tap. Use a gasketed saddle with rigid pipe mains, and a solvent-cemented saddle with PVC mains.
      3) Install according to the manufacturer’s requirements, but always with at least two stainless steel band clamps.

3. Install service stub from sewer main to a location 10 feet (3 m) beyond the right of way line or as specified in the contract documents.
   a. Install according to Article 2504.03, B
   b. Install service stub with a slope between 2% and 5% for 4 inch (100 mm) pipes, and between 1% and 5% for 6 inch (150 mm) pipes and greater.
   c. Terminate end of service stub 10 to 12 feet (3.0 to 3.6 m) below finished ground elevation or as specified in the contract documents.
   d. If the depth of the sewer main causes the service to exceed a depth of 12 feet (3.6 m) or a slope of 5%, install a service riser.
   e. For undeveloped properties, place watertight stopper, cap, or plug in end of sanitary sewer service. Mark the end of the service line as required by the Engineer or as specified in the contract documents.
   f. For reconnection of new service pipe with existing service pipe and new service pipe, comply with the Engineer’s plumbing code.

G. Sanitary Sewer Service Relocation.

1. Relocate existing sanitary sewer services that conflict with new storm or sanitary sewer installations. Existing services located within a conflict zone from 6 inches (150 mm) below the bottom of the proposed sewer pipe to 2 inches (50 mm) above the top of the proposed sewer pipe require relocation.

2. When a conflicting service is encountered:

a. Determine grades and elevations of the existing service and proposed main.

b. Determine the extent of service replacement necessary to relocate the service outside of the conflict zone while maintaining a minimum 1% slope on the sewer service.

c. If it is not feasible to maintain a minimum slope of 1% on the relocated service, a special design and additional work may be required. Stop work and contact the Engineer. Do not remove sewer service unless directed by the Engineer.

d. If service relocation with a minimum slope of 1% is feasible, proceed with removal and replacement of the existing sanitary sewer service.

1) Length of replacement varies. Remove the existing service to the extent necessary to move the service out of the conflict zone.

2) Use new materials complying with Article 4149.02, D.

3) Re-install the service according to Article 2504.03, B.

4) Maintain a minimum 1% grade on relocated service.

H. Sanitary Sewer Abandonment.

1. Prior to placing the sewer plug, the Engineer will verify the sewer line is not in use.

2. Construct sewer plug by completely filling the end of the pipe with concrete. Force concrete into the end of the pipe for a distance of 16 inches (400 mm), or one half the pipe diameter, whichever is greater.

3. If specified in the contract documents, fill the line to be abandoned with flowable mortar or CLSM, according to Article 2552.02, E, by gravity flow or pumping.

I. Connection to Existing Manhole.
Apply Article 2435.03, E.

J. Tolerances.
Apply the following tolerances to utilities installed by open trench construction. For trenchless construction, comply with Section 2553.

1. Gravity Main.

a. Do not allow horizontal and vertical alignment of trenched gravity sewer lines to vary from design line and grade at any point along

the pipe by more than 1% of the inside diameter of the pipe or 1/4 inch (6 mm), whichever is larger.

b. This tolerance is allowed for trenched gravity sewer lines only if design line and grade is sufficient to prevent backslope when tolerance limits are reached.

c. Reverse slope on gravity pipe is prohibited. Remove and reinstall pipe to proper grade.

2. Force Main.

Do not allow horizontal and vertical alignment of trenched force mains to vary from design line and grade by more than 3 inches (75 mm).

K. Conflicts.

1. General.

a. Provide temporary support for existing water, sewer, gas, telephone, power, and other utilities or services that cross the trench.

b. Compact backfill material under existing utility crossing as specified in Section 2552, or construct utility line supports where indicated specified in the contract documents or as directed by the Engineer.

2. Horizontal Separation of Gravity Sewers from Water Mains.

a. Separate gravity sewer mains from water mains by a horizontal distance of at least 10 feet (3 m) unless:

- The top of a sewer main is at least 18 inches (450 mm) below the bottom of the water main, and
- The sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth at a minimum horizontal separation of 3 feet (1 m) from the water main.

b. When it is impossible to obtain horizontal clearance of 3 feet (1 m) and vertical clearance of 18 inches (450 mm) between sewers and water mains, the sewers shall be constructed of water main materials meeting the requirements of Article 4149.02, B; however, provide a linear separation of at least 2 feet (600 mm).

3. Separation of Sewer Force Mains from Water Mains.

Separate sewer force mains and water mains by a horizontal distance of at least 4 linear feet (1.2 m).

4. Separation of Sewer and Water Main Crossovers.

a. Vertical separation of sanitary sewers crossing under any water main should be at least 18 inches (450 mm) when measured from the top of the sewer to the bottom of the water main. If physical conditions prohibit the separation, the sewer may be placed not closer than 6 inches (150 mm) below a water main or 18 inches (450 mm) above a water main. Maintain the maximum feasible separation distance in all cases.

b. Where the sewer crosses over or less than 18 inches (450 mm) below a water main, locate one full length of sewer pipe of water main material so both joints are as far as possible from the water main. The sewer and water pipes shall be adequately supported

and have watertight joints. Use a low permeability soil for backfill material within 10 feet (3 m) of the point of crossing.

L. Cleaning, Inspection, and Testing.
Notify the Engineer at least 24 hours prior to performing testing. The Engineer shall be present to review testing procedures and record results.

1. Cleaning.
- **a.** Clean all sanitary sewers and storm sewers by flushing with high pressure water and removing debris by vacuum extraction, and by removing sheeting, bracing, shoring, forms, soil sediment, concrete, or other debris.
- **b.** Do not discharge soil sediment or debris to drainage channels, existing storm sewers, or existing sanitary sewer systems.

2. Visual Inspection.
- **a.** Check each section of sanitary sewer and storm sewer by lamping.
- **b.** Light should be visible through section of pipe lamped.
- **c.** Visually inspect each run of pipe.
- **d.** Repair or replace defective pipe or joints, or remove and relay pipe not meeting alignment tolerances, as directed by the Engineer.

3. Video Inspection.
- **a. General.**
  - **1)** Conduct video inspection of all new and rehabilitated sanitary sewers after all backfill and compaction operations are completed, but prior to paving.
  - **2)** Notify the Engineer the day prior to inspection so the Engineer may be present during the inspection.
  - **3)** Low spots holding water in excess of 1 inch (25 mm) or 5% of the pipe diameter, whichever is less, will be considered unacceptable.
  - **4)** If unacceptable low spots exist, as indicated by standing water during video inspection, remove and replace sewer as necessary and re-inspect.
- **b. Inspection Procedure.**
  - **1)** Prior to video inspection, run sufficient water through the pipe to saturate potential low spots so they may be detected during inspection.
  - **2)** Inspect each pipe segment between manholes or access points in a single, continuous run. Progress through the entire project in a uniform direction.
  - **3)** Inspect all lateral connections and other observations at right angles utilizing the pan and tilt capabilities of the camera.
  - **4)** Center the video camera in the pipe during the inspection.
  - **5)** Do not exceed 30 feet (10 m) of inspection per minute.
- **c. Inspection Reporting.**
  - **1)** Provide a copy of the video inspection in the recording media specified by the Engineer. Include on screen continuous footage, pipe diameter, direction of viewing, and manhole and street location references in the recording. Affix labels to the

recording media to include the name of the project, the date, and the location of the inspection.

2) Provide a written report of the inspection. In the report, include true to scale drawings of all sewer defects and observation locations. Reference the time stamp on each line item entry on the written report.

4. Sanitary Sewer Leakage Testing.

Perform one or more of the following tests on new sanitary sewer gravity mains and sanitary sewer service stubs. Test sanitary sewer manholes separately as specified in Section 2435.

a. Sanitary Sewer Infiltration Testing.

1) Use only where ground water is more than 2 feet (600 mm) above top of pipe at highest point in section being tested.

2) Provide documented verification of ground water elevations for no less than 24 hours before measurement of infiltration.

3) Measure infiltration in sanitary sewer with a V-notch weir in downstream manhole.

4) The maximum allowable infiltration for new sanitary sewers, including manholes, is 200 gallons per inch of diameter per mile (19 L per mm of diameter per km) of pipe per day.

b. Sanitary Sewer Exfiltration Testing.

1) General.

Use an exfiltration test when ground water level is less than 2 feet (600 mm) above top of pipe at highest point in section being tested. Sectionalize the test section so that the internal pressure in the pipe does not exceed 5 feet (1.5 m) of water.

2) Test Procedures.

a) Install a watertight plug in the inlet of the upstream and downstream manhole of sewer section being tested.

b) Fill the sewer and upstream manhole with potable water until the water elevation in the upstream manhole is 2 feet (600 mm) higher than outside top of pipe in section being tested or 2 feet (600 mm) above existing ground water level, whichever is highest elevation.

c) Allow the water level to stabilize for 30 minutes, then refill the upstream manhole with water to the original level and begin the test.

d) Measure the amount of water lost in the upstream manhole in 1 hour. Use that amount to determine exfiltration in a 24 hour period.

3) Exfiltration Rate.

a) Table 2504.03-1 may be used to determine exfiltration in gallons (liters) per 24 hours by measuring the loss that occurs in 1 hour. The table is applicable only for 48 inch (1200 mm) diameter manholes.

b) The maximum allowable exfiltration for new sanitary sewer, including manholes, is 200 gallons per inch of diameter per mile (19 L per mm of diameter per km) of pipe per day.

Table 2504.03-1: Loss in Gallons (Liters) Per 24 Hours for Drop in Water Level per Hour in 48 inch (1200 mm) Diameter Manhole (table may be interpolated to the nearest 1/4" (6 mm) drop)

Drop	**0"**	**1"**	**2"**	**3"**	**4"**	**5"**	**6"**	**7"**	**8"**	**9"**
	0	188	376	564	752	940	1128	1316	1504	1692
Drop	**0 mm**	**25 mm**	**50 mm**	**75 mm**	**100 mm**	**125 mm**	**150 mm**	**175 mm**	**200 mm**	**225 mm**
	0	712	1423	2135	2845	3558	4267	4982	5693	6405

c) For manholes larger than 48 inch (1200 mm) diameter, use the following formula:

English

$G = 0.0816(H)(D^2)$

Where:

G = loss in gallons
D = diameter of manhole in inches
H = water level drop in manhole in inches

Metric

$L = 353.25(H)(D^2)$

Where:

L = loss in liters
D = diameter of manhole in mm
H = water level drop in manhole in mm

c. Sanitary Sewer Low Pressure Air Testing.

1) General.

a) A low pressure air test may be used in lieu of an exfiltration test except as noted.

b) Air test is not recommended when ground water elevation is 2 feet (600 mm) or greater above the top of the pipe, and cannot be used when ground water is greater than 6 feet (2 m) above the top of the pipe.

c) Use extreme care and follow safety precautions during testing operations. No one is allowed in manholes during testing.

2) Test Procedures.

a) Clean the entire line of all debris. Flush or wet line to produce consistent results.

b) Plug all inlets and outlets to resist the test pressure. Special attention shall be given to stoppers and laterals.

c) Determine the test duration for the section being tested from Table 2504.03-2. This table ignores pipe length and uses the factor 0.472×d (1.20×d), with d being in inches (mm). Pressure holding time is based on average holding pressure of 3.0 psi (21 kPa) or drop from 3.5 psi (24 kPa) to 2.5 psi (18 kPa).

Table 2504.03-2: Test Duration

Size Pipe, inches (mm)	**Test Period Duration (minutes)**
8 (200)	4.0
10 (250)	5.0

12 (300)	6.0
15 (325)	7.0
18 (450)	8.5
21 (525)	10.0
24 (600)	11.5
27 (675)	13.0
30 (750)	14.0
36 (900)	17.0
42 (1050)	20.0
48 (1200)	23.0
54 (1350)	25.5
60 (1500)	28.5

d) Add air to the line segment being tested until the internal air pressure of the sewer line is raised to approximately 4.0 psi (28 kPa) greater than the average back pressure of any ground water that may be over the top of the pipe. Pressure in the sewer should not exceed 5.0 psi (35 kPa). Allow at least 2 minutes for air pressure to stabilize.

e) When pressure has stabilized and is at or above the starting test pressure of 3.5 psi (24 kPa), commence the test. Record the drop in pressure for the test period. The test may be discontinued when the prescribed test time has been completed, even though a 1.0 psi (7 kPa) drop has not occurred.

f) If groundwater level at the time of testing is above the pipe invert, add 0.43 psi air per foot (10 kPa air per meter) of water above the invert to the test air pressure range of 2.5 psi (18 kPa) to 3.5 psi (24 kPa) stated above.

g) If the pressure drop exceeds 1.0 psi (7 kPa) during the test period, the test will be considered to have failed. Repair and retest the line.

d. Sanitary Sewer Vacuum Testing.

1) General.

a) Vacuum testing may be used in lieu of other specified test methods.

b) Use extreme care and follow safety precautions during testing operations. Keep personnel out of and away from manholes during testing.

c) Where practical, clean the pipe prior to testing and wet the pipe surface. Isolate the test segment as necessary, including closing service connections.

2) Test Procedures.

a) Determine the test time for the size of pipe being tested using Table 2504.03-3.

Table 2504.03-3: Minimum Test Time

Nominal Pipe Size, inches (mm)	T (time); Minutes/100 feet (30 m) of pipe
4 (100)	0.3
6 (150)	0.7
8 (200)	1.2
10 (250)	1.5
12 (300)	1.8
15 (375)	2.1
18 (450)	2.4
21 (525)	3.0
24 (600)	3.6
27 (675)	4.2
30 (750)	4.8
33 (825)	5.4
36 (900)	6.0

b) Test time is the time required for vacuum to drop from 3.5 psi (24 kPa) to 2.5 psi (18 kPa).

c) Use a vacuum pump with the capacity to evacuate the sewer test section in time equal or less than that shown in Table 2504.03-3 for the size of pipe being tested.

d) Evacuate air until the internal air pressure of the sewer line is lowered by approximately 4.0 psi (28 kPa). Allow the air pressure to stabilize.

e) When the air pressure is stabilized near the starting test vacuum of 3.5 psi (24 kPa), commence the test by allowing gage pressure to drop to 3.5 psi (24 kPa), then commence time recording. Record the drop in vacuum for the test period.

f) If the drop in vacuum is 1.0 psi (7.0 kPa) or less during the test period, the test will be considered successfully passed.

g) If the drop in vacuum is greater than 1.0 psi (7.0 kPa) during the test period, inspect, evaluate, repair, and retest.

5. Deflection Testing.

a. Perform deflection tests on all PVC sanitary sewer mains. Also perform deflection tests on all HDPE storm sewer or culvert pipe 12 inches in diameter or greater.

b. Perform deflection tests after backfill material has been in place at least 30 calendar days and before paving activity takes place, or as per appropriate sections of these specifications.

c. Pull a 9 arm deflection mandrel complying with applicable ASTM Standards through sewer by hand.

d. Ensure pipe deflection does not exceed 5% of average inside diameter as established by ASTM Standards.

e. Remove and replace pipe exceeding deflection limits.
f. Handle and divert existing flows during deflection testing.

6. Force Main Testing.

a. Provide test pumps, test plugs, pipe, and gages. Make necessary piping connections.
b. Fill the force main with potable water and flush before testing to remove entrapped air. Other water sources may be used if approved by the Engineer.
c. Insert taps as required to remove air. Plug taps after the completion of tests.
d. Use a test pressure of 1.5 times the working pressure at the lowest point along the test section, but no less than 50 psi (350 kPa).
e. Pressurize the test section and allow it to stabilize prior to beginning the leakage test.
f. Maintain pressure to within 5 psi (35 kPa) of the test pressure by pumping in potable water as required.
g. Leakage is the quantity of water that shall be supplied into the test section to maintain pressure within 5 psi (35 kPa) of the specified test pressure during a 2 hour test period.
h. The maximum allowable leakage is determined by the following formula:

English Units

$$L = \frac{(S)(D)(P)^{0.5}}{133{,}200}$$

Where:
L = allowable leakage in gallons per hour
S = length of pipe tested in feet
D = nominal pipe diameter in inches
P = average test pressure in pounds per square inch

Metric Units

$$L = \frac{(S)(D)(P)^{0.5}}{705{,}150}$$

Where:
L = allowable leakage in liters per hour
S = length of pipe tested in meters
D = nominal pipe diameter in mm
P = average test pressure in kPa

Table 2504.03-4 assumes an average test pressure (P) of 50 psi (350 kPa) and length of pipe (S) of 1000 feet (300 m).

Table 2504.03-4: Maximum Allowable Leakage Rate

Nominal Pipe Size inches (mm)	Allowable Leakage gallonshour/1000 feet of pipe (liters/hour/300 m of pipe)
4 (100)	0.21 (0.80)
6 (150)	0.32 (1.19)
8 (200)	0.42 (1.59)
10 (250)	0.53 (1.99)
12 (300)	0.64 (2.39)
14 (350)	0.74 (2.79)
16 (400)	0.85 (3.18)

i. Examine exposed pipe and fittings during testing. Repair all visible leaks.

j. If the test indicates leakage greater than allowed, locate, repair, or replace damaged or defective pipe, and repeat tests until the requirements are met.

2504.04 METHOD OF MEASUREMENT.

A. Sanitary Sewer Gravity Main.

1. Trenched.
Measurement for each type and size of pipe installed in a trench will be in linear feet (meters) along the centerline of the pipe from center of manhole to center of manhole.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along the centerline of pipe.

B. Sanitary Sewer Gravity Main with Casing Pipe.

1. Trenched.
Measurement for each type and size of pipe installed with casing pipe in a trench will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

C. Sanitary Sewer Force Main.

1. Trenched.
Measurement for each type and size of pipe installed in a trench will be in linear feet (meters) along the centerline of the pipe from the outside wall of the pumping station to the center of manhole, or from center of manhole to center of manhole.

2. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along centerline of pipe.

D. Sanitary Sewer Force Main with Casing Pipe.

1. Trenched.
Measurement for each type and size of pipe installed with casing pipe in a trench will be in linear feet (meters) along the centerline of the casing pipe.

2. **Trenchless.**
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe.

E. Sanitary Sewer Service Stub.

1. A sanitary sewer service stub is the portion of the sanitary sewer service from the main to a point 10 feet (3 m) outside of the right-of-way line or as specified in the contract documents.

2. Measurement for each type and size of pipe will be in linear feet (meters) along the centerline of the pipe from the end of the pipe to the centerline of the sewer main.

F. Sanitary Sewer Service Relocation.

1. A sanitary sewer service relocation is the portion of an existing sanitary sewer service in a zone of conflict.

2. Each completed relocation will be counted.

G. Sewage Air Release Valve and Pit.
Each completed installation, including valve, accessories, and pit, will be counted.

H. Removal of Sanitary Sewer.
Measurement for each type and size of pipe removed will be in linear feet (meters) from end to end.

I. Cleaning, Inspecting, and Testing.
None.

2504.05 BASIS OF PAYMENT.

A. Sanitary Sewer Gravity Main.

1. **Trenched.**
   a. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.
   b. Payment is full compensation for trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, wyes and other fittings, pipe joints, testing, and inspection.

2. **Trenchless.**
   a. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.
   b. Payment is full compensation for:
      - Furnishing and installing pipe,
      - Trenchless installation materials and equipment,
      - Pit excavation, dewatering, and placing backfill material,

- Pipe connections, and
- Testing and inspection.

B. Sanitary Sewer Gravity Main with Casing Pipe.

1. Trenched.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.

b. Payment is full compensation for:

- Furnishing and installing both sanitary sewer pipe and casing pipe,
- Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material,
- Furnishing and installing annular space fill material,
- Casing spacers,
- Pipe connections, and
- Testing, and inspection.

2. Trenchless.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.

b. Payment is full compensation for:

- Furnishing and installing both sanitary sewer pipe and casing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Casing spacers,
- Furnishing and installing annular space fill material,
- Pipe connections, and
- Testing and inspection.

C. Sanitary Sewer Force Main.

1. Trenched.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.

b. Payment is full compensation for trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, wyes and other fittings, pipe joints, testing, and inspection.

2. Trenchless.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.

b. Payment is full compensation for furnishing and installing pipe, trenchless installation materials and equipment, pit excavation, dewatering, placing backfill material, pipe connections, testing, and inspection.

D. Sanitary Sewer Force Main with Casing Pipe.

1. Trenched.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.

b. Payment is full compensation for furnishing and installing both sanitary sewer pipe and casing pipe, trench excavation, dewatering, placing bedding and backfill material, furnishing and installing annular space fill material, casing spacers, pipe connections, testing, and inspection.

2. Trenchless.

a. Payment will be at the contract unit price per linear foot (meter) for each type and size of sanitary sewer pipe.

b. Payment is full compensation for:

- Furnishing and installing both sanitary sewer pipe and casing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Casing spacers,
- Furnishing and installing annular space fill material,
- Pipe connections, and
- Testing and inspection.

E. Sanitary Sewer Service Stub.

1. Payment will be made at the contract unit price per linear foot (meter) for each type and size of sanitary sewer service stub.

2. Payment is full compensation for trench excavation, furnishing bedding material, placing bedding and backfill material, tap, fittings, testing, and inspection.

F. Sanitary Sewer Service Relocation.

1. Payment will be made at the contract unit price for each relocation.

2. Payment is full compensation for removal of existing pipe, trench excavation, furnishing new pipe and bedding material, placing bedding and backfill material, connection back to existing service, compaction, testing, and inspection.

G. Sewage Air Release Valve and Pit.

1. Payment will be made at the contract unit price for each sewage air release valve and pit.

2. Payment is full compensation for excavation, furnishing bedding material, placing bedding and backfill material, compaction, and testing.

H. Removal of Sanitary Sewer.

1. Payment will be at the contract unit price per linear foot (meter) for each type and size of pipe.

2. Payment is full compensation for removal, disposal, and capping (if specified) of pipe.

I. Cleaning, Inspecting, and Testing.
Cleaning, inspecting, and testing sanitary sewers, storm sewers, pipe culverts, and rehabilitated pipes (including video inspection) is incidental to other project costs and will not be paid for separately.

Section 2505. Guardrail Construction and Removal

2505.01 DESCRIPTION.
Construct guardrail. Remove existing guardrail.

2505.02 MATERIAL.

A. Formed Steel Beam Guardrail and Low Tension Three Strand Cable Guardrail.
Apply Section 4155.

B. High Tension Cable Guardrail.

1. Meet the manufacturer's materials requirements. For concrete foundations for posts and end anchors, use Class C mix according to Section 2403.

2. Supply spare parts kits for high tension cable guardrail consisting of:
- An extra supply of TL-4 line posts (socketed-type), including post hardware and accessories (caps, reflective sheeting, straps, spacers, and socket covers). This supply is to include enough materials to complete a 300 foot installation.
- An extra supply of anchor posts (socketed-type), including post hardware and accessories (caps, reflective sheeting, straps, fittings, spacers, and socket covers). This supply is to include enough materials to complete one end anchor installation.
- Specialized tools necessary to maintain the guardrail, such as a spreader tool.

3. Spare parts kits do not include a tension meter. Deliver spare parts kit to Contracting Authority's nearest maintenance office.

2505.03 CONSTRUCTION AND REMOVAL OF GUARDRAIL.

A. Formed Steel Beam Guardrail and Low Tension Three Strand Cable Guardrail.

Furnish and install posts, beams or cables, end anchors, and special connections and fittings required in the contract documents. Erect to the specified line and mounting height. Construct guardrail as follows:

1. Installation of Formed Steel Beam Guardrail.

a. Install w-beam or thrie-beam as designated in the contract documents. When not designated, install w-beam.

b. Use w-beam or thrie-beam that is ready for assembly when delivered to the project. Do not punch, drill, cut, or weld w-beam or thrie-beam in the field.

2. Installation of Low Tension Three Strand Cable Guardrail.

a. Attach the three cables to the posts and end anchors according to the contract documents. Attach the cables to the posts using approved hooks, or by other means if specified in the contract documents. Attach compensation devices and turnbuckles so as not to interfere with the function of any part of the installation.

b. Individual cables may be spliced by use of an approved device installed where no interference with any other function will occur. One splice per cable is allowed. Cable may not be spliced within 250 feet (75 m) of another splice.

c. Tighten individual cables using mechanical means. Stretch cables tight so that no sags occur between posts and so that, in the opinion of the Engineer, the finished installation presents a satisfactory appearance.

3. Posts.

a. Drive posts in a manner that does not damage the post. Place backfill material (consisting of material removed or other suitable soil) around posts required to be set in prebored holes. Place the backfill material in lifts not exceeding 4 inches (100 mm). Thoroughly compact each lift before the next lift is placed.

b. Install the posts to be firm, plumb, and at the location, spacing and elevation designated.

4. End Anchors and Terminals.

a. Install end anchors and terminals of the type shown in the contract documents. When anchor bolt holes in concrete bridge end posts do not align correctly for the formed steel beam guardrail terminal connection, drill new anchor bolt holes in the locations required for the terminal connection. Use a core bit to ensure correct anchor bolt hole location and alignment.

b. Cast anchors in place. Use Class C concrete according to Section 2403, except air content may very from 4% to 7%. Finish exposed concrete as directed by the Engineer. Class C concrete may be subjected to loading of the rail in 3 calendar days. Concrete with high early strength may be necessary to meet the requirements of Article 2505.03, D. Class M concrete may be substituted at no

additional cost to the Contracting Authority. Concrete with these proportions can also be subjected to loading in 3 calendar days.

5. **Guardrail Markers and Barrier Markers.**
When indicated in the contract documents, install guardrail markers and barrier markers of the required type meeting the requirements of Article 4186.12.

6. **Delineators and Object Markers.**
When indicated in the contract documents, install delineators and object markers of the required type meeting the requirements of Article 4186.12.

B. High Tension Cable Guardrail.

1. **General.**
   - **a.** Construct high tension cable guardrail by furnishing and installing posts, cables, end anchors, and all special connections and fittings which may be required in the contract documents.
   - **b.** Furnish high tension cable guardrail that:
     - **1.** Meets the requirements of NCHRP Report 350, Test Level 4 criteria.
     - **2.** Is accepted as a crashworthy device by the FHWA.
     - **3.** Exhibits a dynamic deflection for NCHRP Report 350 Test 3-11 of 8 feet (2.4 m) or less.
   - **c.** Approved products are listed in Materials I.M. 455.01.

2. **Installation of High Tension Cable Guardrail.**
   - **a.** Install high tension cable guardrail according to the manufacturer's recommendations. Prior to construction, provide the Engineer with three copies of the manufacturer's current product manuals covering installation and maintenance of the installation. Include signed certification statements for all materials to be incorporated into the installation according to Materials I.M. 455.01.
   - **b.** Tension the cables according to the manufacturer's recommendations at the time of installation, then check and adjust the tension approximately three weeks after installation.

3. **Posts.**
   - **a.** Ensure posts are plumb and at the manufacturer's recommended location, spacing, and elevation.
   - **b.** Furnish "socketed" type posts and install in concrete foundations. Cast the foundations in place according to Article 2505.03, A, 4. Use the dimensions and reinforcement recommended by the manufacturer, except with a foundation depth of at least 42 inches (1.1 m).

4. **End Anchors.**
   - **a.** Incorporate one of the approved end anchors listed in Materials I.M. 455.01. Furnish end anchors produced by the same manufacturer of the high tension cable guardrail.

b. Construct end anchors according to the manufacturer's recommendations for the site specific soil conditions. Soils testing required is incidental to the cable installation.

5. Delineating High Tension Cable Guardrail.

a. Delineate high tension cable guardrail installations using retroreflective sheeting. Apply the sheeting to the last five posts at each end of an installation and throughout the remainder of the installation at a maximum spacing of 50 feet (15 m). Apply Type III or IV retroreflective sheeting that:

- Meets the requirements of Article 4186.03,
- Provides at least 7 square inches (4500 mm^2) of surface area when viewed from a line parallel to the roadway centerline, and
- Is yellow or white and of the same color as the adjacent edge line.

b. Attach sheeting near the top of the post: 1) in a manner recommended by the manufacturer; and 2) to that side of the post from which vehicle impacts are most likely. For installations where impacts are likely to occur from either side, apply the sheeting to both sides of the post.

C. Guardrail Removal.

1. Remove guardrail as shown in the contract documents. Salvage the materials the Engineer considers suitable for future use. Deliver the salvaged materials to the location stated in the contract documents. Salvaged materials become the property of the Contracting Authority. Materials not suitable for future use become the property of the Contactor. Remove non-salvaged materials off the project site.

2. Without damaging any parts, carefully remove, disassemble, and clean the salvaged guardrail. If material is damaged during removal, disassembly, or cleaning, replace with new material of the same kind. Replace damaged materials with new materials (at no cost to the Contracting Authority). Stockpile salvaged materials as indicated in the contract documents. Restore areas disturbed by the removal operation to an acceptable condition.

3. Remove, without damaging, the posts the Engineer designates as salvable. Pull the posts having no salvage value. Place backfill material consisting of suitable soil in the holes. Sand or other granular materials are not acceptable for use as backfill material. Place backfill material in lifts not exceeding 4 inches (100 mm). Thoroughly compact each lift before the next lift is placed. Fill and tamp holes within the same working day.

4. Remove delineators and object markers as shown in the contract documents or as designated by the Engineer. Salvage the materials the Engineer considers suitable for future use. Salvaged materials become the property of the Contracting Authority. Materials not suitable for future use become the property of the Contractor. Remove non-salvaged materials off the project site.

D. Limitations.

1. General.

a. Do not stress attachments to new concrete or to anchor bolts set in epoxy resin until the new concrete or epoxy resin has attained an age of 3 calendar days. Concrete foundations for posts and end anchors may be subjected to cable tensioning after 3 calendar days. These time requirements may be lengthened by the Engineer during cool weather.

b. Complete grading work, if required, prior to removal of existing guardrail or installation of new guardrail.

c. When a roadway is open to traffic during construction, complete guardrail installations within 5 working days from the day the structure, barrier rail, pavement, or shoulder (whichever is the controlling item of work) is sufficiently completed to allow guardrail installation.

d. When a roadway is closed to public traffic for construction, complete all guardrail installations before opening the road to traffic.

e. On a roadway that is open for traffic during guardrail construction, each installation exceeding the 5 working day completion requirement will be subject to a contract price adjustment of $100 per working day. For high tension cable guardrail, this price adjustment will be waived when the installation is designated as crossover protection only and no guardrail or concrete barrier has been removed.

2. Formed Steel Beam Guardrail and Low Tension Three Strand Cable Guardrail.

In areas where guardrail construction is not restricted by other construction, remove existing guardrail (if any) and construct new guardrail, except for end anchors requiring concrete, on the same working day. Fully connect beam rail to all posts. Place concrete for the final end anchor no later than the next working day. Until the final anchor is finished, use a Type E Terminal Section, a Type II Barricade, and a Type A Warning Light to end a guardrail installation that requires end anchors.

3. High Tension Cable Guardrail.

a. In case of a discrepancy between these specifications and the manufacturer's recommendations, these specifications will govern.

b. At locations where the proposed guardrail installation does not interfere with the functioning of the existing guardrail, do not remove the existing guardrail until the high tension cable guardrail system is fully functional.

c. Delineate guardrail end anchors with a temporary traffic drum until the final end anchor is completed and the cables properly tensioned.

2505.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Formed Steel Beam Guardrail and Low Tension Three Strand Cable Guardrail.

1. Installation of Guardrail.

a. Steel beam and cable guardrail quantities will be shown in the contract documents.

b. The cable guardrail quantity will be calculated using one of the cables of cable guardrail, with no deduction for turnbuckles or compensating devices. Changes in the installed length shall be approved by the Engineer. This will also include the length of installations continued across a bridge.

2. Beam Guardrail End Anchors and Terminal Devices.
By count for each type of beam guardrail end anchors and terminal devices constructed. Installations continued across a bridge will not be counted as end anchors.

3. Low Tension Three Strand Cable Guardrail End Anchor.
By count.

B. High Tension Cable Guardrail.

1. High Tension Cable Guardrail.
Linear feet (meters) shown in the contract documents. The length will be calculated as the protection length, not including lengths of high tension cable guardrail end anchors.

2. High Tension Cable Guardrail, End Anchors.
By count.

3. High Tension Cable Guardrail, Spare Parts Kit.
By count for the number of spare parts kits delivered.

C. Removal of Guardrail.

1. Steel beam guardrail: in linear feet (meters) to the nearest 0.1 foot (0.1 m) by measuring along the front of the rail from bolt hole to bolt hole.

2. Cable guardrail: in linear feet (meters) to the nearest 0.1 foot (0.1 m) by measuring along the front of one of the cables with no deductions for turnbuckles or compensating devices.

2505.05 BASIS OF PAYMENT.

Payment for guardrail items will be the contract unit price described below. Payment includes furnishing all materials, equipment, tools, and labor necessary to complete the removal and installation of the guardrail, including excavation and placing backfill. However, excavation in unexpected rock will be paid for as extra work according to Article 1109.03. Unexpected rock will be considered as rock encountered during excavation that was not visible from the roadway and was not indicated in the contract documents. The Engineer may adjust the payment for guardrail according to Article 2505.03, D.

A. Formed Steel Beam Guardrail and Low Tension Three Strand Cable Guardrail.

1. Installation of Guardrail.

a. Per linear foot (meter) for Formed Steel Beam, Thrie-Beam, and Cable Guardrail.

b. Payment for nested formed steel beam and thrie-beam will be included in the contract unit price. Posts, spacer blocks, object markers, delineators, guardrail markers, barrier markers, offset brackets, and remaining hardware are incidental to formed steel beam, thrie-beam, and cable guardrail.

c. For cable guardrail, the following additional items are incidental: hook bolts, turnbuckles, compensating devices, concrete, and remaining hardware.

2. Beam Guardrail End Anchors and Terminal Devices.
Each for the type of beam guardrail end anchor or terminal device. Drilling new anchor bolt holes for formed steel beam guardrail connection is incidental to the terminal device.

3. Low Tension Three Strand Cable Guardrail End Anchors.
Each.

B. High Tension Cable Guardrail.

1. High Tension Cable Guardrail.
Per linear foot (meter). All posts and accessories required by the manufacturer, as well as additional hardware and concrete, are incidental to the item.

2. High Tension Cable Guardrail, End Anchor.
Each. Grading required to meet the manufacturer's recommendations is incidental to the high tension cable guardrail anchor.

3. High Tension Cable Guardrail, Spare Parts Kit.
Each. Payment is full compensation for delivering spare parts kit to the location identified in the contract documents.

C. Guardrail Removal.

1. Per linear foot (meter) for removal of guardrail, including formed steel beam, thrie-beam, cable guardrail, end anchors, and terminals.

2. Payment includes hauling salvaged material to the stockpile site. Placing backfill material around posts and in end anchor footing holes are incidental.

3. Payment for nested formed steel beam and thrie-beam will be included in the contract unit price. Posts, spacer blocks, object markers, delineators, guardrail markers, barrier markers, offset brackets, end anchors, terminals, and remaining hardware are incidental to formed steel beam and thrie-beam guardrail.

4. Posts, hook bolts, turnbuckles, compensating devices, end anchors, and remaining hardware are incidental to cable guardrail.

Section 2506. Flowable Mortar

2506.01 DESCRIPTION.

Place a flowable mortar fill material. Uses include, but are not limited to, placement under existing bridges, around or within box culverts or culvert pipes, in open trenches, or at other locations as shown in the contract documents.

2506.02 MATERIALS.

Meet the requirements for the respective items in Division 41 with the following exceptions:

A. Cement.
Meet the requirements of Section 4101.

B. Fly Ash.
Meet the requirements of Section 4108. Use fly ash from a source approved by the Engineer.

C. Fine Aggregate.

1. Use natural sand consisting of mineral aggregate particles or foundry sand from the castings of ferrous material. Use the gradation shown in Table 2506.02-1:

Table 2506.02-1: Fine Aggregate Gradation

Sieve Size	Percent Passing
3/4 inch (9.5 mm)	100
No. 200 (75 µm)	0-10

2. It is intended that the sand be a fine sand that will stay in suspension in the mortar to the extent required for proper flow. For the Contractor's information, uniformly graded sand in the gradation range shown in Table 2506.02-2 has generally shown good flow characteristics when using the normal amount of fly ash (300 pounds per cubic yard (180 kg/m^3)). Concrete sand normally does not produce the desired flowability.

Table 2506.02-2: Informational Gradation Limits

Sieve Size	Percent Passing
3/8 inch (9.5 mm)	100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	60-100
No. 30 (600 µm)	45-80
No. 50 (300 µm)	12-40
No. 100 (150 µm)	1.5-25
No. 200 (75 µm)	0-5

3. Fine aggregate meeting the above informational gradation limits may be used in the basic proportions shown in Article 2506.02, E, without initial mix design, provided the flowable mortar is used in noncritical fluidity locations described in Article 2506.02, F. The Engineer reserves the right to reject the intended sand if a flowable mortar cannot be produced using the specified proportions.

4. The Contractor is not responsible for certified aggregate testing. The Engineer will provide appropriate inspection (normally, source approval) followed by visual inspection. If foundry sand is used, ensure it meets the requirements of IAC 567 Section 108. Ensure suppliers of foundry sand submit a processing plan to the District Materials Engineer for review and approval.

D. Admixtures.

Air entraining and water reducing admixtures may be added to increase the fluidity of flowable mortar.

E. Mix Design.

1. Use the basic proportioning for flowable mortar shown in Table 2506.02-1:

Table 2506.02-1: Quantities of Dry Materials Per Cubic Yard (Cubic Meter)

Cement	100 pounds (60 kg)
Fly Ash	300 pounds (180 kg)
Fine Aggregate	2600 pounds (1545 kg)

2. Submit samples of fine aggregate, cement, and fly ash intended for use to the Engineer. Submit the samples before the work begins for mix proportions to produce the required efflux time.

3. The Engineer will determine the mix design. The cement content is not to exceed 100 pounds per cubic yard (60 kg/m^3). The total amount of cementitious material is not to exceed 500 pounds per cubic yard (295 kg/m^3).

4. These quantities of dry materials, with approximately 70 gallons (345 L) of water (mixes utilizing foundry sand may require more water), will yield approximately 1 cubic yard (1 m^3) of flowable mortar of the proper consistency. The quantity of water used for the trial mix or at the project may require adjustment to achieve proper solids suspension and optimum flowability.

5. For information, volume loss during the cure period resulting from surface evaporation, moisture migration away from the flowable mortar unit, and hydration have been observed to be less than 4% of the original volume determined in the fluid condition. In mixes utilizing foundry sand, additional fly ash may be required and the limit of total cementitious material will not apply.

F. Fluidity.

1. Measure the fluidity of the flowable mortar using the Corps of Engineers flow cone method CRD-C611-80. Prior to filling the flow cone with flowable mortar, pass the mixture through a 1/4 inch (6.3 mm) screen.

2. In locations where fluidity is critical, such as inside existing culverts and between the beams under existing bridges, use an efflux time of 10 seconds to 16 seconds. The Engineer will measure prior to placement and at least once every 4 working hours until work is complete.

3. In locations where fluidity is not critical, such as for placement below the beams under existing bridges or for use as backfill material in open trenches, use an efflux time of 10 seconds to 26 seconds. The Engineer will visually monitor.

G. Granular Backfill Material.
For granular backfill material used under flowable mortar, meet the requirements of Section 4133.

2506.03 CONSTRUCTION.

A. Proportioning and Mixing Equipment.
Use equipment meeting the requirements of Articles 2001.20 and 2001.21. Provide mixers with sufficient mixing capacity to permit the intended placement without interruption.

B. Flange Filler Material.
When the flowable mortar is to be placed under a bridge, cover the bridge beams with a filler material, as shown in the contract documents, to fill the flange areas in a manner that will minimize intrusion of the mortar into the flange area of the beams. Construction insulation board or any other suitable material may be used.

C. Placement of Mortar under Existing Bridges.

1. First construct the shoulder area as shown in the contract documents, with the drainage system shown. Complete this work in conjunction with pipe placement, if a pipe culvert is required.

2. If a culvert is required, place engineering fabric meeting requirements of Article 4196.01, B, 2 over all joints in the culvert, within the area where flowable mortar is to be placed as backfill material. Place the fabric from the underlying ground line around the culvert, 1 foot (0.3 m) on each side of the joint.

3. Discharge flowable mortar from the mixer by any reasonable means into the area to be filled.

4. Bring the mortar fill up uniformly to the elevation of the first stage fill line, if specified. Cease mortar placement for a period of 72 hours.

5. If there is only one stage of flowable mortar, place granular backfill material in the lower part of the fill and around the pipe as specified. Compact the granular backfill material according to Article 2402.03, H, or thoroughly and uniformly wet with water in a quantity of approximately 10% of the granular backfill material. Complete flooding may be required. Regardless of the method of consolidation, wait 72 hours to commence flowable mortar placement.

6. Place the flowable mortar in a sequential operation from side to side and longitudinally. Begin with fill in one shoulder area, then proceed through each hole in the deck adjacent to the shoulder until mortar is expelled from the adjacent longitudinal hole. Place the last fill on the opposite shoulder. Place mortar through holes in the deck using a suitable funnel which can create a 3 foot (1 m) head during filling.

7. The locations for holes in the deck will normally be shown in the contract documents. When not shown, drill a hole approximately 5 feet (1.5 m) from each end of the bridge in each area between bridge beams. Drill additional holes as necessary so the longitudinal spacing does not exceed 20 feet (6 m). Limit the size of the holes to that necessary to accommodate filling equipment.

8. When placement of flowable mortar is completed and set, remove the mortar in the holes in the deck and replace with a suitable PCC mixture.

D. Placement of Mortar as Culvert Backfill Material.

1. First construct the shoulder area with suitable soil as shown in the contract documents, with the drainage system shown. Complete this work in conjunction with the pipe placement, if the culvert is a pipe.

2. Place engineering fabric meeting requirements of Article 4196.01, B, 2 over all joints in the culvert, within the area where flowable mortar is to be placed as backfill material. Place the fabric from the underlying ground line around the culvert, 1 foot (0.3 m) on each side of the joint.

3. Place granular backfill material meeting requirements of Section 4133 to approximately mid-height of the culvert. Place the backfill simultaneously on both sides of the culvert so that the two fills are kept at approximately the same elevation at all times. Granular backfill material compaction is not necessary.

4. Discharge flowable mortar from the mixer into the remaining area to be filled. Fill simultaneously on both sides of the structure so that the two fills are kept at approximately the same elevation at all times.

5. If the culvert starts to float, cease the filling operation. Apply an external load to the culvert, sufficient to hold it in place, before the filling is continued. As an alternate, the filling may be suspended until the buoyancy effect of the mortar has ceased.

6. Place the flowable mortar to the elevation shown in the contract documents. When not shown, place the mortar as follows:
   a. If the subgrade elevation is not more than 5 feet (1.5 m) over the top of the culvert, place mortar to 1 foot (0.3 m) below subgrade elevation.
   b. If the subgrade is more than 5 feet (1.5 m) over the top of the culvert, place the mortar to an elevation 2 feet (0.6 m) over the top of the culvert. Complete the remainder of the backfill operation using soil designated by the Engineer.

E. Limitation of Operations.

1. Do not place flowable mortar on frozen ground.

2. Flowable mortar batching, mixing, and placing may be started when the temperature is at least 34°F (1°C) and rising, if weather conditions are favorable. At time of placement, mortar shall have a temperature of at least 40°F (4°C). Cease mixing and placing when the temperature is 38°F (3°C) or less and falling.

3. Complete each filling stage in as continuous an operation as practical.

4. Do not allow flowable mortar into streams and waterways.

2506.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the volume of Flowable Mortar furnished and placed, from the nominal volume of each batch and a count of batches. The Engineer will estimate and deduct unused mortar; however, deduction will not be made for a partial batch remaining at the completion of the operation.

B. Granular backfill material used in the lower part of the fill area will be based on the contract document quantity.

C. When the flowable mortar elevation for placing backfill around culverts is shown in the contract documents, payment for Flowable Mortar will be based on the quantity shown in the contract documents.

2506.05 BASIS OF PAYMENT.

A. Payment for Flowable Mortar will be the contract unit price per cubic yard (cubic meter).

B. Payment is full compensation for:
- Placing the flowable mortar,
- Flange filler material,
- Engineering fabric as required,
- Drilling and filling the bridge deck holes, and
- Furnishing all materials, equipment, and labor necessary to complete the work.

C. Payment for granular backfill material used in the lower part of the fill area will be based on the quantity shown in the contract documents, and this will normally be included in the quantity of other granular backfill material on the project.

D. Excavation, placing backfill material for construction of the shoulder area, and moisture control if designated necessary for this work, will be paid for separately. These items will be included in the quantities of other similar work on the project. Furnishing and placing the drainage system in the shoulder area will be considered incidental to the payment for Flowable Mortar.

Section 2507. Concrete and Stone Revetment

2507.01 DESCRIPTION.

A. Place a layer of stone or concrete for protection of earth slopes against erosion from stream flow or wave action. Place according to the contract documents for the class of revetment specified. When specified, place a filter course beneath the revetment.

B. When specified furnish, transport, and place concrete grout within the voids of rock revetment as shown in the contract documents. The intent is to fill the voids of the revetment rock placement without over consolidation.

2507.02 MATERIALS.

A. Revetment.
Meet requirements of Division 41 for the material specified.

B. Grout.

1. General.

a. The Engineer may require adjustment of the mix proportions to achieve proper solids suspension and optimum flowability. After the mix has been designated, do not change it without the Engineer's approval.

b. Use proportioning and mixing equipment that meets the requirements of Articles 2001.20 and 2001.21. Provide mixers with sufficient mixing capacity to permit the intended pour to be placed without interruption.

2. Cement.
Use cement complying with Section 4101, at the rate of 10 sacks (940 pounds) per cubic yard (558 kg per cubic meter).

3. Fly Ash.
Meet the requirements of Section 4108. Fly ash may be substituted for cement for up to 25% by weight (mass) of cement.

4. **Fine Aggregate.**
Meet the requirements of Section 4110. Use 2100 pounds (surface dry weight) per cubic yard (1246 kg (surface dry weight) per cubic meter).

5. **Water.**
Meet the requirements of Section 4102. Use 45 gallons (375 pounds) per cubic yard (170 L (221 kg) per cubic meter), or enough to provide a thick creamy consistency.

6. **Air-entraining Admixtures.**
Meet the requirements of Section 4103. 6% to 10%.

7. **Liquid Curing Compounds.**
Meet the requirements of Section 4105.

C. Filter Blanket.
Apply Article 2107.03, K.

2507.03 CONSTRUCTION.

A. General.

1. For each of the five classes of revetment, begin construction in a trench dug to the elevation shown in the contract documents. Shape the slopes upon which revetment is to be placed and dress them to the extent that, when the revetment is placed to the specified depth, the revetment surface will be in compliance with the lines and grades shown in the contract documents.

2. For control of placement, mark (in a system of grids) those areas designated to receive stone protection. Spot and distribute loads over the surface marked in grids to provide the thickness shown in the contract documents. Control distribution based on the assumed density of 100 pounds per cubic foot (1600 kg/m^3) and the actual weights (mass) delivered.

3. Immediately prior to placing the revetment, the Engineer will inspect the prepared base.

4. After completion of Class A, B, and C revetment, place the excavated material into the trench as backfill.

B. Revetment.

1. **Class A Revetment.**
   a. A layer of the stone specified over the areas indicated in the contract documents.
   b. Place this layer so that each stone is firmly bedded against the bank and in close contact with adjacent stones. The stones need not be laid in courses.
   c. Drive spalls into openings remaining after the layer of stone is placed.

d. Place this layer to a thickness of approximately 15 inches (0.4 m), with no portion having a thickness less than 12 inches (0.3 m).

e. Chip portions of individual rocks projecting more than 2 inches (50 mm) above the general contour of the surface to within these limits.

2. Class B Revetment.

Place by bucket, clam shell or other mechanical means in a manner that will:

- Uniformly distribute the material as shown on the plans,
- Prevent damage to the filter blanket or fabric, and
- Limit disturbance of foundation soils.

3. Class C Revetment.

a. Formed concrete blocks placed in the area shown in the contract documents. Refer to the contract documents for the dimensions of the block and reinforcement.

b. For the concrete, use Class C pavement mix with a coarse aggregate durability of Class 2 or better.

4. Class D and Class E Revetment.

a. Meet the requirements of Section 4130. If filter blanket is required, refer to the contract documents for the material specified.

b. Place revetment stone on the filter blanket. When filter blanket is not required, place revetment stone directly on the prepared slope or area in a manner which will produce a reasonably well graded mass of stone with the minimum practical percentage of voids. Place the entire mass of stone in compliance with the lines, grades, and thicknesses shown in the contract documents. Place revetment to its full course thickness in one operation and in such a manner as to avoid displacing underlying material. Do not place riprap in layers or by dumping into chutes and similar methods likely to cause segregation.

c. Ensure the larger stones are well distributed. The entire mass of stone should comply with the gradation specified in Section 4130. Place the revetment and distribute so that there are no large accumulations of either the larger or smaller sizes of stone.

d. Some roughness in surface is desirable to break up wave action and decrease the velocity of the water, but the mass should be fairly compact with all sizes of material placed in their proper proportions. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the results specified.

e. When the embankment is constantly exposed to erosion, place the riprap protection in conjunction with the construction of the embankment with only sufficient lag to allow for proper stabilization of the embankment. Do not allow embankment materials to mix with revetment materials. When the embankment to be protected is constructed in lifts, revetment can be dumped directly in place from the surface of each lift.

C. Bank Shaping.

When the revetment is to be placed on an existing slope, prepare the foundation for areas on which the revetment is to be placed by shaping, trimming, and dressing. Bring these areas into compliance with the slopes, grades, and cross sections shown in the contract documents. Where such areas are high or low, bring into compliance by cutting and filling, and compact the area so the earth is well compacted.

D. Erosion Stone.

Use erosion stone meeting the requirements of Section 4130. Place the material as shown in the contract documents.

E. Grouting.

1. Placement of Grout.

a. Do not place the grout until the Engineer has inspected and approved the revetment.

b. Flush the rock to be grouted with high pressure water to remove the fines prior to placing the grout. Keep the rock to be grouted wet for at least 2 hours immediately prior to grouting, but do not place the grout in standing or flowing water.

c. Deliver the grout mix to the site and place within 1 1/2 hours after the introduction of cement to the aggregates. Transfer concrete from the mixer to final placement by means which prevent segregation of the aggregate or loss of mortar. Do not allow grout to drop more than 5 feet (1.5 m) vertically unless suitable equipment is used to prevent segregation.

d. Place grout in successive lateral courses starting at the top and progressing to the toe. Discharge the grout directly on the surface of the rock. Direct the flow of grout to prevent it from flowing excessively along the same path and to ensure that all intermittent spaces are filled. Sufficient jarring of rocks may be done to aid penetration of the grout so that all voids are filled and the grout fully penetrates the rock blanket. Work the grout into voids with the use of suitable spades and rods.

e. Do not allow the grouting operation to create a smooth surface. Finish the grout so that face stones are left exposed for one-fourth to one-third of their depth. Finish revetment rock blankets by brooming or other methods to:

- Fill voids caused by sloughing,
- Eliminate runs, and
- Provide a rough surface.

2. Curing and Protection.

a. After completion of any course, do not allow loads on the grouted surface for a period of 24 hours. Protect the grouted surface from injurious action by the sun, rain, flowing water, and mechanical injury.

b. Protect the grouted surface from drying for a curing period of at least 7 calendar days after placement. Keep exposed surfaces moist for the entire period, or until curing compound is applied. Maintain moisture by sprinkling, flooding, fog spraying, or covering

with continuously moistened canvas, cloth mats, straw, sand, or other approved material.

c. If compound is used, spray it on the moist finished concrete surface as soon as free water has disappeared. Apply the compound at a uniform rate of no less than 1 gallon per 15 square yards (3 L per 10 m^2) of surface. Form a continuous adherent membrane over the entire surface.

d. Do not apply curing compound to surfaces that will be required to bond to subsequently placed concrete.

3. Limitation of Operations.

a. Do not place grout on frozen ground.

b. Grout batching, mixing, and placing may be started, if weather conditions are favorable, when the temperature is at least 34°F (1°C) and rising. At time of placement, grout shall have a temperature of at least 40°F (4°C). Stop mixing and placing grout when the temperature is 38°F (3°C) or less and falling.

c. Place each course in as continuous an operation as possible.

4. Inspecting and Testing Fresh Grout.

a. The Engineer will inspect materials and processes used in mixing and placing the grout, and will secure samples for air content. Allow the Engineer free entry to all parts of the plant and equipment.

b. When ready-mixed grout is furnished, provide the Engineer with a statement-of-delivery ticket for each batch delivered to the job site. Ensure tickets show:

- Batch weights (mass) of cement,
- Fly ash (if used),
- Water, fine aggregate, and air entraining agent, and
- Time of loading and revolution counter reading at the time of batching.

2507.04 METHOD OF MEASUREMENT.

Measurement for the items associated with concrete and stone revetment will be as follows:

A. Class A or C Revetment: computed in square yards (square meters) from measurements of the surface as constructed to the nearest 0.1 foot (0.1 m).

B. Class B, D, and E Revetment and Erosion Stone: tons (megagrams) to the nearest 0.1 ton (0.1 Mg). Only material placed according to the contract documents will be measured.

C. Material for Filter Blanket: tons (megagrams) to the nearest 0.1 ton (0.1 Mg).

D. Engineering Fabric: computed in square yards (square meters) from measurements of the material placed to the nearest 0.1 foot (0.1 meter).

E. Concrete Grout for Revetment or Gabion (if specified in the contract documents): cubic yards (cubic meters) of concrete grout furnished and placed computed from the nominal volume of each batch and a count of

batches. The Engineer will estimate and deduct grout that is unused or wasted; however, no deduction will be made for a partial batch remaining at the completion of the operation.

2507.05 BASIS OF PAYMENT.

A. For the construction of revetment of the class specified, payment will be the contract unit price as follows:

1. Revetment furnished and placed: per square yard (square meter) for Class A or C Revetment, or per ton (megagram) for Class B, D, or E Revetment and Erosion Stone.

2. Material for Filter Blanket placed: per ton (megagram).

3. Engineering Fabric placed: per square yard (square meter).

4. Bank Shaping, if required: lump sum contract unit price.

5. When excavation, placing backfill, and (if required) special compaction are designated in the contract documents, payment will be made according to the type of work specified.

B. Payments are full compensation for all work, including bank shaping, furnishing and placing all material, excavation and placing backfill material, and for furnishing all equipment, tools, and labor necessary to complete the work according to the contract documents.

C. When Concrete Grout for Revetment or Gabion is specified in the contract documents, payment will be paid the contract unit price per cubic yard (cubic meter). Payment is full compensation for placing the grout and for furnishing all materials, equipment, and labor necessary to complete the work.

Section 2508. Removal of Paint and Painting Steel Bridge Structures

2508.01 REMOVAL OF PAINT.

A. Non-Hazardous Paint Removal.

1. General.

a. Apply Article 2508.01, A, only to structures previously painted with "non-lead based" paints and to structures with scratch tests indicating a non-hazardous waste (as identified in 40 CFR 261) is expected to be generated during the project. OSHA may regulate other issues. Take whatever precautions are necessary to comply with Federal and State safety and health regulations.

b. To comply with Iowa Code Section 89 B.8, 1, scratch tests are provided elsewhere in the contract documents for information.

2. Bridge Cleaning.

This work involves removing accumulated foreign material and loose paint. It also involves water washing areas designated elsewhere in the contract documents.

a. Removal of Accumulated Foreign Material.

1) Prior to water washing, remove all accumulated foreign material from:

- Beams, member flanges, and gusset plates,
- Abutment bridge seats, pier tops, truss joints, and deck drains, and
- Other locations the Engineer orders.

2) Remove the accumulated foreign material using hand brooms, hand shovels, vacuum cleaners or other methods the Engineer considers acceptable. Collect the removed material and dispose of at an approved waste area according to Federal, State, and local regulations. Apply appropriate measures to ensure that at no time does removed material fall or be disposed in the water or on the land below the bridge.

b. Loosely Adherent Paint.

Prior to water washing, use hand tool methods, complying with SSPC-SP2, to remove loosely adherent paint in areas designated for painting. All paint removal operations will require containment as specified in Article 2508.01, A, 4.

c. Water Washing.

1) Prior to abrasive blast cleaning, use high-pressure water to wash steel surfaces to be repainted, abutment seats, pier caps, and other surfaces that may be designated elsewhere in the contract documents. Limit water pressure so that no paint is removed.

2) Ensure salt contaminants, dirt, bird excrement, and other detrimental foreign material are removed. Detergents or cleaners and scrubbing may be needed in conjunction with water washing. Use clear fresh water that is free of sediments and salt contaminants. After water cleaning, remove all oily or greasy residues using solvent according to SSPC-SP1.

3) Remove chalking from existing painted surfaces onto which paint is to be applied. Examples are transition zones for spot or zone painting and surfaces that will receive a top coat over an existing prime or top coat. In those areas, remove the chalked pigment by water washing.

4) Detergents or cleaners and scrubbing may be needed in conjunction with water washing. Use detergents or cleaners that are compatible with the existing paint system and pre-approved by the new paint manufacturer. Apply according to the product manufacturer's recommendations.

5) Submit MSDS and any technical field guides for any detergent or cleaner to the Engineer for review and approval before using. If detergents or cleaners are used, thoroughly rinse the surface with water to remove all residue prior to painting.

3. Blast Cleaning and Surface Preparation.

a. Abrasive Blast Cleaning.

1) This work involves preparing all designated surfaces to be painted by either:

- abrasive blasting using conventional equipment, and/or
- vacuum blasting equipment.

2) Some hand-tool and/or power-tool cleaning may be required in areas not fully accessible to the other methods.

3) Use an abrasive blasting system that incorporates abrasive recycling in order to reduce waste volume to the greatest extent possible.

b. Standards For Surface Preparation.

1) Abrasive Blasting.

a) Prepare areas to be painted using a dry abrasive blast method to a level (SSPC-SP6 and/or SSPC-SP10) as designated elsewhere in the contract documents. The current SSPC-VIS1, Visual Standard for Abrasive Blast Cleaned Steel, will be used in conjunction with the appropriate written SSPC Standard for acceptance of final surface preparation. Prepare the surface profile (etched height) to be 1.5 to 2.5 mils (25 µm to 50 µm) as measured by replica tape or surface profile comparator.

b) Use hand-tool or power-tool methods, or both, to prepare small areas that cannot be cleaned using abrasive blasting equipment. SSPC Standards applicable to the method(s) applied will be used to evaluate surface preparation.

c) After blasting or mechanical preparation, thoroughly clean the surface to be painted with either HEPA vacuums or dry, oil free, compressed air, or both, to remove all adhering blast residue. Remove all oily or greasy residues with solvent complying with SSPC-SP1, Solvent Cleaning.

2) Removal of Existing Deteriorated Paint by Mechanical Methods.

a) The contract documents may designate areas to be painted which are to be cleaned by mechanical methods. These will be:

(1) Areas of deteriorated paint where the existing top coat is peeled or deteriorated and the underlying existing primer is in sound condition. In these cases, remove only the existing top coat by manual methods complying with SSPC-SP2 so the underlying existing primer is left in place. Remove the deteriorated top coat back to the boundary of soundly adhering top coat. A soundly adhering top coat is defined as that which cannot be lifted from the primer with a putty knife.

(2) Spot areas deemed too small to be effectively prepared by abrasive blasting.

b) Remove the deteriorated paint back to the boundary of soundly adhering existing primer. Regardless of the method used for cleaning, feather all edges of sites

cleaned to a smooth transition between the existing paint and the cleaned area.

c) Use mechanical methods of surface preparation complying with SSPC-SP2 or SSPC-SP3, or both, as modified below.

d) Replace Article 3.5 of SP2, Hand Tool Cleaning, with the following:

3.5 SSPC-VIS3, Visual Standards for Power and Hand-Tool Cleaned Steel, shall be used to evaluate the degree of cleaning.

e) Replace Articles 2.2, 2.3, and 5.3 of SSPC-SP3, Power Tool Cleaning, with the following:

2.2 It is intended that power tool cleaning remove rust, deteriorated paint, detrimental foreign material, and loose mill scale that can be removed by vigorous use of the power tools.

2.3 SSPC-VIS3, Visual Standard for Power and Hand-Tool Cleaned Steel, shall be used to evaluate the degree of cleaning.

5.3 Use power wire brushing, power abrading, power impact, or other power rotary tools to remove rust, deteriorated paint, and loose mill scale. Do not burnish the surface.

f) After mechanical preparation, thoroughly clean the surface to be painted with either HEPA Vacuums or dry, oil free, compressed air, or both, to remove all adhering blast residue. Remove all oily or greasy residues with solvent complying with SSPC-SP1, Solvent Cleaning.

3) Galvanized Elements.

Protect galvanized elements such as deck drain pipes and bearings. Blast clean only if directed by the Engineer. All galvanized elements which are to be cleaned and painted will be paid for as extra work according to Article 1109.03.

4) Rust Blume or Flash Rust.

Rust blume or flash rust is defined as the development of visible rust on bare metal surfaces after cleaning. Reblast the surface, or brush blast the surface and blow it down, just prior to the application of the first coat of paint if:

- Flash rust or rust blume occurs after removal of existing paint, or
- A surface is cleaned and left unpainted for more than 24 hours

5) Pin Hole Rusting.

a) Pinhole rust areas may be designated for painting in the contract documents. In areas where there is pin hole rusting and associated staining, abrasive blasting may not be required if the existing paint is sound other than at the pin holes. Mechanical cleaning, according to SSPC-SP2, may be used in these areas prior to applying the spot primer.

b) If the mechanical methods do not remove heavy staining of sound paint adjacent to the pinholes, remove the stain to the degree recommended by the manufacturer of the primer. Use methods of removal recommended by the manufacturer. Provide a written copy of the recommendations to the Engineer prior to performing the work.

6) Feathering of Repair Areas.

For spot and zone painting work, feather the existing coating surrounding each repair location. A smooth, tapered transition of 1 to 2 inches (25 mm to 50 mm) onto the existing intact coating is required around each repair area. Roughen the existing coating by hand sanding or a solvent wipe in the feathered area to assure proper adhesion for the new paint. Verify soundness of the existing paint by probing the edges of coating around the periphery of the repair areas with a putty knife, according to the requirements of SSPC-SP3.

7) Protection of Unpainted Surfaces.

a) Use whatever precaution is necessary to ensure vehicular traffic, equipment, hardware, fixtures, concrete, and other surfaces are protected against abrasive impact, paint spillage, over-spray, and other damage during the project.

b) For spot or zone painting work, use protective coverings, shields, or masking as necessary to protect surfaces that are outside the designated painting areas. Maintain protection during the entire period work is being performed which could damage those surfaces.

c) Exercise extra care to avoid over-blast damage to the existing coating in non-designated areas. Correct damage to non-designated areas by cleaning, repairing, and repainting at no additional cost to the Contracting Authority. Repair procedures will be approved by the coating manufacturer's technical representative. Submit the manufacturer’s approval to the Engineer for review and approval before the repair work is started.

8) Abrasives.

a) Use steel shot and/or grit, aluminum oxide, or garnet abrasives. This is to ensure hard durable abrasives are used, to encourage abrasive recycling, and to minimize waste generated by the project. Use clean, dry abrasives that are free from contamination. Do not use sand or coal slag.

b) If blasting with previously used or recycled abrasive:

- Obtain a representative sample of that abrasive,
- Have that sample analyzed for TCLP leachable levels of arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver, and
- Submit the laboratory's analytical report to the Engineer for approval prior to use.

c) The Engineer will accept used or recycled abrasives only if the leachable quantity of each metal tested is equal to, or less than, one part per million (1 ppm).

d) Clean and recycle abrasive used during this project to the greatest extent possible. Provide a written abrasive recycling workplan to the Engineer for approval. In this proposal list the equipment and process used for recycling and recovery of the abrasive and monitoring air dispelled from the recycling process.

e) Employ a method to monitor dispelled air from the recycling system that samples and tests for total lead and particulate matter of 0.4 mils (10 µm) and smaller (PM_{10}). Blasting will be suspended immediately if the Engineer deems visible dust or particulate matter is in the air expelled from recycling equipment.

9) Chloride Testing.

a) The Engineer reserves the option to test the blasted surface(s) for residual chloride ions. Chloride ions after blasting and blow down shall be less than 15 µg of chloride per 100 mm^2. Areas that are not equal to, or below, these criteria will need to be re-washed, brush blasted, and retested.

b) The Engineer will measure chloride contamination by using a Surface Contamination Analysis Kit, marketed by KTA-Tator Inc. or an equivalent analytical process.

4. Containment.

a. General.

1) Abrasive blasting using conventional equipment will require a system for total containment of the blast area. Containment includes all containment enclosures (where applicable), monitoring, recovery, and temporary storage of waste. For vacuum blasting, the "contained area" is defined as the area around the blast nozzle and any other connections or equipment where waste, dust, or exhausted air may exit into the environment.

2) Submit to the Engineer a plan for containment enclosures, an analytical report of the abrasives to be used, and a plan for monitoring air quality prior to starting work. A general guideline for containment evaluation abrasive blasting and/or vacuum blasting will be:

No visual or noticeable dust is to be observed escaping into the atmosphere or onto the ground from the contained area during blasting, blow down, or prior to the daily clean-up operations.

3) Suspend blasting if the Engineer determines that air expelled from containment or from the vacuum nozzle has noticeable dust or particulate matter. If the Engineer determines the containment measures are inadequate, alter the removal operation or the containment to meet the Engineer's requirement.

b. Abrasive Blast Cleaning.

1) Use a system which ensures total containment and recovery of the material removed from the structure. Construct bridge containment enclosures over other roadways to allow traffic to

be maintained on the bridge being cleaned as well as on the road under the bridge, according to traffic control requirements in the contract documents.

2) Removed material will be defined as paint chips, abrasive particles, and other blasting residues. Ensure the containment prevents removed material and abrasive from drifting or being deposited, or both, other than within the containment enclosure. The blasting operation will be suspended immediately if the Engineer deems waste cleanup or house keeping measures, or both, to be inadequate. If the Engineer rules the containment measures inadequate, alter the operation or the containment to meet the Engineer's requirement.

3) Use impermeable cover materials, such as tarpaulins, drop cloths, or other approved materials, on or above the ground, waterways, and other surfaces. Recover removed material from the covering materials. Highway pavements and paved surfaces under a structure may be used as a portion of the collection cover for that area providing traffic is maintained on the bridge and on the pavement under the bridge according to traffic control requirements in the contract documents.

4) All areas used for containment and recovery shall be thoroughly cleaned of all debris before work is begun. Close containment areas to the public. If paved surfaces are used for recovery areas, use only areas that are continuous and free of open cracks. Seal cracks to prevent infiltration of blast residue prior to commencing any blasting in that area.

5) Turn the edges of the impermeable cover material upward 1 foot (300 mm) to minimize loss of waste materials. Ensure covers on or over roadways, railways, or waterways do not present a hazard nor remain in place overnight without the Engineer’s written permission. Fasten the edges of the impermeable cover to the vertical drapes to ensure no loss of waste materials. Ensure overlaps of the cover material are a minimum of 3 feet (1 m), securely tied together, and continuously taped to prevent loss of removed material.

6) Extend vertical drapes from above the blasting area to the bottom of the enclosure. Securely anchor them top and bottom and at the laps to prevent spilling or loss of removed material. Use material capable of withstanding wind forces without tearing or having a breach of integrity.

7) Containment enclosures shall be anchored to prohibit enclosure encroachment on open traffic lanes, railroad lanes, and waterways. Ensure removed material will not fall on to surface waters.

c. Monitoring.

1) During abrasive blasting, monitor air quality by conducting air sampling and testing. Perform this work under the direction of a certified Industrial Hygienist. Use a minimum sampling frequency of one sample of 8 hour duration per week.

2) One purpose of the sampling is to allow for the Engineer to determine the effectiveness of the containment. Samples will

be obtained from at least two locations outside and immediately down wind from the containment, according to 40 CFR, Part 50.

3) Employ an air monitoring that identifies total lead and total suspended particulate (TSP) to evaluate site compliance with the requirements of Title 40 Code of Federal Regulations. Provide the results of this monitoring to the Engineer as soon as they become available. Abrasive blasting will be suspended immediately if the Engineer determines expelled air quality measures to be above EPA standards for particulate matter.

4) Air quality sampling and testing will not be required for small localized containments when:

- Blasting operations have an expected duration of less than approximately 3 hours, or
- The expected duration of the total amount of blasting on the project is less than approximately 8 hours.

d. Cleaning by Other Methods.

1) At locations where abrasive blasting is not used, use a waste collection system that ensures containment and collection of the material removed from the structure. Removed material will be defined as paint chips and other residues. Ensure the containment prevents removed material from drifting or being deposited, or both, other than on the containment portion provided.

2) Use impermeable cover materials, such as tarpaulins or drop cloths, on or above the ground, waterways, surface waters, and other surfaces. Use these covering materials to recover removed material.

e. Clean-up Contingency.

1) Clean up any spills that result from the operations at no additional cost to the Contracting Authority. Provide a written plan for clean up of spills to the Engineer prior to removing paint.

2) For removal activities over water, have floating boom devices in place during removal operations. Ensure these devices are capable of preventing waste material from moving away from the site in the event of a breach in the containment system.

f. Recovery and Temporary Storage of Waste.

1) Deposit accumulated bridge cleaning waste in appropriately sized clean new or reconditioned containers with securely sealed lids meeting the requirements of Title 49 Code of Federal Regulations. Recover wastes daily and deposit the wastes into these temporary storage containers. Securely seal the containers to shield the contents from the elements at all times. Consolidate all waste material to a minimum number of containers.

2) Recover all residues and carefully transfer, ensuring no release of residues into the air or contamination of surrounding surfaces. Keep all containers containing residue closed and secured, except during the addition of waste. Ensure residues do not remain on bridge surfaces or on the containment material overnight.

3) Clearly mark all bridge cleaning waste containers in no less than 1 1/2 inch (40 mm) block letters stating:

PAINT WASTE
NONHAZARDOUS
(Date)

The date shall indicate when waste was first put into the container.

4) Construct or furnish a secured temporary storage area of sufficient size for the contained waste material. Enclose temporary storage areas with an 8 foot (2.4 m) chain link fence or a roll-off box with a lockable cover. Plans for other secured temporary storage areas may be submitted to the Engineer for approval.

5) Locate the temporary storage area within the right-of-way of the Contracting Authority at a location the Engineer approves. Ensure the base for waste storage is above the extreme high water elevation, if constructed within a flood plain.

6) For projects that will generate less than 55 gallons (208 L) of waste, the fenced temporary storage area or roll-off box will not be required and the Contractor is responsible for securely storing the paint waste containers on-site during the project.

7) At, or prior to the conclusion of the work, obtain one representative sample of the waste material from each container. Combine samples so that one representative composite sample is made for every 5 waste containers. Submit composite sample(s) to a lab for a Toxic Character Leachate Procedure (TCLP) test for the 8 priority metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Provide the results of this analysis to the Engineer upon receipt. Maintain wastes on site and do not dispose of them until the Engineer has reviewed analytical data and approved of the disposal method.

g. Disposal of Removed Material (Waste).

1) Transport waste materials in approved containers from temporary storage to a lined Subtitle D landfill (for non-hazardous wastes) or Subtitle C, Treatment, Storage, and Disposal Facility (TSDF for hazardous wastes) which accepts bridge painting wastes. Transport the wastes to the landfill facility within 5 calendar days of completion of surface preparation operations.

2) Provide the Engineer with copies of delivery tickets and landfill invoices for all waste material generated by this project.

3) Dispose of all bridge cleaning wastes according to Federal, State, and local regulations.

4) This project is based on the best information available that wastes generated will be non-hazardous for disposal per 40 CFR 261. Disposal of hazardous bridge cleaning wastes will be by extra work according to Article 1109.03.

h. Final Clean up.

1) Apply Article 1104.08.

2) In no case allow any foreign material or other painting related wastes to mix with the wastes generated from abrasive blast cleaning or paint cleaning by other methods.

5. Protection and Clean up.

a. For all work, use every reasonable means to protect the environment, human health and safety, adjacent property, and vehicles from damage resulting from the paint removal operations, according to Article 1107.07. Keep the project site in a neat, clean, and safe working condition.

b. At the end of each working day, clean up and properly containerize all waste material. Special attention is drawn to steel abrasive and its preponderancy to rust and stain surfaces where material is allowed to accumulate.

c. Clean up abrasive on a daily basis and remove any staining which occurs.

d. Protection and clean up will not be measured for payment, but will be considered incidental to all other pay items in this specification.

B. Hazardous Paint Removal.

1. General.

a. Apply Article 2801.01, B, only to structures previously painted with lead based paints and for structures with Scratch Tests indicating a hazardous waste is expected to be generated during the project. Scratch tests are provided elsewhere in the contract documents for information per Iowa Code Section 89B.8, Subsection 1.

b. Take responsibility for whatever precautions are necessary, to comply with Federal and State safety and health regulations.

2. Bridge Cleaning.

Apply Article 2508.01, A, 2.

3. Blast Cleaning of Structural Steel.

a. Waste Notification.

1) This structure has previously been painted with coating materials which contained lead pigments or chromium pigments, or both. Analytical results from scrape tests of the existing paint system are provided elsewhere in the contract documents.

2) The waste produced is expected to contain paint chips with heavy metal constituents, spent abrasive, rust, and possible mill scale. Take whatever measures are deemed necessary to assure protection for human health and the environment.

b. Preconstruction Sampling and Testing.

1) Obtain representative waste samples from the existing paint system using the selected production blasting system and equipment. Have an accredited laboratory test waste material with the Toxic Characteristic Leachate Procedure (TCLP) using EPA test method SW-6010B, TCLP; or an approved equal. Laboratories accredited by the American Industrial Hygiene Association of National Environmental Laboratory Accreditation

Program, or any EPA certified laboratory may perform the paint waste testing.

2) Have waste samples analyzed for, at a minimum, the 8 priority metals. These metals are: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. No later than 12 calendar days following the first day of production blasting, provide the Engineer with analytical results of these tests as well as reasonable estimated quantities of waste that are expected to be generated per month.

3) Conduct preconstruction and post-construction soil and river sediment sampling in the areas potentially impacted by blasting activities. At least 3 weeks prior to commencing work, provide a written program for sampling to the Engineer for review and comment. On the program, identify the number of samples proposed, the sampling locations, and sampling procedure to ensure all areas of potential impact are evaluated and that a statistical basis has been developed.

4) All sampling should be tested for total lead and chromium content using EPA Method SW-6010B, Totals, or approved equal. Locations where it is recommended to take samples include:

- At locations under and within the shadow of the structure,
- Storm sewer intakes and curb drains,
- Areas where ditches could carry debris laden storm water run-off to the river,
- Locations of equipment and waste storage, and
- Sediments along the bank and in water less than 5 feet (1.5 m) deep.

5) Preconstruction sampling locations need to be marked and resampled at the same location upon completion of work. Refer to Article 2508.01, B, 6, for additional information.

6) Provide the Engineer with preconstruction analytical results from soil and sediment sampling at least 3 weeks prior to commencing production blasting or other paint removing activities. After final clean up, but before final acceptance of the project, provide the Engineer with post-construction analytical results from soil and sediment sampling.

c. Environmental Regulatory Permits.

1) The Contracting Authority will obtain and provide an EPA hazardous waste identification number for this project if project specific waste sampling and testing indicate a hazardous waste will be generated.

2) The Engineer will use actual waste analytical results and estimated waste quantity data received from the Preconstruction Sampling and Testing to identify which type of identification number, if any, is required.

3) Obtain all other permits including any required for waste disposal. Apply Article 1107.03.

d. Site Working Documents.

Submit to the Engineer, for review and comment, three copies of all site working documents required in this section. Write each site

working document to be specific for the issues associated with the blast cleaning alternatives selected. Revise any indicated sections of the site working documents to comply with the Engineer's comments and resubmit, if necessary.

1) Site Work Plan.

A minimum of 3 weeks prior to commencing work, provide a written site work plan to the Engineer for review and comment. On the site work plan include, at a minimum, a complete description of:

a) Paint removal methods selected, refer to Article 2508.01, B, 3, e.

b) The equipment and processes to be used including equipment catalog information from the manufacturers for major pieces of equipment.

c) The environmental protection plan including waste sampling procedures and methods used to control emissions into the air, water, and onto the soil.

d) Waste handling, storage, and disposal plan.

e) A preconstruction soil and river sediment sampling plan, refer to Article 2508.01, B, 3, b.

f) The Site Air Monitoring Plan. In this plan, describe the air sampling protocol and analytical procedures, sampling locations, frequency of sampling, and equipment, refer to Article 2508.01, B, 4, c. Use Title 40 Code of Federal Regulations, Part 50 (40 CFR, 50) as guidance when locating air monitoring equipment. Use a minimum frequency for sampling and monitoring that is in accordance with Federal and State requirements, and this specification.

2) Site Health and Safety Plan.

a) A minimum of 3 weeks prior to commencing work, provide a written Health and Safety Plan (H&SP) to the Engineer for review and comment. In this plan detail the compliance program with regulatory requirements including, but not limited to:

- OSHA 29 CFR, 1910 and 1926,
- Resource Conservation Recovery Act (RCRA) and CERCLA 40 CFR, 261 through 300,
- TSCA 40 CFR, 700 – end, and
- Transportation 49 CFR, 100 through 199.

b) Give attention to 29 CFR, Section 1926.62, Lead in Construction Standard. In addition, ensure the H&SP specifically identifies:

(1) The Project Site Safety Officer who is to be on site at all times when work is in progress, and who has the Contractor's authority to effect an immediate operational change or to shut down production until a specification, regulatory, or safety deficiency is corrected. The Project Site Safety Officer has continuous site responsibility for assuring that worker health, safety, and U.S. EPA regulatory requirements

are being met. This includes the duties of the "competent person" as required by 29 CFR, Section 1926.62.

(2) The compliance program as required by 29 CFR, Section 1926.62 which includes the following at a minimum:

(a) A description of each activity in which lead and/or chromium is emitted including the equipment and processes involved,

(b) Standard operating procedures for activities involving hazardous constituents,

(c) Maintenance schedules of equipment utilized for filtration of potentially hazardous constituents,

(d) Crew size and responsibilities,

(e) Description of engineering controls and processes used to control lead exposure or chromium exposure, or both,

(f) A report of the technology considered in meeting the Personal Exposure Limit (PEL),

(g) Air monitoring protocol which will be used to document personnel exposure,

(h) Schedule for implementing the program,

(i) Work practice program including the personal protective equipment,

(j) Housekeeping and hygiene practices,

(k) An administrative control (job rotation) schedule if used, and

(l) A description of H&SP compliance arrangements made between the Contractor and their subcontractors.

(3) Hazardous substances, that are expected to be encountered, PELs for these substances, and site personnel medical monitoring expected.

(4) The levels of personnel training, protection, and protective equipment required for different tasks performed at the site.

(5) Site control and restricted access policy to ensure unauthorized personnel or untrained personnel, or both, are not exposed to unnecessary risks.

c) The signature of a Certified Industrial Hygienist trained in worker environmental health and safety issues is required on the H&SP.

3) Site Contingency Plan.

a) A minimum of 3 weeks prior to commencing work, provide, for the Engineer's review and comment, a written Site Contingency Plan (SCP). In this plan:

(1) Detail the procedures that will be implemented and corrective action that will be taken, should an emergency or unforeseen situation arise.

(2) Specify procedures to minimize hazards to human health and the environment should there be fires, explosions, vandalism, or any other unplanned

sudden or non-sudden release of hazardous waste or hazardous constituents to the air, soil, or surface water.

(3) Detail contingency measures that will be available on site to prevent accidental releases and provide safety to the general public. For example: Security, preventative, and containment measures which will be used to prevent and/or contain:

(a) Spillage or loss of paint wastes.

(b) Spillage of bulk paint, solvents, and thinners during the painting operations,

(c) Spillage or leakage of equipment fuel, oil, or other fluids,

(d) River traffic from encountering floating booms or barge mounted equipment,

(e) Inadvertent public exposure to job site hazards, and

(f) Waste material, or spills on water, from migrating off site and to contain that material until it is cleaned up.

b) Follow current Federal and State regulations in preparing this plan. Have it on file in the locations specified by regulation.

e. Paint Removal.

1) Submit to the Engineer in writing the type of blasting equipment that will be used for the paint removal operations before starting work. Achieve the level of surface preparation specified. In no case will unproven technology or untested technology, or both, be allowed without prior review, testing, and written approval from the Engineer.

2) The blasting process and equipment is required to be part of the Site Work Plan, and the plan shall describe in detail the:

- Method of blasting,
- Work procedures and tasks for this removal method,
- The estimated production rate, in other words, square foot (square meter) per hour,
- Estimated quantity of blasting abrasive utilized per production rate (hour or square foot (square meter)), and
- Procedure and protocols for abrasive recycling.

3) Contain and collect all waste material generated during blast cleaning. Contain any fugitive emissions (solid particulate, fugitive dust). Protect the health and welfare of the public. Protect the environment. Employ adequate administrative and engineering controls to reduce worker exposures to all hazardous constituents present at the site to levels as low as feasible according to industry standards. Refer to Article 2508.01, B, 4, b for additional details.

f. Standards For Surface Preparation.

Apply Article 2508.01, A, 3, b.

4. Containment.

a. General.

1) This work includes the design, erection, maintenance, and removal of the enclosure or containment used to contain wastes generated during the surface preparation. The work also includes characterizing, collecting, and containing wastes generated during the project.

2) Ensure any enclosure complying with, or comparable to, an SSPC Class 3 or better is designed and sealed by a Professional Engineer licensed in the State of Iowa who is qualified in structures. Ensure ventilation in a Class 2 or better containment is designed and sealed by a Professional Engineer licensed in the State of Iowa who is qualified in ventilation.

3) Work required to decontaminate, clean, and test equipment and non-expendable materials or supplies shall be included in this section. Ensure, at a minimum, decontamination and cleaning do not allow debris or dust, or both, to be dislodged by winds or physical contact during handling and movement of a containment structure. In addition, establish a procedure to ensure all equipment and materials are essentially free from hazardous substances when delivered to and removed from the project site.

b. Enclosure.

1) Perform paint removal activities, except for vacuum blasting, within a full enclosure. Design the full enclosure as a system including:

- The frame work and outer covering,
- Attachments to the structure and supporting foundations,
- Waste handling, and
- Ventilation, if required.

2) Include in the enclosure submittal a method or process to catch, accumulate, and ultimately contain all spent abrasive and all paint waste. Include in the enclosure details a description and catalogue cuts of:

- Containment materials and equipment used,
- Material strengths, permeability, and necessary seam closure details,
- Drawings of attachments to the bridge including abutments, piers, deck, parapet rails, and beams, and
- Calculations of superimposed dead and wind loadings.

3) Submit three copies of this design to the Engineer for review and approval at least 3 weeks prior to erecting the enclosure. Use an enclosure that is:

a) Designed to transfer added wind and static loading safely to the bridge. Analyze the structure for gravity and wind loadings from the containment. Provide a copy of this analysis and all supporting calculations in the submittal. If the Engineer determines that the proposed enclosure could have detrimental effects on the structural integrity of the bridge, modify the design of the enclosure at no

additional cost to the Contracting Authority. A copy of the existing bridge plan is available from the Contracting Authority.

b) Designed and constructed to maintain negative pressures inside the enclosure during production blasting and to include an air filtering and dust collection system for all exhausted air, unless site specific data collected during actual blasting operations conclusively show a tight containment with negative air is not required.

c) Designed to employ adequate engineering controls, including ventilation, to reduce airborne contamination to levels as low as feasible.

d) Equal to, or comparable with, SSPC Class 2 or better for Conventional Open Abrasive Blasting.

4) Contamination of the ground, water, or river sediment from project activities is strictly prohibited. Project activities that shall be carefully monitored and controlled to avoid environmental contamination include, but are not limited to:

- The containment,
- Dust collector,
- Abrasive reclaimer,
- Waste accumulation points (storage areas),
- Satellite accumulation points,
- Refueling locations,
- Boat or barge access points, and
- Paint handling, transfer, and mixing operations.

5) Uncontrolled dumping of wastes is strictly prohibited. Immediately clean up spills at no additional cost to the Contracting Authority.

c. Air Emissions and Monitoring.

1) General.

a) Monitor air quality by using high-volume air monitoring equipment. Perform sampling protocol according to the provisions of 40 CFR, Part 50 and its appendices. At a minimum, perform monitoring for total lead and total suspended particulate (TSP) and particulate matter 0.4 mils (10 µm) and smaller (PM_{10}).

b) Use properly calibrated high-volume air sampling equipment at locations of maximum potential impact to the public plus at areas to provide background ambient samples.

c) Identify anticipated monitoring locations and monitoring protocol in the Site Air Monitoring Plan.

d) Have an American Industrial Hygiene Association (AIHA) accredited laboratory analyze all air samples collected.

e) Filter all containment and process air exhausted from air handling equipment or the abrasive recycling process, or both, to remove particulates and regulated constituents to a level below current air quality standards.

f) Capture and contain filtered material using a system designed for this purpose.

g) Establish regulated areas around the dust collector, abrasive reclaimer, containment, and other operations that potentially generate lead emissions or chromium emissions, or both.

h) Properly identify, post, and establish the perimeter of the regulated areas at the OSHA Action Level of 30 $\mu g/m^3$. Limit access within these areas to only those personnel who are properly trained and monitored according to the site Health and Safety Plan.

2) Site Air Monitoring Plan.

a) Ensure compliance with 29 CFR, 1926; 40 CFR, 50; 40 CFR, 60; and 567 Iowa Administrative Code, Chapters 22 and 23, by including nomenclature in the plan for:

- Sampling equipment,
- Sampling procedure and protocol,
- Sampling frequency,
- Locating criteria, and
- Laboratory analysis of air samples.

b) Submit analytical results to the Engineer within 1 week of being received from the testing laboratory. An electronically generated version containing, at a minimum, the information on the standard laboratory reporting form will be an acceptable substitute.

3) Containment Efficiency.

a) The Engineer will not routinely use opacity testing to evaluate a containment's efficiency, but will generally use a "no visible dust or blast media is to be observed escaping into the atmosphere or onto the ground from the contained area during blasting, cleaning, or blow down" criteria.

b) The Engineer may conduct random opacity tests or use high volume or personal cassette samplers for verification monitoring. This monitoring, positioning of equipment, and times are at the discretion of the Engineer. Verification monitoring will be outside of the Contractor's regulated areas and involve the Engineer's sampling equipment. The Engineer's sampling equipment will not be made available for the Contractor’s use.

c) Ensure the National Ambient Air Quality Standards for lead or PM_{10} or visible dust are not violated. If it is violated, an issuance of a Suspension of Work notice will be used until appropriate corrective action is taken.

d) Shut downs for noncompliance with environmental regulations or standards will not be cause for extensions in time, or considered for delay costs.

d. Paint Waste.

1) Paint wastes include all wastes generated by the project. These wastes include, but are not limited to:

- Blast waste,
- Material accumulated from filtering exhausted air,
- Spent abrasive,

- Containment material that cannot be decontaminated for reuse,
- Material containers such as paint and solvent containers, and
- Other wastes that fail the TCLP test as modified below and are categorized as a RCRA hazardous waste.

2) Consider all paint wastes as hazardous until after appropriate analytical data or Materials Safety Data Sheets are available showing conclusive evidence that the waste is below any regulated level for hazardous constituents, or is not initially regulated. Further reduce any waste regulatory value listed in the CFRs by a factor of 20%. For example: 40 CFR, 261.24, identifies lead (D008) as a characteristic hazardous waste if the toxic characteristic is equal to, or greater than, 5.0 mg/L. Wastes containing lead that have leachable levels greater than 4.0 mg/L are considered hazardous and are to be disposed of in a Subtitle C landfill.

3) During generation, accumulate all paint wastes and segregate by individual waste stream. Place in properly labeled storage containers. Use containers that comply with Federal DOT 49 CFR requirements. Follow the handling and storage requirements of 40 CFR, 262 and 40 CFR, 265. Waste streams may be combined after each has been sampled, tested, and characterized, provided combining is acceptable to the disposal facility.

4) As required by the Site Contingency Plan, have a designated, responsible, and trained person available for emergency response around the clock any time wastes are stored on the project. It is recommended the Site Health and Safety Officer be so designated. Ensure this person is available during non-working hours and work shutdowns within a reasonable response time whenever wastes are being stored. Post this person and an alternate's name, telephone numbers, and other required information on the accumulation point's fence and list in the Site Contingency Plan.

a) Accumulation Point.

(1) Erect and maintain an accumulation point, or storage area, sized to accommodate the accumulation of wastes awaiting shipment to a disposal facility. Enclose the accumulation point with an 8 foot (2.4 m) high chain link security fence with barbed wire top, lockable access gates, bermed sides, and properly posted warning signs. Obtain the Engineer’s approval for the location of this accumulation point. Construct it within the existing right-of-way at the project, but out of areas prone to flooding.

(2) For projects that will generate minimal quantities of waste, make a detailed written request to modify this storage security requirement. Submit all requests to modify the security requirement to the Engineer a minimum of 3 weeks prior to commencing production blasting. The Engineer will respond to the Contractor

within two weeks following the request. The Engineer will evaluate the proposal based on:

- The Contractor's estimated waste quantities,
- The proposal's intent to comply with storage regulations and these specifications,
- Expected waste classification (i.e., hazardous or non-hazardous), and
- Other site specific considerations and details which the Contractor provides.

b) Satellite Accumulation Point.

(1) If the Contractor requests in writing, the Engineer will consider a small satellite accumulation point, or points, in the work zone. Properly label containers stored in any satellite area. Tightly close containers to the elements and secure to prevent accidental spillage or loss. At the conclusion of any working day, remove all containers containing accumulated wastes from any satellite accumulation point and place in the accumulation point storage area.

(2) Equipment which incorporates temporary storage of accumulation of wastes during operation will be considered a satellite accumulation point. As such, the equipment will be subject to proper labeling requirements. Waste materials contained within this type of equipment will not be subject to the requirement for daily transfer to the accumulation point storage area.

(3) Secure all materials stored at the accumulation point and satellite accumulation points to prevent spillage or vandalism. Securely cover to protect from the elements. Ensure the Site Health and Safety Officer maintains a permanent record to account for the accumulation of all waste materials and to report the cumulative weekly volumes at the project's progress meetings. Ensure the volume of materials located in the accumulation points and the condition of the storage containers are recorded weekly in the log.

(4) Remove accumulation point and satellite accumulation points (if used) when the Engineer orders, or at the end of the project. Apply Article 2508.01, B, 6.

e. Decontamination Plan.

1) Provide the Engineer with a written Decontamination Plan a minimum of 3 weeks prior to commencing work. In this plan, outline procedures to follow to ensure non-expendable materials and equipment have been properly decontaminated prior to arriving on the project and before being demobilized from the site. Prior to in-bound mobilization, provide the Engineer with a written statement which includes the following:

a) Identification of project, location, owner reference, and contact information and type of wastes generated (hazardous or non-hazardous) at the previous project.

b) Certification that all equipment and non-expendable materials have been decontaminated and are clean. In this certification include analytical data verifying items have been decontaminated and are clean.

2) Before off-loading (or allowing in the right-of-way) equipment or non-expendable material, or both, that: 1) is mobilized to the site without being included in the certification; or 2) arrives at the site in an unacceptable condition, ensure it is:

- Decontaminated,
- Adequately sampled and tested, and
- Accepted as clean by the Engineer.

3) Evaluation of equipment and non-expendable material clean-up used on projects that generate hazardous wastes should include sampling (swipe or destructive) and TCLP testing as an integral part of this plan. It is recommended to follow OSHA's Field Operation's Manual, CPL 2.0 - 2.58 and HUD's Clearance Criteria for Post Abatement Clean-up when developing sampling procedures and protocol for a decontamination plan.

4) For projects that generate no hazardous waste, use equipment that is, at a minimum, judged as visually clean. In addition, perform non-expendable material cleanup in a manner that is, at a minimum, judged as visually clean. No special testing will be required. Sample and test, or dispose of, items that cannot be visually evaluated.

5) If a particular waste stream can be identified as the sole source of hazardous materials, in an otherwise non-hazardous project, the Engineer has the discretion to:

- Separate out that process for a higher level of evaluation (for example sampling and testing), and
- Minimize visual evaluation on the other non-hazardous processes.

5. Paint Waste Transport and Disposal.

a. Waste Sampling and Testing.

1) Sample each waste stream during the project to ensure project goals are being maintained and that a disposal facility's need for waste characterization is being met.

2) Obtain all samples properly, prepare for shipment, and offer for transport using Chain-of-Custody procedures and protocol. Have an accredited laboratory, or a laboratory that participates in EPA's Contract Laboratory program, analyze all samples. Refer to Article 2508.01, B, 3, b, for additional information.

3) Provide all laboratory results to the Engineer as soon as they are received. Obtain an adequate number of samples and analyze them to ensure any waste stream generated during this contract is fully characterized.

4) Sample solid wastes and analyze using TCLP test for the 8 priority metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Perform any additional analytical methods required by the disposal facility.

b. Disposal.

1) A minimum of 3 weeks prior to commencing production blasting, provide the Engineer with a written request to approve a designated disposal facility. Determine which of the following options or combinations are applicable to the job and selected removal process, or processes:

a) Permitted, Subtitle C, Treatment, Storage, and Disposal Facility (TSDF) for any hazardous waste generated at the site.

b) Permitted, geosynthetic lined, Subtitle D landfill for non-hazardous waste generated at the site.

c) Treatment and disposal facility for waste water generated from personal decontamination wash water.

2) With this request include a letter of tentative commitment from the facility to accept and dispose of the project's waste or selected waste streams. Dispose of hazardous waste only in a permitted TSDF that has obtained and currently holds an EPA, TSDF identification number. The Engineer will evaluate any facility submitted by conducting an environmental audit, records review, and reference check of that facility.

3) After receiving the Engineer's approval of the facility (or facilities), begin the formal process of obtaining final disposal permits which may be required by that facility. Provide the Engineer with copies of all final documents pertaining to the disposal permit. Obtain a signed contract with the approved TSDF or other facility for wastes produced at the site before accumulating waste (hazardous or non-hazardous) in the amount of 1000 pounds (450 kg) or within 1 month of beginning paint removal operations.

4) Clean all shipping containers for regulated raw materials or consumable supplies received at the project to "RCRA empty". Properly recycle or dispose of at the appropriate disposal facility.

5) The Engineer, on a case-by-case basis, will consider proposals for beneficial reuse, reclamation, or recycling of waste products generated during the course of the project. A minimum of 3 weeks prior to commencing work, provide a written Value Engineering Incentive Proposal, according to Article 1105.15, identifying a waste recycling program to the Engineer for consideration. In the submittal, provide the Engineer with ample detail to thoroughly and completely review and research the proposal.

c. Transportation and Manifesting.

1) Ensure that no waste leaves the site without a properly prepared waste manifest. Manifest all hazardous waste shipments using a Uniform Hazardous Waste Manifest, obtainable from EPA or the approved disposal facility. For all

shipments of non-hazardous waste, propose a manifest. Obtain the Engineer's approval for the manifest.

2) Have the Site Health and Safety Officer sign the manifest prior to shipment. Signatures will be on behalf of the Contracting Authority, according to 40 CFR, 262. At the conclusion of each shipment, have the Site Health and Safety Officer deliver to the Engineer and appropriate agencies, copies of the required pages from the Uniform Hazardous Waste Manifests, according to the instructions included on the manifest.

3) When material is being transported or readied for transport, ensure all waste containers are properly labeled and marked according to Federal regulations (40 CFR, 262 and 49 CFR, 172). Ship all wastes with a permitted transporter holding a current EPA transporters identification number. Provide the Engineer with the required emergency response telephone number for the Uniform Hazardous Waste Manifest.

4) Maintain a file of all waste shipped for disposal or recycling. Have the Site Health and Safety Officer immediately notify the Engineer if a waste shipment (hazardous or non-hazardous) does not reach the designated facility. Further, have the Site Health and Safety Officer coordinate with the Engineer to assure that the signed original of each Uniform Hazardous Waste Manifest is received from the designated facility by the Engineer within 35 calendar days of the date the waste was accepted by the initial transporter. For shipments of hazardous waste, if the signed TSDF copy is not received in 10 additional calendar days (45 calendar days total) have the Site Health and Safety Officer immediately:

a) Prepare and submit an Exception Report to the EPA Region VII Administrator, 901 North 5th Street, Kansas City, KS 66101-2728. Provide a copy of this report to the Engineer.

b) Initiate actions to track and locate that shipment (applicable for both hazardous and non-hazardous waste shipments).

5) Provide the Engineer with a photocopy of:

- The signed Generator Copy page from the Uniform Hazardous Waste Manifest on the day of waste shipment, and
- The fully signed Return to Generator page from the Uniform Hazardous Waste Manifest on the day it is received from the disposal facility.

6. Protection and Clean-up.

a. General.

1) For all work, use every reasonable means to protect the environment, human health and safety, adjacent property, and vehicles from damage resulting from the paint removal operations, according to Article 1107.07.

2) Keep the project site in a neat, clean, and safe working condition.

3) At the end of each working day, clean up and properly containerize all waste material. Special attention is drawn to steel abrasive and its preponderancy to rust and stain surfaces where material is allowed to accumulate.

4) Clean up abrasive on a daily basis and remove any staining which occurs.

b. Site Environmental Evaluation.

1) Do not contaminate the soil or bodies of water with lead or other hazardous materials.

2) Soil or river sediments are considered to have been contaminated with lead or chromium from the project if either of the following two conditions occurs. Return the soil or river sediments to back-ground levels by methods acceptable to the Engineer and all applicable regulatory authorities (at no additional cost to the Contracting Authority).

a) If the geometric mean pre-project level is less than or equal to 200 ppm (totals), and an increase in the post-geometric mean total content of 100 ppm or more occurs.

b) If the geometric mean pre-project level is greater than 200 ppm, and the post-geometric mean concentration exceeds the pre-job geometric mean plus two standard deviations, or increases in the post-geometric mean level of 100 ppm occurs, whichever is greater.

c. Final Clean-up.

1) Perform final cleanup of all work on this project according to Article 1104.08 and procedures established in Article 2508.01, B, 4.

2) No separate payment will be made for furnishing protection and cleanup. The costs for protection and cleanup are included in the contract unit prices bid for the various items of work in the contract.

7. Project Submittals and Written Plans.

The Contractor and Engineer shall adhere to the following requirements to ensure appropriate project paper work is submitted in a timely manner. No work will be allowed or progress payments made unless these items have been submitted, reviewed, corrected, and approved as necessary.

a. Three weeks prior to commencing work.

1) Site Soil and River Sediment Sampling Program, as described in Article 2508.01, B, 3, b.

2) Site Work Plan, as described in Article 2508.01, B, 3, d.

a) Environmental Protection Plan.

b) Waste Handling, Storage, and Disposal Plan.

c) Site Air Monitoring Plan.

3) Site Health and Safety Plan.

4) Site Contingency Plan.

5) Decontamination Plan, as described in Article 2508.01, B, 4, e.

6) Written proposal for Beneficial Waste Reuse, as described in Article 2508.01, B, 5, b.

b. Prior to in-bound mobilization.
Certification of Equipment Decontamination, as described in Article 2508.01, B, 4, e.

c. Three weeks prior to erecting containment.
Containment Design, as described in Article 2508.01, B, 4, b.

d. Three weeks prior to commencing production blasting.

1) Analytical results from soil and river sediment sampling, as described in Article 2508.01, B, 4, b.

2) Request to Modify Accumulation Point Security, if applicable, as described in Article 2508.01, B, 4, d.

3) Written request for Disposal Facility Approval, as described in Article 2508.01, B, 5, b.

e. Twelve calendar days following 1st day of production blasting.

1) Furnish analytical data from project sampling paint waste, as described in Article 2508.01, B, 3, b.

2) Furnish estimated waste production quantities.

f. Prior to painting.

1) Written paint mixing procedure, as described in Article 2508.02, E, 4.

2) Manufacturer's Recommendations, as described in Article 2508.02, B, 2.

3) Written designation of the paint manufacturer's technical representative, as described in Article 2508.02, E, 7.

2508.02 PAINTING OF STRUCTURAL STEEL.

A. General.

This work consists of fully repainting, zone painting, or spot painting (or any combination of these) structural steel at designated locations using a paint system designated elsewhere in the contract documents. The work includes:

- Furnishing the coating system specified,
- Application, protection, and curing of paint coatings,
- Protection of all parts of the structure from paint spatter,
- Environmental protection,
- Final cleanup, and
- Supplying all equipment, scaffolding and rigging, labor, and materials.

B. Material Acceptance.

1. Use paints that:

- Are equal to or less than 3.2 pounds per gallon (5.5 kg/L) for volatile organic compounds (VOC). Calculation of VOC content shall account for thinning necessary for field application, and
- Contain pigments which are free from or have constituents at levels below a threshold that when disposed of would be regulated by the Title 40 Code of Federal Regulations Part 261.

2. Furnish three copies of the coating manufacturer’s certification document for each shipment intended for use on this project. Ensure the document includes the following information:

- Date of shipment to the project,

- Name of painting Contractor or company to which the shipment was made,
- Brand names and product identification numbers,
- The most current Technical Data sheets and MSDS for coatings, thinners, and tints,
- Batch or lot numbers, and
- Batch or lot numbers and producer mill certificate for any zinc pigment, certifying compliance to at least the purity requirements of ASTM D 520 Type II.

3. Provide the Engineer with three copies of the latest Technical Data Sheets, MSDS sheets, and coating manufacturer's written approval for caulking material to be used on this project.

4. Provide the Engineer with two copies of the certification document prior to starting work. Make an additional copy available on-site.

C. Paint System.

The paint system, Epoxy, Moisture Cured Urethane, or Zinc Silicate, for this project is designated elsewhere in the contract documents. The different systems are as follows:

1. Primer Coat.

a. Use a Zinc-rich Epoxy, Zinc-rich Aromatic Moisture Cured Urethane, or Zinc-rich Silicate applied at a rate that results in a targeted dry film thickness (dft) of:
- 3 to 5 mils (75 to 125 µm) for Epoxy.
- 3 to 4 mils (75 to 100 µm) for Moisture Cured Urethane.
- 3 to 5 mils (75 to 125 µm) for Zinc Silicate.

b. There is no color specified for the primer.

c. Dry film thickness listed assumes a surface profile of 1.5 to 2.5 mils (25 µm to 65 µm). If this is not the case, either because of previous blast cleaning operations or improper quality control on this job, additional dft of primer may be required. In those cases, contact the paint manufacturer to provide a written alternate primer and possible application modifications. Prior to applying additional alternate primer, provide the written alternative to the Engineer for review and approval. Ensure that in no case do surface peaks project above the primer coverage.

d. The use of penetrating sealer, if required, will be designated elsewhere in the contract documents. A penetrating sealer may be required in any of the following areas:
- Where there are cracks and seams,
- In feathered (transition) areas,
- Areas with surfaces prepared by mechanical methods.

e. Apply the sealer at a rate that results in a targeted dft recommended by the paint manufacturer.

2. Intermediate Coat.

a. Use an Aluminum Epoxy Mastic or Aromatic Moisture Cured Urethane applied at a rate that results in a targeted dft of:

- 5 to 7 mils (125 to 175 μm) for Aluminum Epoxy Mastic.
- 3 to 4 mils (75 to 100 μm) for Moisture Cured Urethane, pigmented with micaceous iron oxide.
- No intermediate coat is required for a zinc-rich silicate system.

b. Tint the intermediate coat to a different color than the primer and finish coats.

3. Finish Coat.

a. Use an Aliphatic Polyurethane, Aliphatic Moisture Cured Urethane, or Waterborne Acrylic applied at a rate that results in a targeted dft of:

- 3 to 5 mils (75 to 125 μm) of Aliphatic Polyurethane for the Epoxy system.
- 2 to 3 mils (50 to 75 μm) of Aliphatic Moisture Cured Urethane.
- 2 to 3 mils (50 to 75 μm) of Waterborne Acrylic for the Zinc Silicate system.

b. For the top coat use Federal Color Number 14223 for highway bridges or the color specified in the contract documents.

D. Acceptable Products.

1. General.

a. Refer elsewhere in the contract documents for the system specified for this project. Acceptable suppliers and products for each system are listed in Materials I.M.s 482.02 through 482.06. Choose material for the paint system specified (including thinners, tinting, etc.) from one of the coating manufacturers.

b. When specified in the contract documents, use a penetrating sealer that is:

- Designated by the paint manufacturer for the system specified, and
- Tinted to a different color than that of the primer.

2. Epoxy System.

Use a three coat epoxy paint system consisting of:

- A Zinc-rich Epoxy primer,
- A High-solids Aluminum Epoxy Mastic intermediate coat, and
- An Aliphatic Polyurethane top coat.

3. Moisture Cured Urethane.

Use a three coat moisture cured urethane paint system consisting of:

- A Zinc-rich Aromatic Moisture Cured Urethane primer,
- A Moisture Cured Urethane - pigmented with micaceous iron oxide intermediate coat, and
- An Aliphatic Moisture Cured Urethane top coat.

4. Zinc Silicate.

Use a paint system consisting of a single coat of Zinc Silicate primer with a Waterborne Acrylic top coat system.

E. Application.

1. General.

Apply paint using brush, roller, or spray methods. Apply paint in strict compliance with the coating manufacturer's latest written recommendations. Regardless of the method of application, ensure the specified minimum dft is achieved. Ensure the manufacturer's recommended maximum dft requirement for each coat is not exceeded without approval of the paint manufacturer's technical representative. Additionally:

a. Ensure product parameters, such as application, thinning, mixing, pot life, ventilation, curing, and so forth comply with the manufacturer's recommendations.

b. Ensure the prime, intermediate, and finish coats have a smooth, uniform appearance free from runs, sags, cracks, dry spray, over-spray, or other defects.

c. Shield concrete and galvanized products so that paint application on steel is full and complete without over-spray.

d. Upon completion, permanently stencil the word "painted" followed by the Contractor's name, the month, year, coating system, and manufacturer of the coating system applied. Stencil this information on an inconspicuous surface in a manner and location the Engineer approves.

e. Provide OSHA compliant access for the Engineer to check the surface preparation before painting and the dft after each coat is applied.

2. Painting.

a. Penetrating Sealer.

Apply penetrating sealer to areas designated in the contract documents. Allow to cure according to the coating manufacturer's recommendations before the prime coat is applied.

b. Prime Coat.

1) Apply a prime coat to all areas blasted clean or mechanically cleaned, or both. Apply this coat to areas of bare metal within 24 hours of being blast cleaned. Brush blast the entire prepared area before paint is applied if:

- The prepared surface shows any sign of flash rust, or
- The prime coat is not applied within 24 hours after blast cleaning.

2) Use methods acceptable to the Engineer to re-prepare areas which were prepared by mechanical methods and are showing flash rust.

3) Pay special attention to all rivets, bolts, edges of connections, areas of pack rust, and areas which may be difficult to access. These areas may require ringing/stripping.

4) Allow the prime coat to cure according to the coating manufacturer's recommendations before the intermediate coat is applied.

c. **Intermediate Coat.**
   1) Apply the intermediate coat to all areas that received a prime coat. Allow to cure according to the coating manufacturer's recommendations before the finish coat is applied.
   2) The Zinc Silicate system does not require an intermediate coat.

d. **Finish Coat.**
   Fully cover the intermediate coat with the finish coat. Fully cover other surfaces with the finish coat if designated in the contract documents.

3. **Recoating.**
   a. **Surface Condition.**
      1) Ensure surfaces are free of dirt, oxidation products, oil, and other detrimental material prior to painting. Perform cleaning which may be necessary according to the coating manufacturer’s recommendations.
      2) Protect all painted surfaces to prevent soiling or detrimental weather conditions during painting and through the tack-free stage.
   b. **Minimum Time.**
      1) No additional coat(s) of paint may be applied until the preceding coat has dried. Recoat according to the coating manufacturer's recommendations for time, temperature (ambient and/or surface), and weather conditions.
      2) If minimum recoat times are not given by the coating manufacturer, wait at least 24 hours, and until the previous coat is tack-free, before applying the next coat.
   c. **Maximum Time.**
      Do not exceed the coating manufacturer's maximum time between coats. If the maximum recoat time is exceeded for any coat, provide the Engineer with a written correction procedure, or approval to proceed without correction, obtained from the coating manufacturer’s technical representative.

4. **Mixing.**
   a. Mix paint according to the coating manufacturer's recommendations. Do not use previously opened or partially used containers of paint. Partial kit mixing will not be allowed.
   b. Together with the coating manufacturer, provide a specific mixing procedure for the Engineer’s review prior to performing the work. Follow this procedure unless the Engineer approves a written request to modify it.

5. **Dry Film Thickness.**
   a. The Engineer will determine the dft of each coat and the total paint system using procedures described in SSPC-PA 2. Excessive coating thickness is as equally undesirable as unacceptably thin coating thickness, and both will be sufficient cause for rejection.
   b. Targeted dft is specified herein. Touch up areas having less than specified dft to increase dft to at least that specified in this Article for the system specified. Depending on the condition of the steel

substrate and paint system being used, it is possible these areas will require reblasting and repainting.

c. Excessive thickness will be evaluated on a case-by-case basis in consultation with the coating manufacturer. Depending on the condition of the steel substrate and paint system being used, it is possible these areas will require reblasting and repainting.

6. Cracks and Seams.

a. Use a best effort combination of blasting and possible hand or power tool cleaning to clean cracks and seams that are formed by junctions of joining members, splices, gusset plates, rivets, bolts, nuts, and similar surface irregularities. After application of any penetrating sealer and prior to application of the prime coat, caulk all cracks and seams that are equal to, or greater than, 3/16 inch (10 mm) wide with a durable caulking compound recommended by the paint manufacturer.

b. Seal cracks and seams less than 3/16 inch (10 mm) wide with the prime coat. Seal cracks and seams that cannot be sealed with the prime coat using caulk before the intermediate coat is applied. In the case of Zinc Silicate, this will be before the top coat is applied.

c. Use lead free caulking compound, supplied with the latest technical data and MSDS sheets. Obtain the paint manufacturer’s and the Engineer’s approval prior to incorporation into the project.

7. Technical Assistance.

a. Have the coating manufacturer whose products are used on this contract designate a qualified technical representative to support this project. The technical representative shall be available for on-site assistance and project coating consultation as may be required.

b. Difficulties in scheduling on-site technical assistance will not be considered a sufficient reason for approving time extensions to the contract period.

c. Ensure that, in all cases, application parameters are according to the product's Technical Data Sheet or the manufacturer's written recommendations, unless superseded elsewhere in this specification or in the contract documents.

F. Application Conditions.

1. Apply the manufacturer's published weather restrictions for each coating, except as modified below.

2. Paint only when weather conditions are such that the surfaces to be painted are entirely free from moisture, frost, ice, and snow. When painting in an area protected from the above conditions, protect the surface under cover until the paint is dry.

3. If wet paint is exposed to humidity, rain, snow, or condensation, allow it to dry. Remove damaged paint, reclean the surface, and repaint.

4. Moisture Cured Urethane coating may only be applied when:

- Surface temperatures are between 38°F (4°C) and rising and 100°F (37°C).
- Relative humidity is less than or equal to 95%.

5. Bubbling or pinholing which may occur in Moisture Cured Urethane will be evaluated using SSPC-VIS2. Bubbling or pinholing shall be less than 0.1% as defined by SSPC-VIS2, Photographic Standard No. 8.

2508.03 COAST GUARD REQUIREMENTS.

Apply the following for contracts that require work in and over navigable waters.

A. Comply with the following requirements:
- Established by the Corps of Engineers, the U. S. Coast Guard, and others relative to construction work in and over navigable waters, and
- Applicable to this project, but not covered by existing permits.

B. Construction work includes, but not necessarily limited to:
- Bridge washing, paint removal, cleaning structural steel by blasting, and painting structural steel,
- Containment enclosures, safeguards and temporary falsework or platforms, and lighting during construction, and
- Anchorage of barges and construction equipment, temporary restriction of channel width, and the removal of all temporary construction.

C. Ensure operations within or over the river comply with the requirements or directions of the U.S. Coast Guard District Engineer.

D. The following precautionary measures shall be taken during the performance of this work:

1. Perform work so that the free flow of navigation is not interfered with and navigable depths are not impaired.

2. Ensure floating equipment working in the channel displays lights and signals as required by the current Inland Navigational Rules.

3. If scaffolding or nets are suspended below low steel in the navigation span, contact the Coast Guard Office in St. Louis, Missouri, so that the temporary reductions in clearance for river traffic can be checked and appropriate notices can be published. Remove such scaffolding or nets at night, if required by the Coast Guard.

4. Take positive precautions to prevent spark producing, flame producing, lighted, or other damaging objects from accidentally dropping onto barges or vessels passing beneath the bridge. Cease all flame cutting, welding, and similar spark-producing operations over the channel when vessels are passing beneath the bridge.

5. Ensure work does not interfere with displaying navigation lights on the bridge at night.

6. Immediately remove any material, machinery, plant, or appliance which is lost, thrown from the bridge, sunken, or misplaced during the progress of the work, and which in the Engineer's opinion may be dangerous or obstructive to navigation. Immediately notify the Engineer and provide a description and location of the obstruction. When required, mark or buoy such obstructions until the obstruction is removed.

E. The Federal Water Pollution Control act, as amended, prohibits the discharge of oil, including oil based paints, or hazardous substances into the waters of the United States. The law requires any person in charge of a vessel or facility from which oil or a hazardous substance is discharged shall immediately report the discharge to the U.S. Coast Guard National Response Center at 800.424.8802.

F. The owner/operator of a vessel or facility from which the pollutant is discharged is subject to a civil penalty of up to $5000 and is liable for cleanup costs, if any.

G. Inform the U.S. Coast Guard office in St. Louis, Missouri, the status of this work to enable them to issue cautionary notices to mariners. If the Contractor has a marine radio at the job site, furnish the Coast Guard the call sign and operating frequency so that the information can be included in their notices.

H. No changes in channel conditions or in river bank conditions from natural causes or by reason of channel improvements or other construction, nor methods of river control by the United States or the state are to be considered as having any bearing or effect on the obligations of the contract nor justification for any claim for additional payments or extensions of time.

I. In the event that the United States Coast Guard or other constituted authorities should, during the progress of work, issue directions or orders affecting the Contractor's operations or order of procedure, promptly file with the Engineer a copy of such order or restrictions from the Corps of Engineers, U.S. Army, U.S. Coast Guard, and/or other authority having jurisdiction.

2508.04 METHOD OF MEASUREMENT.
Lump sum items. No method of measurement.

2508.05 BASIS OF PAYMENT.

A. Payment for the items below will be the lump sum contract price.

1. **Bridge Cleaning for Painting.**
   Payment is full compensation for furnishing materials, labor, and equipment to perform the work in accordance with contract documents.

2. **Blast Cleaning of Structural Steel.**
   Payment is full compensation for furnishing materials, labor, and equipment to perform the work in accordance with contract documents.

3. **Containment.**
   a. Payment is full compensation for furnishing materials, labor, and equipment necessary to install and maintain the containment during blast cleaning operations or paint removal by other methods.
   b. For non-hazardous paint removal, payment is also full compensation for monitoring, sampling, testing, reporting, temporary enclosures, temporary storage of waste, and disposal of waste.
   c. For hazardous paint removal, payment is full compensation for:
      - Furnishing all materials, labor, and equipment to perform all work necessary for containment enclosures,
      - Air monitoring, sampling, and testing,
      - Decontamination,
      - Handling, sampling and testing, containerizing, and storage of paint waste, and
      - Installing, maintaining, and removing the waste accumulation points.

4. **Paint Waste Transport and Disposal.**
   Payment is full compensation for furnishing materials, labor, and equipment to perform all work necessary for:
   - The proper transport of paint waste,
   - The proper disposal of paint waste,
   - Analytical testing of paint waste,
   - Obtaining all necessary permits and manifests, and
   - Preparation of permits and manifests.

5. **Painting of Structural Steel.**
   Payment is full compensation for:
   - All materials, labor, equipment,
   - Providing material acceptance documents, and
   - Providing technical assistance in accordance with contract documents.

B. Coast Guard Requirements will be incidental to the items of work for which they apply.

Section 2509. Cleaning, Surface Preparation, and Painting of Galvanized Surfaces

2509.01 DESCRIPTION

A. For the galvanized steel designated for painting on the plans:

1. Clean the surface.

2. Prepare the surface for painting.

3. Apply an intermediate coat of polyamide epoxy with a coating thickness of 3 mils to 4 mils (75 µm to 100 µm).

4. Apply a topcoat of aliphatic polyurethane which matches the Federal Standard Color number listed in the contract documents.

B. Clean, prepare, and paint the surface in the same shop to ensure single source responsibility of the entire coating system. Submit the sequence of operation to the Iowa Department of Transportation, Attention: Structures Engineer, Office of Materials, 800 Lincoln Way, Ames, IA, 50010. Describe the procedure used in preparing the galvanized surface, the brand names of the paint to be used, and certification that the paint that is used is compatible with galvanized surfaces.

2509.02 MATERIALS

A. One of the two-coat epoxy/polyurethane paint systems listed in Materials I.M. 482.08.

B. Ensure all materials used in the coating system are compatible and from the same manufacturer.

C. Ensure all materials are in unopened, original, dated containers from the manufacturer. Material used shall be within manufacturer's shelf life.

D. Ensure all materials have been and continue to be stored in such a manner as to prevent freezing and/or overheating. Follow the manufacturer recommendations as to maximum and minimum storage temperatures.

2509.03 CLEANING, PREPARATION, AND PAINTING

A. Surface Preparation of Galvanized Surfaces.
Prepare and prime the surface as soon as possible after galvanizing. The surfaces shall be primed within 24 hours of the galvanizing operations. There shall be no visible signs of zinc oxide or zinc hydroxide, which first appear as a fine white powder.

B. Surface Smoothing
Remove zinc high spots by cleaning with hand or power tools as described in SSPC SP2 or SP3. Remove the zinc until it is level with the surrounding area, taking care that the base coating is not removed by the cleaning methods. After cleaning, inspect the surface for conformance to the required zinc thickness according to ASTM A 123 using a magnetic or eddy current type thickness instrument complying with ASTM E 376. Repair all items falling below the required zinc thickness, before or after removal of high spots, according to ASTM A 780.

C. Surface Cleaning

1. Hot dip galvanized surfaces shall be clean and free of oil and grease before they are painted.

2. No water quenching, or chromate conversion coating, of the galvanized surface that is to be painted is allowed. These processes interfere with the adhesion of the paint coatings to the zinc surface.

3. Use one of the following methods, as deemed necessary by the paint manufacturer, for surface cleaning galvanized surfaces:

a. Aqueous Alkaline Cleaning.
An alkaline solution, with a pH of 11 to 13 may be used to remove traces of oil, grease, or dirt. Alkaline cleaner shall not be used for removal of heavy build-up of zinc oxide or wet storage stain. The solution may be applied through immersion in a tank filled with the solution, spraying, or brushing with a soft bristle brush. After cleaning, rinse thoroughly in hot water or water under pressure. Use heat drying to accelerate the complete removal of water from the surface.

b. Solvent Cleaning.
Typical cleaning solvents, such as mineral spirits or high-flash naphtha, may be used to remove oil and grease. The procedure used shall be specified in SSPC SP1. Proper rags or brushes shall be used to wipe the galvanized parts. These rags or brushes shall be cleaned or recycled often since oil can accumulate on their surfaces and be transferred back to the galvanized part. After cleaning, rinse surfaces thoroughly in hot water or water under pressure. Allow to dry completely before proceeding.

D. Surface Preparation

Use any of the following methods, as per the written recommendation of the paint manufacturers, to prepare the galvanized surface for painting:

1. Sweeping Blasting.

a. The purpose of the sweep blasting is to deform, not to remove, the galvanized metal. Repair areas falling below the required zinc thickness, before or after the sweep blasting, according to ASTM A 780. The procedure for this process can be found in SSPC SP7.

b. Abrasive sweep or brush blasting which uses a rapid nozzle movement will roughen the galvanized surface profile. Ensure the abrasive material provides a stripping action without removing excess zinc layers. Particle size should be in the 8 mils to 20 mils (200 µm to 500 µm) range.

c. Materials that can be used are aluminum/magnesium silicate, soft mineral sands with a mohs hardness of 5 or less, corundum, limestone, and organic media such as corncobs or walnut shells. Sweep blast zinc at a rate of no less than 130 square yards per hour (110 m^2/h) using these types of abrasives. Substrate should be maintained at a temperature greater than 5ºF (3ºC) above the dew point temperature.

d. Following abrasive blast cleaning, blow surfaces down with clean, compressed air. The formation of zinc oxide on the blasted surface will begin very quickly so the paint coating shall be applied immediately, and no later than within 60 minutes, after sweep blasting.

2. Wash Primer Treatment.

a. This process involves the use of a metal conditioner to neutralize surface oxides and hydroxides along with etching the surface. One example of a wash primer is SSPC-Paint Specification No. 27. The process is based on three primary components: 1) a hydroxyl-containing resin; 2) a pigment capable of reacting with resin and acid; and 3) an acid capable of making the resin insoluble by reacting with the resin, the pigment, and the zinc surface. The result is a film of approximately 0.3 mils to 0.5 mils (8 µm to 13 µm). Failures can occur if the film exceeds 0.5 mils (13 µm). The film is usually applied by spray, but may be applied by soft bristle brush, dip, or roller coater. Using these latter coating methods, it may be difficult to control film thickness.

b. For drying time prior to topcoating, follow the manufacturer's instructions.

c. This wash primer treatment may be better suited to certain types of paint systems. See SSPC-Paint Specification No. 27 for the best match of this treatment to a paint system.

3. Acrylic Passivation/Pretreatment.

a. The passivation/pretreatment process consists of applying an acidic acrylic solution to the newly galvanized surface and then allowing it to dry, forming a thin film coating. When applied, the solution first reacts with the zinc surface forming a passivating conversion coating while simultaneously forming an acrylic coating suitable for painting on top of the passivation layer. The underlying conversion coating provides strong adhesion to the galvanized surface while the thin film acrylic layer provides barrier protection that inhibits corrosion and provides a highly compatible surface for the application of organic paint films. There are versions of these solutions that contain chrome and versions without chrome.

b. The application methods for these water-based treatments are: dipping, flow coating, spraying, or other appropriate means. Following application, the coating is dried in an oven or in air. In some instances the coating is applied to hot galvanized articles, in which case separate drying is not necessary. Rinsing is not required. The coating is approximately 0.04 mils (1 µm) thick.

c. Painting is possible any time during a period of four months after application if the surface is free of visible zinc oxides or zinc hydroxides. If harmful contaminants such as dust, dirt, oils, grease, or deposits are present, they shall be removed with a mild alkaline degreasing solution (pH 11.5 maximum), followed by a thorough rinse with hot water (140ºF (60ºC) maximum temperature) or a pressure wash, and then thoroughly dried. This treatment is applied in the galvanizing plan or later in the paint shop. When applied in the paint shop, the surface shall first be appropriately cleaned as described above to remove contaminants picked up after galvanizing.

E. Final painting.

1. Apply all materials under conditions within the tolerances listed below. Keep permanent records of the processing conditions during the complete finishing process.
   - Air temperature 50ºF (10ºC) minimum and 90ºF (32ºC) maximum.
   - Steel surface temperature 50ºF (10ºC) minimum and 100ºF (37ºC) maximum.
   - Humidity 85% maximum.
   - Steel temperature at least 5ºF (3ºC) above the dew point.

2. Ensure all surfaces are dry and free from dust, dirt, oil, grease, or other contaminants.

3. Ensure total thickness, including epoxy intermediate coat and urethane topcoat, is from 5 mils to 10.5 mils (130 µm to 260 µm) dry film thickness.

4. After the painted galvanized steel has been erected in the field, touch up all areas where the shop paint has been damaged using the same materials from the same manufacturer as specified for shop application.

5. Submit the paint manufacturer's product data sheets to the Engineer prior to the start of work. Follow the requirements as outlined in the data sheets. Apply the intermediate coat of epoxy in two applications.

6. Ensure the coating is packaged in separate containers bearing a label clearly showing the name of the manufacturer, brand name of the product, lot number, and date of manufacture.

7. Ensure the topcoat matches the Federal Standard Color number listed in the contract documents. Submit samples of the topcoat color to Iowa Department of Transportation, Office of Materials, 800 Lincoln Way, Ames, IA 50010.

8. Special handling will be required to prevent damage to the paint system during lifting, shipping, and installation.

9. After completing construction, properly prepare and repaint, according to the manufacturer’s specifications, all defects or damage to the paint system. Ensure steel surfaces to be repainted are free of contaminants, including dirt or concrete. For repairs use the same paint from the same manufacturer as was used for the shop painting. Protect adjacent surfaces not to receive paint by masking or other means of protection.

F. Shop Conditions

Ensure surfaces to be painted after surface preparation remain free of moisture and other contaminants. Control the operations to ensure that dust, dirt, and/or moisture do not come in contact with surfaces prepared or painted that day. In addition to the manufacturer's written instructions for

surface preparation and painting, apply the following conditions (when in conflict, the most restrictive conditions govern):

- Apply paint only when steel and air temperatures are 40ºF (4ºC) or above. Do not apply paint to steel that is at a temperature that will: 1) cause blistering or porosity; or 2) be otherwise detrimental to the life of the painted surfaces.
- Do not apply paint when the steel surface temperature is less than 5ºF (3ºC) above the dew point.
- Do not apply paint to wet, damp, or frosted surfaces.
- Do not apply paint when the relative humidity is above 85%.
- Work accomplished under unfavorable weather conditions will be considered unacceptable. Complete recleaning and painting of these areas will be required, at no additional cost to the Contracting Authority.

G. Equipment.

Prior to beginning any painting operations, ensure air equipment passes the requirements of ASTM D 4285. This test will be repeated as determined by the Engineer. Comply with the following:

1. Cleaning and painting equipment.

- Includes gages capable of accurately measuring fluid and air pressures.
- Has valves capable of regulating the flow of air, water, or paint as recommended by the equipment manufacturer.
- Is maintained in proper working order.

2. Spray painting and surface preparation equipment.

- Utilizes filters, traps, or separators recommended by the manufacturer of the equipment.
- Filters, traps, and separators kept clean using the methods and intervals recommended by the manufacturer of the equipment.
- Paint pots equipped with air operated continuous mixing devices.

3. Pressure type abrasive air blasting equipment.

Capable of providing the minimum required pressure and volume, free of oil, water, and other contaminants.

H. Quality Control.

1. Conduct a quality control program, consisting of the items below, that ensures the work accomplished complies with the contract documents:

- Qualified personnel to manage the program and conduct quality control tests,
- Proper quality measuring instruments,
- Quality Control Plan, and
- Condition and quality recording procedures.

2. Ensure personnel managing the quality control program have experience and knowledge of industrial coatings and the measurements needed to assure quality work. Ensure the personnel performing the quality control tests are trained in the use of the quality control

instruments. These personnel are not to perform surface preparation and painting. Have painters perform wet film thickness measurements.

3. Provide necessary equipment to perform quality control testing of shop conditions, equipment, surface preparation, and profile and paint film thickness. Calibrate the equipment according to manufacturer's recommendations.

4. Implement a Quality Control Plan, approved by the Engineer, which includes: 1) a schedule of required measurements and tests as outlined herein; 2) procedures for correcting unacceptable work; and 3) procedures for improving surface preparation and painting quality as a result of quality control findings. Supply and use forms approved by the Engineer to record the results of quality control tests. Make these forms available at the work site for the Engineer to review.

5. The purpose of the quality control program is to assist the Contractor in the proper performance of the work. Quality control tests performed by the Contractor will not be used as the sole basis for acceptance of the work.

2509.04 METHOD OF MEASUREMENT
None.

2509.05 BASIS OF PAYMENT
The cost of cleaning, surface preparation, and painting of galvanized structural steel is incidental to the contract price for the items that have galvanized steel designated for painting as listed in the contract documents. This cost includes:

- Labor, materials, and equipment to complete the cleaning, surface preparation, and painting according to this specification.
- Costs to repaint or repair the paint system after erection.

Section 2510. Removal of Pavement

2510.01 DESCRIPTION.
Remove PCC pavement including reinforcing, pavement widening, HMA pavement, detour pavement, and integral and separate curb. Break up PCC pavement and leave in place. Remove anchor lugs in continuously reinforced PCC pavement.

2510.02 MATERIALS.
None.

2510.03 CONSTRUCTION.

A. Pavement Removal.

1. General.

a. Remove pavement as specified in the contract documents. Within the pavement area, remove utility accesses, intakes, service boxes, integral and separate curb, and junction boxes.

b. Remove pavement to be processed for reuse or stockpiled for salvage or recycling. Do so in a manner that minimizes inclusion of fine material from the shoulder, subgrade, or other underlying course or other foreign material.

c. When a portion of concrete pavement is to be removed and the remaining portion is later abutted at its top surface with new pavement, saw the breakout line of the old slab to full depth.

d. Remove to a new saw line and replace, at no additional cost to the Contracting Authority, all concrete broken or damaged beyond the breakout line designated by the Engineer.

e. When pavement removal results in road closure to public or local traffic, start the removal operation no more than 2 weeks before the succeeding operation is scheduled to begin. Apply the 2 week requirement to each succeeding operation until the closure is no longer necessary.

f. All concrete, reinforcing, or other metal items which are removed and not specified for stockpiling, salvaging, recycling, or any other placement becomes the property of the Contractor. Remove according to Article 1104.08.

2. Portland Cement Concrete.

a. If PCC pavement or other broken concrete is to be placed in fills, cut off protruding steel to within 3 inches (75 mm) of encasing concrete. Place it in alternating layers of broken concrete and soil with a maximum depth of either layer of 2 feet (0.6 m). Do not place broken concrete within 2 feet (0.6 m) of the final cross section. Limit the maximum size of broken concrete to approximately 0.25 square yard (0.2 m^2).

b. For PCC pavement or broken concrete to be used as revetment, meet the requirements of Article 4130.01.

c. When pavement removal is adjacent to a bridge, railroad crossing, or similar structure, do not use heavy breaking equipment within 20 feet (6 m) or within the reinforced section at the bridge approach, whichever is larger or applicable. Apply Article 1105.12, H, to use of this type of equipment.

d. Cut the pavement full depth approximately 2 feet (0.6 m) from the bridge. Use a jack hammer or other hand methods to break up and remove pavement within that area. Beyond 2 feet (0.6 m) and within the bridge approach or 20 feet (6 m), a tractor mounted jack hammer or similar light equipment may also be used.

3. Hot Mix Asphalt.

Remove asphalt pavement as specified in the contract documents.

4. PCC Pavement with HMA Resurfacing (Composite Pavement Section).

The contract documents may specify that the HMA Resurfacing be removed from the PCC pavement as a separate operation. When not specified, the Contractor may remove the composite pavement as a single operation.

5. **Removal and Crushing of Pavement.**
The contract documents may require the pavement be removed and crushed. When required, the contract documents will specify the size or gradation, or both, to which to crush the pavement. The contract documents will also specify where the crushed material is to be stockpiled or used in the contract.

6. **Removal of Intakes and Utility Accesses.**
Remove the top and sides of the structure a minimum of 10 feet (3 meters) below the subgrade or 6 feet (1.8 meters) below the finished grade in other areas. Plug all of the pipes in the structure to be removed using Class C concrete. If the structure is more than 10 feet (3 meters) deep, fill the remaining structure with flowable mortar. Place compacted fill over excavation.

B. Breaking Up Old Pavement.
When specified in the contract documents, shatter concrete pavement (maximum size of unbroken concrete to be 0.5 square yard (0.4 m^2)) and leave in place.

2510.04 METHOD OF MEASUREMENT.

Measurement for the items below will be as follows:

A. Removal of Pavement.
Square yards (square meters). This includes areas of utility accesses and intakes within the pavement area, and integral and separate curb. Removal of reinforcing steel will be incidental to removal of pavement and will not be measured for payment.

B. Breaking Up Pavement.
Square yards for the area of pavement broken up and left in place according to the contract documents.

C. Removal of Anchor Lugs.
By count for each traffic lane.

D. Pavement Scarification.
Square yards (square meters) where the HMA Resurfacing has been scarified prior to the removal of the pavement. HMA Resurfacing removed and crushed with the PCC pavement will be included in the area of pavement scarification if the composite crushed material meets the gradation and composition required by the contract documents.

E. Removal and Crushing of Pavement.
Square yards (square meters) removed and crushed according to the contract documents.

F. Removal of Intakes and Utility Accesses.
By count.

2510.05 BASIS OF PAYMENT.
For removal of pavement and breaking up pavement as specified, payment will be the contact unit price as described below. Payment is full compensation for furnishing all tools, equipment, labor, and materials for completion of the work as specified in the contract documents.

A. Removal of Pavement.

1. Per square yard (square meter).

2. When recycling is not mandatory, the cost of recycling pavement removal into granular subbase, granular shoulders, or special backfill material is included into the cost of the items for which the recycled pavement material will be used.

3. The cost of saw cut and integral and separate curb is included in the contract unit price for the Removal of Pavement, Pavement Scarification, or Removal and Crushing of Pavement.

B. Breaking up Pavement.
Per square yard (meter) for the area of pavement broken up and left in place according to the contract documents.

C. Removal of Anchor Lugs.
Each. If removal of anchor lugs is not a bid item in the contract documents, payment will be $400 per lane for each anchor lug removed.

D. Pavement Scarification.
Per square yard (square meter).

E. Removal and Crushing of Pavement.
Per square yard (square meter).

F. Removal of Intakes and Utility Accesses.
Each. Payment is full compensation for the work of plugging pipes, filling remaining structures with flowable mortar, and placing compacted fill.

Section 2511. Removal and Construction of Sidewalks and Recreational Trails

2511.01 DESCRIPTION.
Remove sidewalks and recreational trails or portions of them and/or construct new sidewalks and recreational trails according to the contract documents.

2511.02 MATERIALS.

A. Portland Cement Concrete.

1. Use Class B Portland cement concrete for sidewalks and recreational trails. Place according to Section 2301.

2. For sidewalk and recreational trail construction included in PCC paving projects, the Contractor may use the approved paving mixture for the project. A Class 2 durability or better aggregate, according to Article 4115.04, will be required.

3. When sidewalk or recreational trail construction is associated with a bridge project, the Contractor may use the concrete approved for the bridge structure with Class C as the minimum.

B. Hot Mix Asphalt.

1. For sidewalks and recreational trails not adjacent to pavement, use 100,000 ESAL, 3/8 inch (9.5 mm) HMA, according to Section 2303.

2. When the recreational trail or sidewalk is adjacent to the pavement and also functions as the pavement shoulder, use 1,000,000 ESAL, 1/2 inch (12.5 mm) base mixture.

3. Use PG 58-28 or PG 52-34 Performance Grade binder as specified in the plans.

C. Subbase and Granular Surface.
Use the subbase and granular surface specified in the contract documents.

D. Detectable Warnings.
Install detectable warnings that comply with Materials I.M. 411.

2511.03 CONSTRUCTION.

A. Removal of Sidewalks and Recreational Trails.

1. Remove the sidewalks and recreational trails as shown in the contract documents. If only portions of the sidewalks or recreational trails are to be removed, form removal boundaries with a full depth vertical saw cut before breaking the removal.

2. Remove and replace (at no additional cost to the Contracting Authorities) any areas of the sidewalk or recreational trail not designated for removal but which are removed, broken, or damaged by removal operations. Remove sidewalks and recreational trails according to Article 2510.03, A.

B. Preparation of Subgrade.

1. **Sidewalks.**
Prepare the subgrade by excavating or filling with suitable earth to a depth below the finished grade line so that, when tamped or rolled until smooth, firm, and hard, the subgrade will be uniform and at the required depth below the finished grade line.

2. Recreational Trails.

a. When the recreational trail is to be constructed on natural subgrade, special compaction of subgrade for the recreational trail will be required:

- Disk, scarify, mix, and recompact the top 12 inches (300 mm) of subgrade with moisture and density control.
- Compact to no less than 95% maximum density as determined by Iowa DOT Materials Laboratory Test Method 103, with moisture content no less than optimum or more than 4% above optimum moisture content.

b. When the recreational trail surface is to be constructed on an existing granular surface, prepare the subbase (existing granular surface) according to the contract documents.

C. Portland Cement Concrete.

1. Placing.

a. Hand Finished Sidewalks and Recreational Trails.

1) Use wood or steel forms complying with Article 2301.03, A, 3, a, 1, c.

2) Thoroughly moisten the subgrade.

3) Deposit the concrete for the full depth of slab in one operation. Consolidate it by tamping or vibration.

4) Screed the excess concrete off flush with the forms.

5) Thoroughly consolidate edges adjacent to all forms, expansion joints, curbs, or fixtures in the surface.

b. Slip Form Sidewalks and Recreational Trails.

1) Use self propelled slip form pavers that meet the requirements of Section 2301.

2) Other slip form paving machines require the Engineer's approval. Use machines designed for the specific purpose of placing, consolidating, and finishing concrete sidewalk and recreational trail slabs without use of fixed side forms,

2. Curb Ramps.

a. Install detectable warnings when constructing curb ramps. Install them according to the manufacturer's recommendations. Use detectable warnings that contrast visibly with the adjoining surfaces, either light-on-dark or dark-on-light. Refer to Americans with Disabilities Act Accessibility Guidelines (ADAAG) for contrast requirements at http://www.access-board.gov/adaag/html/adaag.htm#4.29.2.

b. If crossings are marked, locate the ramp, exclusive of flares, entirely within the crosswalk markings.

3. Finishing.

After consolidating the concrete, finish the surface to a uniform, slip resistant, wet burlap drag or broom finish texture true to the line and grade specified in the contract documents. If a broom is to be used, drag a suitable broom transversely across the surface of the plastic concrete.

a. Sidewalks.

1) After floating the surface, finish the edges of the slabs using a suitable edging tool. Ensure the finished surface has a cross slope of 1/4 inch per foot (20 mm/m) for drainage, unless shown otherwise.

2) For PCC sidewalks set transverse joint spacing to be equal to the sidewalk width. Cut the concrete through for no less than 25% of the depth with a pointed trowel or suitable spading tool. Then edge the concrete on both sides. In place of using a pointed trowel or suitable spading tool, the Contractor may cut these lines within 12 hours after concrete placement using a 1/8 inch (3 mm) blade saw approved by the Engineer. Metal dividers will be considered for approval, in place of cutting.

b. Recreational Trails.

1) For PCC recreational trails set transverse joint spacing to be equal to the pavement width. Saw all transverse joints (tooling will not be allowed). Cut transverse joints 1/8 inch (3 mm) wide and no less than 1 inch (25 mm) in depth. No sealant will be required.

2) Place a longitudinal joint in recreational trails more than 12 feet (3.6 m) wide.

4. Protection and Curing.

After finishing, cure and protect the concrete using one of the methods described in Article 2301.03, K.

5. Isolation Joints.

Construct isolation joints at all points where sidewalks or recreational trails meet other walks, curbs, or fixtures in the surface. Construct them by installing a 1/2 inch (13 mm), full depth strip of approved premolded joint material.

6. Time for Opening Pavement for Use.

Open PCC sidewalks and recreational trails a minimum of 7 calendar days after placement or when flexural strength reaches 400 psi (2.75 MPa) as determined by Materials I.M. 383.

D. Hot Mix Asphalt.

Construct HMA sidewalks and recreational trails according to Article 2303.03 using Class 1C compaction.

E. Smoothness.

1. Ensure sidewalk and recreational trail smoothness comply with Article 2301.03, H, 4, except for the requirements for pavement and bridge approach sections for Primary projects.

2. Areas may be checked by the Engineer with a surface checker and are not to exceed 1/4 inch in 10 feet (6 mm in 3 m). For each bump exceeding these requirements, the Contractor will be assessed $50 or the bump corrected as agreed upon by the Engineer and Contractor.

F. Weight Limits.
Limit construction equipment on both PCC and HMA sidewalks and recreational trails to a maximum of 5 ton (5 Mg).

G. Pavement Markings.
Place pavement markings according to Section 2527.

2511.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Removal of Sidewalk or Removal of Recreational Trail.
Square yards (square meters) shown in the contract documents.

B. Sidewalk or Recreational Trail.
Square yards (square meters) shown in the contract documents. Deductions will not be made for fixtures having an area of 1 square yard (1 m^2) or less.

C. Special Compaction of Subgrade for Recreational Trail.
Stations (meters) shown in the contract documents.

D. Detectable Warnings for Curb Ramps.
Square feet (square meters) shown in the contract documents.

2511.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Removal of Sidewalk or Removal of Recreational Trail.

1. Per square yard (square meters).

2. Payment is full compensation for all equipment, labor, and disposal for removal of the sidewalk or recreational trail as specified in the contract documents.

B. Sidewalk or Recreational Trail.

1. Per square yard (square meter).

2. Payment is full compensation for furnishing all material, equipment, and labor to construct the sidewalk or recreational trail according to the contract documents.

C. Special Compaction of Subgrade for Recreational Trail.

1. Per station (meter).

2. Payment is full compensation for furnishing all material, equipment, and labor to construct the special compaction of subgrade for recreational trail according to the contract documents.

D. Detectable Warnings for Curb Ramps.

1. Per square foot (square meter).

2. Payment is full compensation for furnishing all material, equipment, and labor to construct the detectable warnings for curb ramps according to the contract documents.

Section 2512. Portland Cement Concrete Curb and Gutter

2512.01 DESCRIPTION.

A. Construct PCC curb and gutter, separate from the construction of a pavement according to the contract documents.

B. Produce, transport, and place concrete according to Section 2403 when curb or curb and gutter construction is associated with a bridge structure.

2512.02 MATERIALS.

Meet the requirements of Division 41 for respective materials. Ensure the consistency of the concrete, as measured by the slump test, does not exceed 3 inches (75 mm).

A. Use Class C concrete for curb or curb and gutter not associated with a bridge structure. Place according to Section 2301.

B. Use Class D concrete when curb or curb and gutter construction is associated with a bridge structure.

2512.03 CONSTRUCTION.

Meet the following requirements for PCC curb or curb and gutter construction:

A. Preparation of the Subgrade.

1. Prepare the subgrade upon which concrete curb or curb and gutter is to be placed by excavating or filling with suitable earth to a depth below finished grade line so that, when tamped or rolled until smooth and firm, the subgrade will be uniform and at the desired depth below finished grade line.

2. When curb or curb and gutter is constructed on a filled section, extend the compacted fill a minimum of 1 foot (0.3 m) outside the form line. Ensure it is no lower than the base of the form at the form line. Thoroughly moisten the subgrade or cover it with a layer of plastic film meeting requirements of Section 4107 before placing concrete.

B. Slip Form Equipment.
Slip form equipment may be used.

C. Forms.

1. Unless slip form equipment is permitted, form all straight sections of curb and gutter with steel forms for the full depth of the concrete. Wood forms may be used on curving sections.

2. Place a steel face, rigidly welded or bolted to the main form, on any extensions used to obtain the required depth of form.

3. Ensure the top face of forms does not vary from a true plane by more than 1/8 inch in 10 feet (3 mm in 3 m). Ensure the upstanding face, including any extension, does not vary from a true plane by more than 1/4 inch in 10 feet (6 mm in 3 m). Remove forms that are bent, twisted, warped, broken, or battered from the work. Allow Engineer to inspect and approve repaired forms before using.

4. Use flexible or rigid forms of proper curvature for curves having a radius of 100 feet (30 m) or less.

5. While concrete is being placed and consolidated, form the front face of the curb with fixed or movable forms. If movable slip forms are used, use forms that are least 6 feet (1.8 m) long with a suitable opening for placing and consolidating concrete. Obtain Engineer's approval for slip forms.

6. Set forms with the upper edge to the correct line and grade. Firmly hold forms in place with adequate stakes and bracing.

7. Forms with height greater than the thickness of the concrete may be used, with no additional cost to the Contracting Authority for extra concrete required, if:
   - The upper edge is set accurately to line and grade, and
   - The subgrade is excavated to meet the bottom edge of the form in a slope not steeper than one vertical to four horizontal.

D. Placing Concrete.

Place concrete to construct curb and gutter as an integral unit. Consolidate the concrete during placement with internal vibration operating at a frequency between 3,500 vibrations per minute (vpm) and 8,000 vpm.

E. Finishing.

1. After concrete has been consolidated and face forms have been removed, finish the surface to a uniform texture. Use a suitable edging tool to perform edging along all forms and expansion and contraction joints.

2. Ensure the finished surface conforms to the lines and grades shown in the contract documents. Ensure the gutters drain as indicated in the contract documents, with no depressions that trap water.

F. Protection and Curing.
After finishing, cure and protect the concrete using one of the methods described in Article 2301.03, K.

G. Joints.
Construct joints for PCC curb and gutter according to Section 2301 and the contract documents.

2512.04 METHOD OF MEASUREMENT.
The Engineer will measure the linear feet (the length to the nearest 0.1 m) of Curb or Curb and Gutter along the face of the curb at the gutter line.

2512.05 BASIS OF PAYMENT.

A. Payment for Curb or Curb and Gutter will be the contract unit price per linear foot (meter).

B. Payment is full compensation for:
- Furnishing all materials,
- Preparation of subgrade, and
- Placing, compacting, finishing, and curing the concrete curb or curb and gutter.

Section 2513. Concrete Barrier

2513.01 DESCRIPTION.

A. This section describes the production and construction of concrete barrier, both permanent and temporary, as shown in the contract documents.

B. Used temporary barrier rail furnished and placed as temporary barrier rail shall have been manufactured according to the contract documents after December 20, 1988.

C. Used barrier rail shall be included in installations containing units with similar shape and dimensions with compatible connecting loops.

D. Use F-shape temporary concrete barrier rail on roadways with a posted speed limit greater than 45 mph. Use F-shape temporary barrier rail, Type A, as defined in the Standard Road Plans, in all situations requiring the railing to be in place during the winter work period as defined in Article 1108.02, F.

2513.02 MATERIALS.
Use materials for concrete barrier and temporary concrete barrier rail meeting the requirements of Division 41 for the respective materials, and the following paragraphs. Use only approved supports and bedding grout when placing permanent precast concrete barrier.

A. Cement.
Apply Section 4101. Type I or Type III Portland Cement may be used.

B. Aggregates.
Use Class 2 or better durability coarse aggregate, unless otherwise specified.

C. Admixtures.
Apply Section 4103. Use air entrainment. To improve workability or retard hardening, other approved admixtures may be used with Engineer's approval. Those containing more than 1.0% chlorides will not be allowed.

D. Bolts, Anchors, and Other Metal Fastenings.
Apply Article 2407.02, G.

E. Steel Reinforcing.
Apply Section 2404. Unless otherwise specified, use epoxy coated reinforcement for all reinforcement other than temporary concrete barrier.

F. Guardrail and Barrier Markers.
Use guardrail and barrier markers, if required, that meet the requirements of Article 4186.12.

2513.03 CONSTRUCTION.

Unless otherwise designated, concrete barrier may be cast-in-place, precast in an approved casting yard or plant and hauled to the placing site, or slip formed at the project site. Approved manufacturers of precast barrier are listed in Materials I.M. 571, Appendix A. Use Precast barrier produced in a plant for which the District Materials Engineer has approved equipment, procedures, and quality of concrete. Provide, or have the Fabricator provide, technical personnel who are experienced and skilled in the procedures being used. Have these personnel collaborate fully with the Engineer in all technical aspects of the work.

A. Concrete.

1. Precast.

a. Use concrete specified in Article 2513.03, A, 2, or as approved by the Engineer, and complying with Section 2403. Proportion, mix, place, and cure the concrete in a manner that will produce the minimum compressive strength at the time designated, as specified in Table 2513.03-1:

Table 2513.03-1: Compressive Strength

	Strength Before Moving From Casting Bed (psi (MPa))	Strength At Age 28 Days (psi (MPa))
Precast	1750 (12)	5000 (34.5)

b. Allow concrete to reach strength at age 28 days before storing in multilayers or shipping.

c. Use 7% as a target value for the air content of fresh, unvibrated concrete, with a maximum variation of plus 1.5% or minus 1.0%.

2. **Cast-in-Place and Slip Form.**
   a. For cast-in-place, use Class C concrete complying with Materials I.M. 529. For slip form, use Class BR complying with Materials I.M. 529.
   b. Submit Class BR mix design to the District Materials Engineer for approval at least 7 calendar days prior to placement. Apply Section 2403, except meet the following mix design requirements:
      1. **Cement for Class BR.** Use a minimum cement content of 603 pounds per cubic yard (358 kg/m^3).
      2. **Water.** Do not exceed Table 2513.03-2 for total mixing water and free moisture in the aggregate. Minimum slump is 1/2 inch (12.5 mm).

Table 2513.03-2: Mixing Water and Free Moisture

Class of Concrete	Pounds (kg) of Water Per Pound (kg) of Cementitious Material
BR (Slip Form)	0.450
C (Cast-in-Place)	0.488

      3. **Aggregates for Class BR.** Use a well graded combination of aggregates complying with Materials I.M. 532. Provide a target gradation and apply the limits of Table 2513.03-3. A new target gradation will require the Engineer's approval.

Table 2513.03-3: Gradation Limits

Sieves	Limits
No. 4 (4.75 mm) and larger	± 5%
No. 8 (2.36 mm) to No. 30 (600 µm)	± 4%
No. 50 (300 µm)	± 3%
No. 100 (150 µm)	± 2%
No. 200 (75 µm)	Maximum 1.5% Passing

      4. **Admixtures.** Use air entrainment. Use 7% as a target value for the air content of fresh, unvibrated concrete, with a maximum variation of plus 1.5% or minus 1.0%. To improve workability and aid in air entrainment, water reducing or retarding admixtures may be used according to Article 2513.02, C.

      5. **Fly Ash and GGBFS.** Use the conditions and allowable rates of fly ash and GGBFS substitution in Table 2513.03-4:

Table 2513.03-4: Fly Ash and GGBFS Substitution

Cement Type	Maximum Allowable Substitution[(a)]	Time Period
Type I, II	35% GGBFS 20% Fly Ash	March 16 to October 15
Type IS, IP	20% Fly Ash	March 16 to October 15

Type I, II	20% Fly Ash	October 16 to March 15
Type IS, IP	0%	October 16 to March 15
[(a)] Maximum total mineral admixture substitution is 50%.		

B. Equipment.
Use equipment that meets the requirements of Section 2001 and the following:

1. Forms.
Ensure forms for all concrete barrier are true to dimensions as shown in the contract documents, true to line, mortar tight, and sufficiently rigid to maintain the required shape during placement, vibration, and curing. Ensure inside surfaces are smooth and free of any projections, indentations, or offsets.

2. Bins.
Apply Article 2001.06.

3. Weighing and Proportioning Equipment.
Apply Article 2001.20. A vibrator will not be required on the cement batch hopper.

4. Mixing Equipment.
Apply Article 2001.21. A continuous mixer with volumetric proportioning may be used with the Engineer's approval.

C. Proportioning, Mixing, and Placing Concrete.

1. Apply Article 2407.03, D, except apply the finishing requirements in Article 2403.03, P, 2, b, only to temporary barrier rail.

2. For precast temporary and permanent barrier cast upside down, finish the bottom of the concrete, exposed at the top of the form, as provided in Article 2403.03, P.

D. Curing.

1. Cast-in-Place and Precast.

a. Cure using a method preventing loss of moisture and maintaining an internal concrete temperature of no less than 40°F (4°C) during the curing period. Apply Article 2407.03, D when elevated temperature curing is used.

b. When nonelevated temperature curing is used, keep the concrete barrier damp with wet burlap for a minimum of 12 hours after casting. If forms remain in place during the 12 hours, only the exposed concrete surface will require the wet burlap application. Complete finishing operations after this period in an expedient manner. Once finishing and all necessary repairs have been accomplished, apply clear curing compound to all exposed surfaces as specified.

2. **Slip Form.**
Cure slip formed concrete barrier by application of a clear curing compound. No moist cure period will be required. Apply clear curing compound to the concrete barrier rail within 15 minutes after final finishing, provided that the free water (sheen) has appreciably disappeared from the concrete surface.

3. **Clear Curing Compound.**
   a. Apply a clear curing compound, when specified, to all exposed surfaces. Use a compound that complies with Article 4105.07. Use a fine spray to form a continuous, uniform film on the surface and vertical edges of the pavement slab. Apply clear curing compound as soon as the free water has appreciably disappeared, but no later than 30 minutes after finishing. Use an application rate of no less than 200 square feet per gallon (5 m^2/L). Use a fugitive dye to ensure uniform application and coverage.
   b. Prior to application, thoroughly agitate the curing compound in the supply drum immediately before transfer to the sprayer. After removal of forms following finishing, apply this compound promptly and at the same rate to exposed surfaces. If the coating is damaged within 72 hours after being applied, recoat the affected area without delay. Further sealing is not necessary.

E. Removal of Forms.
For precast and cast-in-place concrete barrier, forms may be removed before the concrete has attained 250 psi (1.7 MPa) in flexure. If form removal interrupts the moist cure process, accomplish form removal without delay and immediately reapply the moist cure process. Ensure form removal does not cause damage to, or deformation of, the barrier.

F. Finish.

1. For permanent precast and cast-in-place concrete barrier, apply Article 2407.03, L, except do not commence the finishing operation until completion of the initial wet cure period.

2. Ensure permanent precast barrier is free from honeycomb or surface defects. When defects develop, evaluate production procedures and make corrections. Patching of such defects is to be very limited.

3. Finish temporary barrier rail according to Article 2403.03, P, 2, b.

4. For slip form concrete barrier, the finish remaining after the steel form passes will not require further surface manipulation. Apply Article 2403.03, P, 2, b. Ensure the finished slip form barrier is free from honeycomb or surface defects. Complete patching operations only as directed by the Engineer and according to Article 2407.03, L.

G. Tolerances.

1. Ensure all newly fabricated units of temporary barrier rail are free from honeycomb, surface spalling, and surface defects. Ensure corner

breaks and bottom spalls after shipping and placement do not exceed 1 square foot (0.1 m^2) of total surface area, which includes the base.

2. Other than honeycomb, shallow voids, not exceeding 3/4 inch (19 mm) diameter, which appear on the formed surface after proper consolidation will not be considered as surface defects. They need not be filled unless they appear in an abnormal concentration.

3. For concrete barrier, apply the tolerances of Table 2513.03-5:

Table 2513.03-5: Tolerances for Concrete Barrier

Item	Precast Fabrication[a] (Permanent or Temporary)	Cast-In-Place or Slip Form Installation
Length	± 3/4 inch (± 19 mm)	
Width	± 1/4 inch (± 6 mm)	[b]
Height	± 1/4 inch (± 6 mm)	[b]
Horizontal Straightness (Sweep)	1/2 inch maximum in 10 feet (12 mm maximum in 3 m)	3/4 inch maximum in 10 feet (19 mm maximum in 3 m)
Top Straightness (Vertical)	1/4 inch maximum in 10 feet (6 mm maximum in 3 m)	3/4 inch maximum in 10 feet (19 mm maximum in 3 m)
Exposed Ends (Deviation from square)	± 1/4 inch (± 6 mm)	

[a] Installation of permanent precast barrier includes shimming and grouting such that adjoining sections match within 1/4 inch (6 mm) on the sides and top, and the finished height is not less than required by the contract documents.

[b] The width and depth are not to be less than required by the contract documents.

4. Ensure each unit of temporary barrier rail does not have spalls, corner breaks, and bottom spalls totaling more than 5 square feet (0.5 m^2) of surface area, including the base.

5. Ensure connecting loops on all barriers are not deformed. Ensure they are true to dimensions.

6. Ensure gaps between units do not exceed the dimensions shown in the contract documents.

H. Handling, Storage, and Hauling New and Used Precast Units.

1. Do not lift or stress precast barrier units in any way before they have developed the strength specified. Support units at designated pickup points. Do not use connecting loops as pickup points.

2. Ensure fabrication, storage, handling and transporting will not result in cracking, twisting, or other damage. Minor chips on edges may be patched with the Engineer's approval. Breakage and chipping may be cause for rejection.

3. Ensure tiedowns are not in direct contact with concrete surfaces, which may cause chipping or breakage
4. Do not subject units to excessive impact.

5. Replace at no additional cost to the Contracting Authority units that, in the Engineer's opinion, are damaged in such a way as to impair their appearance or suitability. Mark new barrier units for the proper identification according to Materials I.M. 571.

6. The Engineer will mark temporary barrier rail units that are rejected with an orange painted "R" approximately 12 inches (300 mm) high and 6 inches (150 mm) wide on both ends to show that piece has been rejected for use as a traffic control device.

2513.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Concrete Barrier: linear feet (meters) shown in the contract documents, based on the contract quantity from end to end of the barrier including end sections.

B. Reinforcement in concrete barrier for bridge structures: as provided in Article 2404.04.

C. Reinforcement in concrete barrier for other than bridge structures will not be measured separately.

2513.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Concrete Barrier, of the type specified: linear feet (meters).

B. Reinforcement in concrete barrier for new bridge structures: as provided in Article 2404.05. The quantities will be included in the quantities for the superstructure or abutments.

C. Reinforcement in retrofit concrete barrier: not paid for separately.

D. Payment as described above is considered full compensation for all work involved.

Section 2514. Curb Removal

2514.01 DESCRIPTION.

A. Remove curb from PCC pavements which are to remain in place. Remove flumes and construct and shape shoulders as specified in the contract documents.

B. The contract documents may also include granular surfacing of shoulders, seeding and fertilizing, and other additional work.

2514.02 MATERIALS.

None.

2514.03 CONSTRUCTION.

A. Removal of Curb.

1. Remove all integral curb using methods which will not damage concrete that is to remain.

2. When the contract documents do not provide for resurfacing, remove the curb using a grinding machine designed for that purpose.

3. Grind the curb flush with the adjacent pavement surface within a tolerance of ± 1/4 inch (5 mm). Grind the surface to project inside the curb the minimum amount necessary to assure complete curb removal, but not more than 2 inches (50 mm). Ensure the resulting surface has a texture satisfactory to the Engineer.

4. When the contract documents provide for resurfacing, remove the curb by grinding or other methods the Engineer approves. Other methods may include chipping or sawing and breaking. Ensure the method chosen provides complete removal of curb that extends above the pavement surface. Ensure it also provides a safe and smooth surface to accommodate traffic.

5. When removal is by sawing and breaking, perform the work as shown in the contract documents and as follows:

a. Make a vertical saw cut along the edge of the curb nearest the centerline of pavement. At the end of the curb section, extend the saw cut to the extreme end of the curb. At this point make a saw cut at right angles and extend to the pavement edge.
b. Where flumes occur in curb sections, extend the saw cut across the throat of the flume.
c. On resurfaced pavement, locate the saw cut 7 1/2 inches (190 mm) from the pavement edge. Cut to a depth of 3 inches (75 mm) below the surface of the resurfacing.
d. Immediately before breaking the curb, clean the sawed groove free of dirt, stones, or any foreign matter to a depth at least 1 inch (25 mm) below the pavement surface.

6. Remove concrete, including resurfacing concrete and concrete across the throats of flumes, to the dimensions shown in the contract documents. Cut off all reinforcement exposed and loosened.

7. When curb is removed by grinding, remove the ground material from the pavement surface. The ground material may be deposited as an edge fillet or spread on the adjacent shoulder surface.
8. Unless provided otherwise, remove broken concrete according to Article 1104.08.

B. Removal of Flumes.
Removal of flumes includes removal of shoulder basins, slope drains, and discharge basins. Place backfill in the area excavated for flume removal. Compact as directed by the Engineer. Remove flume material according to Article 1104.08.

C. Removal of Posts.
Remove posts as directed by the Engineer. Fill holes resulting from post removal. Compact as directed by the Engineer.

D. Shoulders.

1. Construct shoulders as shown in the contract documents, according to Article 2302.03, F.

2. Fill in depressions resulting from removal of flumes, slope drains, and discharge basins. Use excess shoulder material shaped and compacted with a mechanical tamper or by other methods the Engineer approves.

E. Traffic Control.

1. Traffic control complying with Section 2528 will be required for this work. Work areas will be limited to approximately 1/2 mile (0.8 km) in length.

2. Do not allow traffic in a lane while a drop-off exists at the edge of the pavement in that lane. Schedule work so there are no lane closures or drop-offs at the edge of the pavement overnight.

3. Complete shoulder and fillet or granular surfacing edge treatment on the first side of the pavement at a location before commencing curb removal on the second side of the pavement.

2514.04 METHOD OF MEASUREMENT.

Measurement for curb removal work satisfactorily completed will be as follows:

A. Removal of Curb.
According to Article 2213.04, A.

B. Removal of Flumes.
According to Article 2213.04, B.

C. Shoulders.
According to Article 2302.04, D.

D. Removal of Posts.
The number of posts removed, as specified, will be determined by count.

2514.05 BASIS OF PAYMENT.

Payment for the items involved in curb removal, measured as specified above, will be as described below. Payment is full compensation for all labor, equipment, and materials to remove the curb, posts, flumes, and for the construction of shoulders as specified.

A. Removal of Curb.
According to Article 2213.05, A.

B. Removal of Flumes.
According to Article 2213.05, B.

C. Shoulders.
According to Article 2203.05, D.

D. Removal of Posts.
Contract unit price for the number of posts removed as specified.

Section 2515. Removal and Construction of Paved Driveways

2515.01 DESCRIPTION.

Remove paved drives or portions of drives. Construct new PCC driveways according to the contract documents.

2515.02 MATERIALS.

A. When paved driveways are to be constructed in conjunction with a PCC paving project, the class of concrete being used on the project may be used for driveways. If that class of pavement is not chosen for use, or if the contract contains no item for PCC pavement, pavement widening, or base, then use Class C concrete.

B. For the construction of paved driveways, meet the requirements of Division 41 for the respective materials.

2515.03 CONSTRUCTION.

A. Removal of Paved Driveways.

1. Remove paved driveways as shown in the contract documents.

2. When old concrete pavement is to be removed and later abutted at its top surface with new concrete pavement, saw the designated breakout line to full depth before breaking the pavement. Remove to a new line and replace all concrete broken or damaged beyond the breakout line designated by the Engineer at no additional cost to the Contracting Authority.

3. Apply Article 2510.03, A to the removal of driveways.

B. Construction of Paved Driveways.
Unless specified otherwise, construct new paved driveways to the dimensions shown in the contract documents.

1. Preparation of Subgrade.
Prepare the subgrade by excavating or filling with suitable earth to a depth below the finished grade line so that, when tamped or rolled until

smooth, firm, and hard, the subgrade is uniform and at the required depth below the finished grade line.

2. Portland Cement Concrete.

a. Placing.

1) Hand Finish.

a) Use forms complying with Article 2301.03, A, 3, a, 1, c.

b) Ensure the subgrade is thoroughly moistened.

c) Deposit concrete for the full depth of slab in one operation. Consolidate it by tamping or vibration. Screed off the excess concrete flush with the forms. Thoroughly consolidate edges adjacent to all forms, expansion joints, curbs, or fixtures in the surface.

2) Slip Form.

Use self propelled slip form pavers meeting the requirements of Section 2301. For other slip form paving machines, obtain the Engineer's approval. Use machines designed for the specific purpose of placing, consolidating, and finishing concrete driveway slabs without use of fixed side forms.

b. Finishing.

1) After consolidation, finish the concrete surface with a burlap drag.

2) After the surface has been floated, finish the edges of the slabs with a suitable edging tool.

c. Protection and Curing.

After finishing, cure and protect the concrete using one of the methods described in Article 2301.03, K.

d. Joints.

1) Cut through the concrete for no less than 25% of the depth with a pointed trowel or suitable spading tool. Edge the concrete on both sides. In lieu of using a pointed trowel or suitable spading tool, these lines may be cut within 12 hours after placement of concrete with a 1/8 inch (3 mm) blade saw that is approved by the Engineer. Metal dividers will be considered for approval, in lieu of cutting.

2) Construct isolation joints at all points where driveways meet other walks, curbs, or fixtures in the surface. Construct these joints by installing a 1/2 inch (13 mm), full depth strip of approved premolded joint material.

3) Seal contraction joints according to Article 2301.03, P.

e. Time for Opening Pavement for Use.

Open PCC driveways a minimum of 7 calendar days after placement or when flexural strength reaches 400 psi (2.75 MPa) as determined by Materials I.M. 383.

3. Hot Mix Asphalt.

Construct HMA driveways according to Article 2303.03. Apply Class II compaction.

4. Smoothness.

a. Where abutting pavement is to be placed adjacent to the pavement being checked, ensure the surface does not deviate by more than 1/4 inch (6 mm) when checked 1 inch (25 mm) from the edge with a

3 foot (1 m) straightedge used transversely and a 10 foot (3 m) straightedge used longitudinally.

b. Areas may be checked by the Engineer with a surface checker. These are not to exceed 1/4 inch in 10 feet (6 mm in 3 m). For each bump exceeding these requirements, the Contractor will be assessed $50 or the bump corrected as agreed upon by the Engineer and Contractor.

5. Weight Limits.
Limit construction equipment on both PCC and HMA driveways to 5 tons (5 Mg).

2515.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. Removal of Paved Driveway.
Square yards (square meters), to the nearest square foot (0.1 m^2), shown on the contract documents for each paved driveway removed.

B. PC Concrete Driveways.
Square yards (square meters), to the nearest square foot (0.1 m^2), shown on the contract documents for each paved driveway of the thickness specified. This includes areas through sidewalks. No deductions will be made for fixtures having an area of 1 square yard (1 m^2) or less.

2515.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Removal of Paved Driveway.

1. Per square yard (square meter).

2. Payment is full compensation for all equipment, tools, and labor for removal of the driveways as specified in the contract documents.

B. Portland Cement Concrete Driveway.

1. Per square yard (square meter) for the thickness specified.

2. Payment is full compensation for furnishing all material, equipment, tools, and labor to construct the driveway in accordance with the contract documents.

Section 2516. Removal and Construction of Retaining Walls and Steps

2516.01 DESCRIPTION.
Remove retaining walls and steps as designated, and construct new PCC retaining walls and steps according to the contract documents and the following provisions.

2516.02 MATERIALS.

For construction of retaining walls and steps, meet the requirements of Division 41 for the respective materials.

2516.03 CONSTRUCTION.

A. Removal of Retaining Walls and Steps.
When the contract documents indicate that retaining walls and steps are to be removed, break and remove the walls and steps designated by the Engineer according to Article 2510.03, A.

B. Construction of Retaining Walls and Steps.
Construct walls and steps to the dimensions shown in the contract documents and according to Section 2403. Unless designated otherwise, use Class C concrete as specified in Section 2403. Give exposed vertical surfaces a Class 2, strip down surface finish.

2516.04 METHOD OF MEASUREMENT.

Measurement for walls and steps removed and replaced will be as follows:

A. Removal of Retaining Walls and Steps.
Cubic yards (cubic meters) shown in the contract documents, without remeasurement.

B. Construction of Walls and Steps.
Cubic yards (cubic meters) shown in the contract documents. When the quantities of concrete have been modified by direction of the Engineer, the Engineer will compute the cubic yards (cubic meters) of concrete involved in the modification and adjust the quantity accordingly.

2516.05 BASIS OF PAYMENT.

Payment for retaining walls and steps removed and constructed will be the contract unit price as follows:

A. Removal of Retaining Walls and Steps.

1. Per cubic yard (cubic meters).

2. Payment is full compensation for the cost of all labor and equipment necessary to remove and haul the material according to Article 1104.08.

B. Construction of Retaining Walls and Steps.

1. Per cubic yard (cubic meter). Includes modifications ordered by the Engineer.

2. Payment is full compensation for furnishing all materials required, including all steel reinforcement specified, and all equipment and labor necessary to construct the walls and steps as specified.

Section 2517. Railroad Approach Sections

2517.01 DESCRIPTION.

Construct pavement sections at junctures of railroad according to the contract documents.

2517.02 MATERIALS.

For construction of railroad approach sections, meet the requirements of Divisions 23 and 41 for the respective material.

A. PCC Paving Projects.
Use either Class C PCC or the same class PCC as specified for the pavement.

B. HMA Paving Projects.
Use an HMA mixture that is one mix level above the approaching surface course. Use PG 64-22 asphalt binder.

2517.03 CONSTRUCTION.

A. PCC Paving Projects.

1. Form, place, finish, and cure the PCC according to Section 2301.

2. The Engineer may require the railroad approach section to be placed one lane at a time for the convenience of the traveling public. When the header slab is constructed in two sections, construct a centerline joint as shown in the contract documents. When the joint is not provided for, place 1/2 inch (No. 15) tie bars no more than 4 feet (1.2 m) apart and extend them no less than 18 inches (450 mm) into each section.

B. HMA Paving Projects.
Place the HMA according to Article 2303.03, C, 4, with maximum 2 inch (50 mm) lifts. Compact according to Article 2303.03, C, 5, Class II.

2517.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Railroad Approach Section, PCC.
Square yards (square meters) shown in the contract documents.

B. Railroad Approach Section, HMA.
Square yards (square meters) shown in the contract documents.

2517.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Railroad Approach Section, PCC.

1. Per square yard (square meter).

2. Payment is full compensation for:
- Excavation for modified subbase and subdrain,

- Furnishing and installing subdrain,
- Furnishing and installing subdrain outlet,
- Furnishing and placing porous backfill material,
- Furnishing and placing modified subbase backfill material, and
- Furnishing and installing reinforcing steel, tie bars, and dowel assemblies.

B. Railroad Approach Section, HMA.

1. Per square yard (square meter).

2. Payment is full compensation for:
- Asphalt binder and tack coat,
- Excavation, modified subbase, and subdrain,
- Furnishing and installing subdrain,
- Furnishing and installing subdrain outlet,
- Furnishing and placing porous backfill material,
- Furnishing and placing modified subbase backfill material,
- Furnishing and installing fiber board barrier, and
- Furnishing, placing, and compacting HMA.

Section 2518. Safety Closure

2518.01 DESCRIPTION.
This section concerns Safety Closures erected as specified in the contract documents. Two types of safety Closures will be specified: Road Closures and Hazard Closures.

2518.02 MATERIALS.
Use orange mesh safety fence meeting the requirements of Article 4188.03.

2518.03 CONSTRUCTION.

A. Erection.

1. Road Closures.
a. Place a fence meeting the requirements of Article 2518.02 across the roadway from outside edge of shoulder to outside edge of shoulder. Securely support the fence so it is in a vertical position without sagging.
b. Place a Type III barricade, described in Part 6 of the MUTCD, immediately in front of the fence at the approximate roadway centerline. Mount a ROAD CLOSED (RII-2) sign over the top two rails of the Type III barricade.
c. Erect road closures as specified in the contract documents. Erect them on the mainline of the roadway where public traffic is diverted onto an on-site detour and where public traffic is prohibited from entering the work area.

d. Erect road closures beginning with the start of the contract period as specified in the contract documents, or when the work commences.

2. Hazard Closure.

a. Place a fence meeting the requirements of Article 2518.02 across the roadway from outside edge of shoulder to outside edge of shoulder. Securely support the fence so it is in a vertical position without sagging.

b. Place a Type III barricade, described in Part 6 of the MUTCD, immediately in front of the fence at the approximate roadway centerline.

c. Erect hazard closures as specified in the contract documents. Erect them at locations within a work area when construction involves major hazards on existing or relocated roadways. Such hazards may be located at streams, gullies, railroads, bridge approaches, and driveway locations. Through public traffic should not normally encounter a hazard closure.

d. Erect hazard closures beginning with the start of the contract period as specified in the contract documents, or when the work commences.

B. Responsibility.

1. Maintain the location and condition of the safety closures. Any Contractor who temporarily moves the safety closure for equipment or delivery of materials, shall replace it in its original position and is responsible for the restriction of public traffic into the closed area.

2. If a safety closure placed by the Contractor is required for an area after the Engineer's approval of completed work for that specific area, maintenance of that safety closure will become the responsibility of the Contracting Authority. The Engineer will document in writing the transfer of authority.

3. The Engineer will notify the Contractor of the date of removal of safety closures. The safety closure remains the property of the installing Contractor. If the safety closure is not removed by the date specified in the notification, it will become the property of the Contracting Authority and the Contractor will be charged for any removal costs.

2518.04 METHOD OF MEASUREMENT.

The Engineer will count each Safety Closure (either road closure or hazard closure) erected.

2518.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price for each Safety Closure counted.

B. Payment is full compensation for furnishing all material, labor, and equipment necessary to erect, maintain, and remove the Safety Closure, unless indicated otherwise in the contract documents.

Section 2519. Fence Construction

2519.01 DESCRIPTION.

Furnish all material, set posts, and erect the fence according to the contract documents.

2519.02 MATERIALS.

Meet requirements of Section 4154 for the type of fence specified.

2519.03 CONSTRUCTION.

Furnish and erect field fence or chain link fences of the type and dimensions shown in the contract documents and according to the following provisions:

A. Field Fence

1. General.

a. Erect the fence along the right of way line, parallel to and 1 foot (300 mm) inside the right of way line, unless shown otherwise in the contract documents. Unless required otherwise by the contract documents, install the wire on the roadway side of the posts.

b. Prior to placement, provide a smooth ground profile free of all tall grass and debris in the area the fence is to be placed.

c. When rock is encountered, employ the appropriate means of excavation to the bottom of post elevation. Place backfill using suitable material placed and thoroughly compacted by tamping until the post is firmly embedded, plumb, and true to alignment.

2. Brace Post Assembly.

a. Locate brace posts so the horizontal brace will make contact with both posts while posts are in the vertical position. Set all posts as shown in the contract documents.

1) Angle posts will be required where vertical alignment of fence changes 30 degrees or more.

2) Corner posts will be required where horizontal alignment of fence changes by 10 degrees or more.

3) When required in the contract documents, install pull post assemblies at right-of-way breaks of less than 10 degrees, horizontal alignment changes less than 30 degrees, and property corners.

4) An end post assembly will be required where a fence begins or ends.

b. Place and tamp backfill material, consisting of a well graded crushed stone meeting requirements of Section 4120 or a PCC mix approved by the Engineer, around angle, corner, end, gate, and brace posts. Ensure backfill material contains sufficient moisture to be readily and thoroughly compacted by tamping at the time backfill material is placed.

c. Posts may be driven if demonstrated that driving can be done in a manner that will not damage the post. Drive the post plumb and true to alignment. Place backfill material in voids around driven posts that require straightening. Thoroughly compact backfill material by tamping.

d. Install metal braces as shown in the contract documents. Place them so they will not hold water on top of the brace. At installations with two brace wires, maintain tension in both directions.

3. Pull Post Assemblies.

a. Pull post assemblies are required when the distance between pull posts is greater than 960 feet (300 m) in straight lines of fence. Pull post assemblies are for the purpose of tightening fence wire by mechanical means. Use mechanical means to tighten fence fabric from both directions to the middle post. Use a staple to secure each line wire of the fence fabric and barbed wire at pull posts. Drive the staples so they are not parallel with the wood grain and are tight.

b. Set posts to comply with the provisions in Article 2519.03, A, 1, above.

4. Line Posts.

a. In each run of fence between brace posts, set line posts at the interval designated in the contract documents. Use wood posts no smaller than 4 inch (100 mm) top diameter.

b. In runs of fence 1,000 feet (300 m) or less, use steel line posts that are all of the same type. Set steel line posts by driving. Do not damage posts while driving.

c. Set wood line posts in bored holes no smaller than 9 inches (225 mm) in diameter or by driving in a manner which will not damage the post. Thoroughly tamp soil removed from bored holes back into the hole.

d. Set all posts plumb and true to line. Reset all posts that are:

- Out-of-plumb more than 1 inch (25 mm).
- Out-of-line more than 2 inches (50 mm).

e. At each steel post, secure each line wire of the fence fabric and barbed wire to the post by a wire tie or clip. Wrap the clip around the wire on each side of the post, holding the wire tightly to the post to preventing slipping up or down the post.

5. Stretching Fence Fabric.

a. Cut and tie off fabric at all pull posts. Pass each line wire to the pull post. Secure the wire with no less than four wraps tight around itself. Stretch the wire until:

- All slack is taken up,
- All longitudinal wires are taut, and
- Approximately 50% of the factory fabricated fence crimp is removed.

b. Apply tension in the fabric by mechanical means using equipment designed for such use. Hold the fabric until the end of each line wire has been tightened around the pull post and securely wrapped on itself. From the pull post around the angle or corner post to the other pull post, hand tension the fabric at the angle or corner post assembly.

c. For pull post assemblies, extend the fence fabric past the brace post and attach to the pull post. Cut and wrap each line wire of the

fabric around the pull post. Secure line wire by no less than four wraps tight around itself.

6. Stretching Barbed Wire.

a. Secure each strand of barbed wire at pull posts by wrapping around the post with no less than four wraps tight around itself.

b. Apply tension to each individual strand of barbed wire by mechanical means using equipment designed for such use.

c. Hold the wire until the end of each wire has been tightened around the pull post and the end is secured on itself before the tension is released.

7. Splices.

a. Fabricate splices in fence fabric, as detailed in the contract documents by one of the following methods:

- Attaching the fabric to pull posts according to Article 2519.03, A, 3, or by wire splice,
- Approved fence splice,
- Crimp connector, or
- Rod method.

b. Fabricate splices in barbed wire, as detailed in the contract documents, by either:

- Attaching the wire to pull posts according to Article 2519.03, A 6, or
- Approved fence splice or crimped connector recommended for barbed wire which develops a strength of at least 85% of the wire strength.

c. Fabricate splices in brace wire by approved splice or crimped connector recommended for brace wire which develops a strength of at least 85% of the wire strength, as detailed in the contract documents.

8. Gates.

a. Mount gates so that they swing fully and do not sag or drag on the ground. Provide them with a galvanized, welded chain:

- Long enough to completely encircle the post and the end frame of the gate.
- With chain links large enough to use with a padlock.

b. Drive a 4 inch (100 m) diameter wood post in the ground to provide an adequate stop to prevent the gate from opening to a point that would damage the gate.

9. Electrical Grounds.

Field fence will not be required to be grounded except as required in the contract documents.

10. Channel Crossing Fence.

a. Construct channel crossing fence complying with, and at locations indicated in, the contract documents.

b. Channel crossing fence, of the type specified in the contract documents, will be required when:

- A stream or ravine is to be crossed and it is impractical to fit the line fence to the existing ground line, and
- More than two additional barbed wires are required below the normal line fence to adequately close the opening.

c. Set the posts and stretch the barbed wire and secure as specified for field fence.

d. Use barbed wire with a spacing of no more than 6 inches (150 mm).

e. For Type A channel crossing fence, use extra length wood posts and additional field fence materials to close the opening satisfactorily. For Type B channel crossing fence, construct a floodgate as shown in the contract documents, in addition to extra length wood posts and additional field fence materials needed to close the opening satisfactorily.

11. Flood Plain Fence.

Use materials specified for field fence. Use wood line posts only, spaced as shown in the contract documents, and with the fence fabric on the downstream side of the posts. Otherwise, construct flood plain fence to meet requirements for field fence.

B. Chain Link Fence.

1. General.

Unless indicated otherwise in the contract documents, use chain link fence that is a nominal 72 inches (1.8 m) in height with steel posts connected with pipe rails at the top and tensioned stretcher wire at the bottom.

2. Posts.

a. The Engineer will designate the location of each end, angle, corner, and gate post.

b. Set posts with the required brace post assembly at each end, angle, corner, and gate. Set all posts vertically as shown in the contract documents.

c. Fill the hole around each post with PCC meeting the requirements of Section 2403.

d. Ensure dirt or other foreign material is not mixed with concrete as it is placed. Forms will not be required if, in the opinion of the Engineer, the earth around the hole is dry and firm enough to permit satisfactory placement. Fill the hole around the post completely with concrete. Neatly finish the concrete to slope up to the post approximately 1 1/2 inches (38 mm) above the ground surface. Protect the concrete from drying by covering with soil or burlap kept wet for 24 hours or by applying white curing compound.

e. Set posts a minimum of 24 hours before fence is stretched.

f. Instead of drilling holes for posts and filling with concrete, other equivalent means of securely anchoring the posts into the ground may be used if the Engineer approves.

g. So that no section of fence longer than 500 feet (150 m) is constructed with line posts only, place pull posts, constructed

according to the contract documents, between end, angle, corner, and gate posts, as necessary.

h. Install the top rail according to the contract documents.

3. Chain Link Fabric.

a. Unless required otherwise, place the fabric on the side of the posts closest to the roadway to be protected. For non-roadway installations, attach the fabric on the side designated in the contract documents.

b. Construct as follows:

1) Secure each end of each run of chain link fabric by a stretcher bar inserted in the final link of the fabric. Use a stretcher bar that is as long as the fabric is wide.

2) Secure this bar and the tight fabric to the end post by tension bands equally spaced no more than 15 inches (380 mm) apart.

3) Place a tension wire tightened by mechanical means approximately 4 inches (100 mm) from the lower edge of the fence.

4) Securely attach the chain link fabric to the braces, top rail, tension wire, and all intermediate posts at intervals of no more than 1 foot (300 mm) by wire ties or clips.

5) Uniformly smooth the ground surface along the line of the fence for a width of 2 feet (600 mm) so that the fabric will conform to the ground surface.

4. Gates.

Erect gates as shown in the contract documents.

5. Electrical Grounds.

a. Properly ground chain link fence that crosses beneath any primary electrical power transmission line, other than a secondary feeder line for individual customer service. Ground the fence at the point of transmission line crossing and at a distance of 25 to 50 feet (7.5 m to 15 m) in each direction from the crossing. Construct the grounding installation as detailed in the contract documents.

b. Ground chain link fence erected adjacent to and within 50 feet (15 m) of a primary power line by placing ground rods at no more than 500 foot (150 m) intervals.

c. Include at least one ground in each applicable straight section of fence. The Engineer may require the installation of an additional ground at the terminus of a section of fence or at other locations near areas of pedestrian traffic. Connect the ground rod to the fence as shown in the contract documents.

2519.04 METHOD OF MEASUREMENT.

Measurement for the items associated with fence construction will be measured as follows:

A. Field Fence or Chain Link Fence: linear feet (meters) constructed, of the height and type specified, measured along the fence at the bottom of the fabric, excluding the length of gates or fence otherwise measured for payment.

B. Field Fence Brace Panels: by count of the metal braces properly installed for the various units.

C. Channel Crossing Fence: linear feet (meters) of the type specified and constructed according to the contract documents, measured along the fence at the bottom of the fabric between end posts for the channel crossing fence.

D. Flood Plain Fence: linear feet (meters) constructed, measured along the fence at the bottom of the fabric between end posts for the flood plain fence.

E. Gates: by count of each type and size installed.

2519.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price as follows:

1. For the various types of fence: Per linear foot (meter).

2. Field Fence Brace Panels: each. Payment is compensation for brace wires and metal braces.

3. Gates: each.

B. Payment is full compensation for furnishing all material and for construction of fence as provided herein, including clean up after the work is complete. Excavation will not be paid for separately, but excavation in unexpected rock will be paid for as extra work. Unexpected rock will be considered as rock encountered during post installation, but not visible from the roadway nor indicated in the contract documents.

C. Electrical grounds required in the contract documents will not be paid for separately. Payment for additional electrical grounds required by the Engineer will be according to Article 1109.03, B.

Section 2520. Field Laboratory and Field Office

2520.01 DESCRIPTION.
Furnish and maintain field office space or laboratory space, or both, to be used for project testing of:

- Earthwork where moisture control or moisture density control is required,
- Subbase, base, and pavement, and
- Any other designated use.

2520.02 MATERIALS.
None.

2520.03 FIELD LABORATORY AND FIELD OFFICE.

A. Field Laboratory.

1. General.

Meet the following requirements. Items a through h are meant as a guide rather than minimum requirements. The Engineer may approve suitable alternative facilities.

a. Weather tight field laboratory space with minimum inside dimensions of 7 feet by 18 feet (2 m by 5.5 m) with 7 feet (2.1 m) of head room.

b. Two doors: one at least 32 inches (800 mm) wide with screens, and one for emergency.

c. Outside walls with screened windows which can be used for ventilation.

d. Desk with drawers, three chairs, a closet, and a suitable work table space.

e. Splinter free and solid floor.

f. A floor broom and fire extinguisher.

g. Anchor bolts firmly attached to accommodate a mechanical sieve shaker (template furnished upon request).

h. Lockable laboratory space (with appropriate number of keys) that is set level and stable for minimum vibration. The laboratory space may be independent or dependent on other space, but is for the exclusive use of the Contracting Authority.

i. Adequate lights and heavy duty, 110 volt electrical outlets, suitably placed.

j. An exhaust fan or fans.

k. A laboratory stove or stoves with hoods vented to an exhaust fan

l. A sink with potable water supply to sink faucet.

m. Air conditioning and heat to maintain a temperature approximately between 70°F (20°C) and 80°F (27°C).

n. A touch tone telephone in the field laboratory. It may be an extension of a telephone located elsewhere at the plant site. The Contractor is responsible for paying all installation charges for the telephone. The Contracting Authority will pay for all long distance call charges made by its employees, according to Article 1109.03.

o. Suitable sanitary facilities located within 75 feet (25 m) of the laboratory for use by the inspection forces.

2. Furnishing Field Laboratory.

A field laboratory will be required as follows:

a. Field Laboratories.

1) Field laboratories will be required for acceptance testing when specified on the proposal. The items for which the field laboratory is intended will be designated. If base and pavement are of similar types which require similar plant and testing facilities, only one field laboratory will be shown on the proposal for both items.

2) Furnish the field laboratory before all work is started. Keep the field laboratory on the project at all times regardless of work being performed or testing required. Duplicate field laboratories may be required when the plant facilities are duplicated or dispersed so that plant operation of base or pavement work cannot be monitored from one field laboratory.

3) Relocate laboratories used to control asphalt binder or Portland cement proportioning as the plant facilities are relocated. Field laboratories used primarily to test densities of base, subbase, or earthwork may be required to be relocated once for each 4 miles (6.5 km) or fraction thereof in the length of the project.

b. Field Laboratories for Materials Inspection.

1) Materials will be inspected at the project site if prior inspection has not been made, and a materials laboratory may be required for this purpose. If inspection prior to shipment to the project site is necessary, in the opinion of the Engineer, or agreeable to the Engineer and Contractor, furnish inspection facilities near the location for inspection.

2) Inspection facilities will be necessary at the site of production or warehousing of:

- Pipe,
- Cement,
- Asphalt,
- Structural steel and other metal items,
- Precast concrete,
- Aggregates,
- Other materials requiring or utilizing approved warehousing, and
- Proportioning and mixing plants for concrete and bituminous mixtures at permanent facilities.

3) Ensure inspection facilities are suitable for the use intended, including testing space or office space for record keeping, or both. Facilities may vary from designated or separate space in a shared building for occasional inspection, to a materials laboratory (defined below) for continuous and full time use.

4) Material laboratories will be required for any inspection for individual or combinations of projects involving more than:

- 5,000 tons (5000 Mg) of aggregate from an individual source for use in pavement, base, or subbase, or
- 10,000 tons (10,000 Mg) of aggregate for other purposes.

5) Ensure laboratories are located close to production operations. For facilities furnished jointly, ensure the laboratory is within a driving distance of 5 miles (8 km) from each source.

6) For the materials laboratory, furnish facilities similar to those specified in Article 2520.03, A, 2, a. Equip the laboratory for testing the type of material to be produced according to an equipment listing available upon request. The Engineer may modify parts of this specification to allow for:

- Facilities furnished prior to first use of this specification,
- Small amounts of material to be furnished from widely separated sources, or
- Unusual testing procedures.

B. Field Office.

1. General.

Meet the following requirements. Items a through i are meant as a guide rather than minimum requirements. The Engineer may approve suitable alternative facilities.

- **a.** Office space separate and apart from any building occupied by the Contractor and for the exclusive use by the Contracting Authority.
- **b.** Conveniently located near the work, as may be directed by the Engineer.
- **c.** Weather tight, insulated, and painted, and of a size as to enclose a nominal area of 192 square feet (18 m^2) of floor space.
- **d.** At least five windows having a total sash area no less than 30 square feet (3 m^2).
- **e.** Windows fitted with locking devices and hung to open and close.
- **f.** Outside door fitted with a cylinder lock, and all keys turned over to the Engineer.
- **g.** Fit the windows and door with screens.
- **h.** A plan table, a plan storage rack, a desk, three straight chairs, a drafting stool, a water cooler dispenser, a floor broom, and a 10 pound (4.5 kg) rated capacity carbon dioxide fire extinguisher.
- **i.** Non-furnished area partitioned from the larger area for use as storage.
- **j.** Heating and air conditioning to maintain an approximate temperature between 70°F (20°C) to 80°F (27°C).
- **k.** No less than two wall power outlets and sufficient ceiling lighting fixtures in the office to provide a minimum of 70 foot-candles (750 luxes) of light on all working surfaces.
- **l.** A single trunk telephone in the office.
- **m.** Suitable sanitary facilities within 75 feet (25 m) of the office for the use of the inspection forces.
- **n.** An all weather access road and parking area (both maintained) for not less than five vehicles at the field office for the use of the inspection forces.

2. Furnishing Field Office.

- **a.** Furnish the field office before all work is started. For the duration of this contract, maintain the building in a satisfactory state of repair and supply all heating fuel, electricity, and drinking water. The Contractor is responsible for paying all installation charges. The Contracting Authority will pay for monthly telephone charges.
- **b.** Notify the Engineer 3 calendar days before removing a field office.

C. Limitations.

Contractor's maintenance of these facilities does not include normal housekeeping.

2520.04 METHOD OF MEASUREMENT.

The Engineer will count the Field Laboratories or Field Offices, or both, furnished according to this specification, as required by the contract documents. Field laboratories furnished for materials inspection will not be counted for payment.

2520.05 BASIS OF PAYMENT.

A. Payment for each Field Laboratory or Field Office, or both, will be the contract unit price.

B. Payment is full compensation for furnishing, moving, and maintaining the field laboratory or field office, or both, and for furnishing the utilities and sanitary facilities.

Section 2521. Certified Plant Inspection

2521.01 DESCRIPTION.

Certified plant inspection will be required for Interstate, Primary, state park, and institutional projects. It will apply to other projects only when designated. When this specification applies, furnish or oversee certified plant inspection for the work, as specified herein.

2521.02 REQUIREMENTS.

A. For certified plant inspection, comply with Materials I.M. 213, using personnel certified for the type of inspection to be accomplished and using prescribed test equipment the Contractor furnishes. Ensure the equipment is also available for use by the Engineer for monitoring purposes.

B. When a field laboratory or office is furnished, as provided in Section 2520, exclusive use by the Engineer for inspection purposes is intended. Additional field laboratory space and equipment and/or office space for use by the Contractor to fulfill the requirements of Certified Plant Inspection are incidental to the contract unit price for the item for which this inspection is required.

C. Delivery of samples to the District Materials Laboratory may also be required. Comply with the provisions in Section 2534.

2521.03 APPLICATION.

A. This specification applies to all HMA, HMA patching material, PCC, structural concrete, and flowable mortar, except where excluded by a note in the contract documents.

B. The Engineer may waive aggregate gradations, moisture, and specific gravity tests based on previous satisfactory experience with the plant for PCC which is furnished at a maximum rate of 25 cubic yards (25 m^2) per day, whether from one or more sources. This may be based on quantities planned by the Contractor several days ahead of placement.

2521.04 METHOD OF MEASUREMENT.

Certified plant inspection will not be measured.

2521.05 BASIS OF PAYMENT.
Certified plant inspection will not be paid for separately and is to be included in the contract unit price for the item for which this inspection is required.

Section 2522. Tower Lighting

2522.01 DESCRIPTION.

A. This specification is for fabrication and construction of tower lighting systems, consisting of footings, towers, luminaires, and associated appurtenant items required by the contract documents. Apply Section 2523 to other components of this system.

B. Each individual installation consists of:
- A reinforced concrete footing,
- A tubular steel tower of circular or other approved cross-section of the length indicated in the contract documents,
- Approved luminaires of the proper number,
- An approved lowering device, and
- The electrical system described in the contract documents.

2522.02 MATERIALS.

A. Submit copies of the following to the Office of Materials for review for compliance before these materials are shipped to the project:
- A certified mill analysis for each heat of steel used in the pole and pole assembly, and
- Certified test results for support cables.

B. Refer to Article 2522.03, D for welding requirements.

C. Notify the Office of Materials of the shop fabrication schedule.

D. Verify one copy of a mill certification accompanies each shipment to the project and two copies are sent to the Office of Materials to:
- Identify materials included in each shipment, and
- Ensure that materials and fabricated materials may be used in the work promptly after delivery.

E. Final approval of all materials and fabricated materials will be based on:
- A certification that methods and materials used in fabrication comply with the contract documents,
- Satisfactory reports from random monitoring inspections performed during fabrication, and
- Verification of satisfactory compliance at the time of final inspection of the construction site.

2522.03 CONSTRUCTION.

A. Shop Drawings.

1. Submit drawings according to Article 1105.03.

a. Tower lighting equipment (if applicable):

1) Tower design data.

2) Lowering device, showing wiring diagram and materials.

3) Luminaires, including photometric data.

b. Additional drawings may be required on a project specific basis according to the contract documents.

2. Along with the shop drawings, include a statement that methods and materials to be used in fabrication comply with the contract documents. Note and identify all materials or methods for which specific requirements have not been previously stipulated.

3. Provide the Engineer with an appropriate certification of compliance with all design requirements. Along with the certification, include copies of all calculations necessary for proper design of the tower shaft and component features of the tower assembly.

4. Have a Professional Engineer licensed in the State of Iowa perform the structural design. The Contractor's certification is to appear on the drawings. Provide the Engineer with the base shear, base moments, and vertical loads on the bottom of the base plate.

5. Obtain the Engineer’s written concurrence for the various items involved prior to fabricating or assembling parts.

B. Footings.

1. Construct footings as required in the contract documents at the specified locations. Unless specifically stated otherwise, construct footings using methods and materials complying with current specifications.

2. Place anchor bolts according to Article 2405.03, H, 3. Place conduit and all other appurtenant or optional features of the footing as shown in the contract documents.

C. Transporting Towers.

1. When transporting towers over the highways of the State of Iowa, comply with all applicable laws, rules, and regulations governing such movements. Obtain all required permits for such movements.

2. Limit the overall length of the hauling unit and tower to 120 feet (35 m) or less.

D. Welding.

1. Weld and fabricate steel structures according to Article 2408.03, B except that gas, metal arc, and flux cored arc welding processes will be permitted.

2. A list of approved brands of electrodes may be obtained from the Office of Materials.

3. Examine all fillet welds accessible for inspection using magnetic particle inspection according to ASTM E 709 (at no additional cost to the Contracting Authority).

4. Use ultrasonic inspection, according to the requirements of Article 2408.03, B, to perform a 100% examination of all transverse butt welds and all specified 100% penetration longitudinal butt welds on the pole. Perform a 100% visual inspection of all longitudinal butt welds. Supplement the visual inspection with magnetic particle inspection on all areas of questionable visual results. If defects are found in the area tested, perform additional inspection for a minimum of 5 feet (1.5 m) on each side of the defect (at no additional cost to the Contracting Authority). The cost of these inspections is incidental to other items in the contract.

E. Lighting Tower.
Ensure the structural design of the tower and its appurtenances meet the requirements of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," with the following clarifications:

1. **Wind Velocity.**
   Use a design wind velocity (V) of 90 mph (145 km/h).

2. **Total Wind Force.**
   Calculate the total wind force on luminaires on the basis of the sum of projected areas for each individual luminaire. Base the projected area of individual luminaires on manufacturer's recommendations.

3. **Steel Tubular Shape.**
   Use a compact section.

4. **Anchor Bolts, Washers, and Nuts.**
   Ensure galvanizing for anchor bolts, washers, and nuts meets the requirements of ASTM A 153, Class C; or ASTM B 695, Class 50.
   a. Furnish each anchor bolt with one leveling nut and two anchoring nuts. Use anchor bolts that:
   - Meet the requirements of ASTM F 1554, Grade 105 (724 MPa),
   - Are full-length galvanized,
   - Are high-strength low alloy steel, and

- Unless specified otherwise, are Unified Coarse Thread Series with Class 2A tolerance.

b. Color code, in red, the end of each anchor bolt intended to project from the concrete to identify the grade.

c. Use galvanized washers that meet the requirements of ASTM F 436.

d. Use heavy hex, galvanized nuts that meet the requirements of ASTM A 563, DH. Nuts may be over-tapped according to the allowance requirements of ASTM A 563.

5. Pole Base.

a. Use a solid plate. Keep the holes cut out in the base plate for utility lines to a minimum, subject to the Engineer's approval.

b. Design the pole base and anchor bolt system to resist both tension and compression resulting from bending moments and direct loads.

6. Poles.

The poles may be furnished in single welded units or in telescoping sections.

a. Single Welded Units.

1) Fabricating the tower by welding two or more shaft sections together is permitted. If the pole sections are welded together, butt weld all transverse pole splices with full penetration welds.

2) Use a method for connecting the sections that results in a smooth joint with no projections on the exterior of the shaft.

3) Unless specifically authorized otherwise, all welded connections of shaft sections are to be made in the fabricator's shop.

4) If hauling length restrictions do not allow the tower shaft to be shop fabricated in one piece, furnish a telescoped pole.

b. Telescoping Sections.

1) If the pole sections are telescoped together, ensure the overlapped splices:

- Are equal in strength and rigidity to that of welded splices, and
- Do not exceed four sections for poles up to and including 120 feet (35 m) in length and do not exceed five sections for poles between 120 feet (35 m) and 160 feet (50 m) in length.

2) Ensure the telescoping sections overlap a length which is the larger of the following, and the overlap has full contact between faying surfaces:

- 2 feet (0.6 m), or
- 1.5 times the nominal diameter of the shaft at the splice level.

3) Ensure pole sections to be telescoped together are factory test fit to verify straightness of the pole and accuracy of the mating surfaces. Ensure the sections are match marked for accurate field assembly. In the field, mechanically fit the telescoping sections using factory supplied equipment. Submit field

assembly procedures for the Engineer's review and concurrence.

7. **Longitudinal Seam Welds.**
   a. Minimum 60% penetration, except for the following areas where complete penetration welds are required:
      1) Within 6 inches (150 mm) of circumferential welds which are complete penetration butt welds.
      2) For a distance of the nominal splice length plus 6 inches (150 mm) on both sections of telescopic (slip type) field splices of high level lighting (pole type) supports.
   b. When designated in the contract documents:
      - Radiographically inspect 100% of the full penetration sections of longitudinal seam weld, and
      - Use the magnetic particle method to inspect a random 10% of the partial penetration section of the longitudinal seam welds.

8. **Poles with Welded Transverse Splices.**
   Bevel all backing plates for transverse welds.

9. **Poles with Telescoped Lab Joints.**
   Bevel the lower section of the joint. The beveling is required to prevent possible interference with the operation of the lowering device.

10. **Hand Hole.**
    a. Ensure the pole provides an opening for a minimum 10 inch by 30 inch (250 mm by 750 mm) handhole to allow for servicing and maintenance of the lowering devices. Ensure the handhole is reinforced to maintain the design strength of the pole.
    b. Install a neoprene or rubber gasket to make the handhole weatherproof. Obtain the Engineer’s acceptance for the gasket prior to installation. Foam adhesive-back rubber gaskets are unacceptable.
    c. Ensure the door is hinged and is fabricated from the same type of steel as the poles. Ensure the securing hardware is stainless steel and provisions have been made to allow for the door to be bolted securely shut.

11. **Pole Base Plate.**
    a. Prior to welding, ultrasonically test the pole base plate using a Straight Beam Search Unit, meeting requirements of the current AWS D1.1, Structural Welding Code, to determine the extent of laminar type discontinuities in the plate.
    b. After welding the pole to the base plate, use the same ultrasonic testing described above to ensure there are no laminar tears in the base plate.

12. **Shaft, Base Plate, and Integral Shaft.**
    a. Ensure the shaft, base plate, and integral shaft components are fabricated with steel meeting the requirements of ASTM A 709 Grade 50 (345 MPa), with a minimum yield strength of 50,000 psi (345 MPa). All steel required to be ASTM A 709 Grade 50 (345

MPa) shall meet impact requirements specified for main members in Article 4152.02. If the Engineer approves, certain components of the tower assembly may be fabricated from steel meeting requirements of ASTM A 709 Grade 36 (250 MPa).

b. Ensure that after fabrication pole shafts, anchor bolts, base plate, washers, nuts, and all steel items are:

- Fully galvanized inside and outside according to ASTM A 123 or ASTM A 153 as appropriate, and
- Are of uniform color and appearance.

F. Tower Lighting Luminaire.
Meet the following provisions:

1. Luminaire Assembly.
Rain tight aluminum housing and slipfitter with an internally mounted ballast designed for operation with the specified lamp.

2. Optical System (when required).
Specular aluminum or prismatic glass reflector and a prismatic glass refractor or a clear lens.

3. Luminaires with open bottom optical systems.
Prismatic glass reflectors and refractors.

4. Luminaires with horizontal burning lamps
Totally enclosed optical systems with prismatic glass refractors.

5. Specular aluminum reflectors.
Protective coating of oxide applied by the anodic oxidation process. The manufacturer's certification that the coating is not less than 6 milligrams per square inch (0.01 mg/mm^2) and that the reflectivity of the specular surface is not less than 82% is required.

6. The lamp socket.
Mogul multiple and porcelain enclosed. Lamp gripping device for vertical burning lamp sockets.

7. Glassware.
Annealed, thermal-shock-resisting, borosilicate glass.

8. Slipfitter.
Accommodate a standard two-inch (50 mm) pipe bracket and provide for leveling of the luminaire.

9. Light source.
High pressure sodium lamp of the size shown in the contract documents.

10. Ballast.
Regulated high-power-factor type with starting current lower than operating current. Maintains lamp wattage within ± 10% with a line voltage regulation of ± 10%, with no less than 90% power factor.

G. Luminaire Lowering Device.

Consists of a luminaire frame and head frame, support cables, winch, and electrical cable, along with associated appurtenant devices. Ensure the lowering device properly lowers the luminaires to a position within 5 feet (1.5 m) of the ground for maintenance, and maintains their alignment when raised to the operational position.

1. Luminaire Frame and Head Frame.

a. Ensure the luminaire frame and head frame assembly meet the requirements of ASTM A 709 Grade 50 (345 MPa). For the purpose of Charpy V-notch toughness requirements, all steel required to be ASTM A 709 Grade 50 (345 MPa) will be considered main members. Miscellaneous appurtenant steel components may be constructed using ASTM A 709 Grade 36 (250 MPa) steel. Ensure all steel and the head frame dome are galvanized.

b. Attach the luminaire frame to two or three lift cables. Attach a multiple conductor electrical cable to the luminaire frame with a double weave, stainless steel, grip type, strain relief connection. Pass all cables through a head frame assembly mounted at the top of the tower shaft, as shown in the contract documents. Ensure they pass freely through the shaft during raising and lowering operations.

c. Ensure the luminaire frame is designed to accommodate the specified number of luminaires on mounts consisting of 2 inch (50 mm) slipfitters.

d. Ensure the head frame assembly is enclosed and shielded from the elements by means the Engineer approves.

e. Install three or more spring loaded centering arms with rubber or nylon rollers (or other approved means) to control lateral movement of the luminaire frame during raising or lowering operations. Ensure the centering arms interlock with each other so the tower is centered within the luminaire frame.

2. Support Cables.

a. Install support cables of anti-rotational aircraft type stainless steel with a minimum diameter of 3/16 inch (4.8 mm) and having a safety factor of 5. Space them 120 degrees apart where attached to the luminaire frame. Attach them to a terminating device which is located within the tower shaft and provides a means of equalizing tension of the lift cables.

b. Ensure the terminator and attached components are shaped to prevent interference to the raising or lowering operation caused by irregularities on the interior surface of the tower shaft.

3. Winch.

a. Install and securely anchor a winch assembly that:

- Consists of a worm gear speed reducer with either one or two output shafts with cable drum attached.
- Is capable of supporting five times the maximum lifted load.
- Includes an integral drag brake to prevent unwinding, slipping, or free spooling of the winch cable.

- Includes a drum provided with keepers to ensure that the cable will properly wrap onto the drum.
- When powered by the internal power unit, raises the luminaire ring at a minimum rate of 12 feet (4 m) per minute.

b. Install a stainless steel, anti-rotational aircraft type winch cable with 1/4 inch (6.4 mm) minimum diameter and a safety factor of 3 to be used to raise and lower the luminaire frame. Attach the cable to the terminator. Include a safety device that is capable of stopping upward motion of the terminator at any time, in case of winch cable failure. Include a torque limiting device with the winch or power unit.

c. Install a top-latching system. Do not install non-latching systems. Ensure the following:

- Latch barrels are cast, high strength, copper-free aluminum or cast stainless steel.
- Latching is accomplished by the alternate raising and lowering of the luminaire ring assembly using the winch and hoisting assembly.
- There are no moving latch parts or springs attached to the head frame assembly.
- The latch mechanism is not impaired by the formation of ice and does not require adjustment after the original installation.
- Indicator flags are used to show when the luminaire supporting ring is in the latched or unlatched position.

d. Install pulleys that are:

- Stainless steel type designed for the respective types and sizes of cables used, and
- Equipped with permanently lubricated, sealed bearings or oil impregnated bronze bushings mounted on stainless steel shafts.

4. Electrical Cable.

a. Install a multiple conductor cable complying with the requirements for flexible cord. Ensure it is designed to meet all physical requirements for satisfactory operation of the lowering device. Ensure all provisions for electrical disconnects are accessible from ground level.

b. Attach the electrical cable to the terminator with a strain relief device as used at the luminaire frame. Ensure electrical connectors for the power and control circuits are rigidly attached to the terminator.

c. Ensure conductors for connections from the power cable to the luminaires are protected by suitable raceways or are made with weatherproof cables securely anchored to the luminaire frame. A luminaire frame of hollow cross section may be used as a raceway. Ensure all connections are made in weather tight boxes or within the luminaire housings.

H. Erection.

1. After testing has been accomplished to the satisfaction of the Engineer, the tower may be erected on the foundation.

2. Precise aligning and erecting of all components of the tower lighting system is essential. Plumb towers during full cloud cover, prior to sunrise or after sunset, as approved by the Engineer, to prevent thermal expansion effects on the steel tower due to heat from sunshine. Verify in at least two directions, 90 degrees apart, with a transit. Plumb all towers within a tolerance of 50% of the pole top diameter. Tighten anchor bolt nuts, after the tower has been plumbed, using the following procedure:

a. Perform this work only on days with winds less than 15 mph (25 km/h). Tighten all of the nuts in the presence of the inspector. Once the tightening procedure is started, it shall be completed on all of the base plate nuts without pause or delay.

b. Use properly sized wrenches or sockets, or both, designed for tightening nuts or bolts, or both, to avoid rounding or other damage to the nuts. Do not use adjustable end or pipe wrenches.

c. Ensure base plates, anchor rods, and nuts are free of all dirt or debris.

d. Apply stick wax or bees wax to the threads and bearing surfaces of the anchor bolt, nuts, and washers.

e. Tighten top nuts so they fully contact the base plate. Tighten leveling nuts to snug tight condition. Snug tight is defined as the full effort of one person on a wrench with a length equal to 14 times the bolt diameter but not less than 18 inches (460 mm). Apply full effort as close to the end of the wrench as possible. Perform tightening by leaning back and using entire body weight to pull firmly on the end of the wrench until the nut stops rotating. Perform a minimum of two separate passes of tightening. Sequence tightening in each pass so that the nut on the opposite side, to the extent possible, is subsequently tightened until all of the nuts in that pass have been tightened.

f. Tighten top nuts to snug tight as described for the leveling nuts.

g. Match-mark the top nuts and base plate using paint, crayon, or other approved means to provide a reference for determining the relative rotation of the nut and base plate during tightening. Further tighten the top nuts tightened in two passes, as listed in the Table 2522.03-1, using a striking or hydraulic wrench. Follow a sequence of tightening in each pass so that the nut on the opposite side, to the extent possible, is subsequently tightened until all nuts in that pass have been turned. Do not allow the leveling nut to rotate during the top nut tightening.

Table 2522.03-1: Bolt Tightening

Anchor Bolt Size	First Pass	Second Pass	Total Rotation
Less than or equal to 1 1/2 inch (38 mm) diameter	1/6 turn	1/6 turn	1/3 turn
Greater than 1 1/2 inch (38 mm) diameter	1/12 turn	1/12 turn	1/6 turn

h. Lubricate the jam nuts, place, and tighten to snug tight.

3. Cover the void between the base plate and top of the foundation as shown in the contract documents.

4. Construct and test all other components of this system according to Section 2523.

I. Miscellaneous.

1. Have a manufacturer's service engineer present, on site, to advise during the installation of at least one complete lowering system. Duties of the manufacturer's service engineer include directing all adjustments to the lowering system to insure positive latching and unlatching (a minimum of three complete raising and lowering cycles) and other necessary work.

2. Provide three complete raising and lowering operations for the other towers, providing the same adjustment and commissioning as demonstrated by the manufacturer's service engineer on the first tower.

2522.04 METHOD OF MEASUREMENT.

Measurement for the various items of work involved in tower lighting, satisfactorily completed, will be as follows:

A. Towers.
By count for the various lengths specified in the contract documents.

B. Luminaires.
By count.

C. Footings.
As outlined in the following sections:

Piling	Section 2501
Structural Concrete	Section 2403
Reinforcement	Section 2404
Excavation	Section 2402

2522.05 BASIS OF PAYMENT.

A. Payment for the various items of work involved in tower lighting will be the contract unit price as follows:

1. **Towers.**
Each for the various specified lengths.

2. **Luminaires.**
Each.

3. **Footings.**
As outlined in the following sections:

Piling	Section 2501

Structural Concrete	Section 2403
Reinforcement	Section 2404
Excavation	Section 2402

B. Payment for towers is full compensation for furnishing all materials, equipment, tools, and labor for construction of the towers complete, including an approved lowering device, and related equipment, anchor bolt assembly, and responsibility during the testing period.

C. Payment for other components of the tower lighting system will be as provided in Article 2523.05.

Section 2523. Highway Lighting

2523.01 DESCRIPTION.

Furnish all work, apparatus, and materials to construct, install, and place in operation, to the Engineer's satisfaction, a complete highway lighting system as shown in the contract documents.

2523.02 MATERIALS.

A. Install lighting materials that meet the requirements of Division 41.

B. Use cast-in-place concrete that meets the requirements of Section 2403.

2523.03 CONSTRUCTION.

A. General.

1. Furnish and install all components of the lighting system not furnished by the utility company serving the installation, including all incidental items appurtenant to the operation of the system.

2. Ensure all apparatus, materials, and work comply with the contract documents and with standards, practices, and codes of the electrical industry. Particular attention is directed to the following:
- NEC, latest edition, including amendments.
- IEEE Standards and Practices.
- ANSI Standards and Practices.
- NEMA Standards.
- UL Standards.

3. Ensure the completed lighting installation complies with all local and special laws, codes, or ordinances of all Federal, State, and municipal authorities with due jurisdiction.

4. The Contracting Authority will be responsible for the cost of electric power used during installation and testing of lighting equipment and prior to final acceptance of the work. Do not put the installation into use prior to final acceptance without the Engineer’s approval.

B. Shop Drawings.

1. Before any items are ordered or installation is started, the following list of shop drawings shall be submitted for approval according to Article 1105.03:

a. Required Shop Drawings:

1) Lighting poles and mastarms.
2) Transformer bases.
3) Slip bases.
4) Roadway luminaires with lamps.
5) Iowa DOT Standard Road Plan RM-41, Underdeck Lighting (High Pressure Sodium Luminaire).
6) Control cabinet components.
a) Enclosure.
b) Door latch mechanism.
c) Contactor.
d) Circuit breaker (main).
e) Circuit breaker (branch).
f) Photoelectric control.
g) Test switch(es).
h) Breather drain.
i) Wiring diagram, showing wire type and size
j) Component placement drawing.
k) Control fuse holder.
l) Surge suppressor.
7) Iowa DOT Standard Road Plan RM-40, Cable Splices and Connectors.
8) Insulated wire and cable.
9) Additional drawings may be required on a project specific basis in accordance with the contract documents.

b. Shop Drawings Not Required:

1) Wood pole.
2) Concrete.
3) Reinforcing steel.
4) Anchor bolts, nuts, and washers.
5) Other bolts, nuts, and washers.
6) Ground rods and clamps.
7) Iowa DOT Standard Road Plan RM-42, Type 1 Handhole.
8) Rigid steel conduit and fittings.
9) Rigid aluminum conduit and fittings.
10) Plastic conduit and fittings.
11) Plastic warning tape.
12) Bare copper ground wire.

2. Meet the following provisions for shop drawings:

a. Submit all drawings simultaneously for each project.
b. Include catalog cuts, diagrams, drawings, brochures, or other descriptive data required by the Engineer.
c. Include a schematic diagram and a component placement diagram of the control cabinet and panel.
d. Ensure all wire and cable sizes, placement of components, and dimensions are shown on the diagrams.

e. Ensure all drawings are completely legible and contain adequate information to identify that the described components comply with the contract documents.

f. Ensure identification markings on the described items correspond to like markings shown on the drawings to provide easy identification of the item.

g. Ensure apparatus or materials are not installed until the Engineer has reviewed and concurred with descriptive data.

h. Ensure each sheet or bound pamphlet is imprinted with the county and project number.

i. Ensure each set is assembled and contains one copy of the required data for each item listed on the schedule.

3. Incorrect or incomplete submittals will be returned to the Contractor for correction. The Engineer may require certified test results and samples of materials for consideration of all items including those described by reviewed drawings.

C. Cooperation with Utility Companies.

1. The utility company is to provide secondary service to the project in the vicinity indicated. Consult and cooperate with the utility company in locating the distribution lines and service poles so lines will be as short and direct as possible. If the utility company is unable to perform the required work, furnish and install the service poles (payment will be according to Article 1109.03). The Contracting Authority will be responsible for the cost for extension of power lines and for furnishing and installing meter sockets and meter loops as required in the contract documents.

2. The entire transformer pole installation, when required, including all accessories and appurtenances, is to be installed by the utility company that is to supply service according to their agreement for service. Cooperate with the utility company so that connections may be made in the proper manner and at the proper time.

3. Furnish all apparatus and material for the pole mounted control station, as shown in the contract documents. Upon acceptance of the project, they will become the Contracting Authority's property.

4. If pad mounted transformers and control stations are specified, ensure they are furnished and installed as specified in the contract documents. Ensure they are approved by the designated utility company.

D. Excavation.

1. Drill the holes for pole footings and direct embedded poles.

2. Details of trenching for underground circuits will be shown in the contract documents.

3. Pile the excavated material away from the trench to prevent cave-ins.

4. Accurately grade the trench bottom to provide for placement of cable or duct work at a uniform depth.

5. Ensure surface water does not enter the trench. Remove water that is present before duct work is installed, unless directed otherwise by the Engineer.

E. Placing Backfill.

1. After inspection of the completed trench, duct work, and cables, place backfill consisting of the material that was removed into the trench, unless stated otherwise in the contract documents or directed by the Engineer. Place backfill material in layers with the first layer not exceeding 2 feet (0.6 m) of loose thickness and each succeeding layer not exceeding 1 foot (0.3 m) of loose thickness. Compact each layer using hand or mechanical tampers. Do not use material containing glass, metal, concrete, brick, cinders, or any other abrasive material for backfill within 6 inches (150 mm) of the cable or conduit. Install approved plastic warning tape in all trenches.

2. Use the removed material to place backfill around direct embedded poles and handholes. Place the material in layers not exceeding 6 inches (150 mm) of loose thickness. Compact using hand or mechanical tampers.

3. Shape excess material to original contours as directed by the Engineer.

4. Shape all other disturbed areas to the original contours as directed by the Engineer.

F. Seeding and Fertilizing.

In locations where erosion control work has been completed or turf has been established, restore the areas disturbed by application of seed and fertilizer as indicated in the contract documents.

G. Footings.

1. Construct cast-in-place concrete footings for all lighting units not located on structures or barriers. Form and pour the top portion of all footings in form work to at least 6 inches (150 mm) below the finished ground level. Ensure the footings conform in all respects to the details, including reinforcement and alignment to provide the correct overhang, as indicated in the contract documents.

2. Ensure finished surfaces are smooth and free from stains and foreign material.

3. Construct an alternate footing, as directed by the Engineer, when shale, sandstone, broken and shattered rock, solid rock, or other similar materials are encountered.

4. Place anchor bolts to provide for placement of nuts and washers on the top and bottom of the transformer base or pole flange, leaving ample room for adjustment and plumbing the pole. When slip bases are used, position anchor bolts so that they do not interfere with the operation of the slip base. Place anchor bolts according to Article 2405.03, H, 3.

H. Breakaway and Slip Bases.

1. Furnish and install breakaway bases or slip bases of the size and type specified in the contract documents for each light pole not mounted on a roadway bridge. Use the same type and manufacturer for all bases for a project. Install a commercially available product. Comply with the details of bases shown in the contract documents.

2. Ensure each breakaway base has a nonmetallic spacer impervious to galvanic action placed between the breakaway base and pole base mounting flange.

I. Aluminum Transformer Bases.

Ensure the bottom flange of aluminum transformer bases are painted on the inside and outside surfaces with two coats of zinc-rich paint.

J. Poles and Mastarms.

1. Furnish and install poles at all locations indicated in the contract documents. Install poles of the lengths shown in the contract documents.

2. Carefully erect all poles and mastarms. Check for vertical alignment, mounting height, and overhang, after installation, with mastarm and luminaire installed.
3. Rake single mastarm poles so the side of the shaft opposite the mastarm is plumb. Erect poles without mastarms, or with more than one mastarm, so the center line of the pole shaft is plumb within a tolerance of 1/32 inch per foot (3 mm/m).

4. Check the pole posture at no less than three radial locations on the shaft. For poles required to have plumb shaft center lines, space the checking positions approximately 120 degrees apart, as viewed from above. For raked poles required to have one side plumb, space the check points on the side to be plumbed at 90 degrees in either direction, as viewed from above.

5. Plumb the poles using double nuts on each anchor bolt. Locate the nuts:
   - Above and below the bottom mounting flange of the breakaway base, or
   - Above and below the pole base or slip base mounting flange where breakaway bases are not required.

6. Install anchor bolt washers according to the details in the contract documents.

7. Base leveling shims or alternate pole mounting methods will be permitted only when indicated.

8. After the erection has been inspected and approved, fill the space between the mounting flange and the concrete footing with an approved non-shrink grout and finish as detailed.

9. Install mastarms of the type and length specified. Unless shown otherwise in the contract documents, mastarms greater than 8 feet (2.4 m) in length are to be Type B, and all others Type A. Use the same type and material for all lighting poles and mastarms on a project.

10. Install insect barriers in the ends of all mastarms at the point of luminaire attachment.

11. Install wood poles of the length and class specified. Set them plumb in drilled holes as directed by the Engineer. Embed the poles no less than 8 feet (2.5 m). Additional embedment may be required by the Engineer if warranted by soil conditions.

K. Luminaires.

1. Furnish and install luminaires of the type and rating specified.

2. All roadway luminaires shall be leveled after installation unless a tilt is specified.

3. When light distribution is specified, ensure the luminaire has the necessary components and is adjusted properly.

4. Provide the Engineer with printed instructions regarding luminaire components and adjustment.

L. Circuits.

1. Unless specified otherwise, install an underground, multiple system roadway lighting circuit that is totally encased in conduit. Construct circuits and control stations according to the contract documents.

2. Ensure circuits are complete with all necessary accessories for proper operation. Thoroughly coordinate disconnecting devices, protective devices, and all other equipment to secure a safe operating lighting system. If any changes in arrangement of the circuit system are considered necessary by the Contractor, submit details of changes and reasons to the Engineer for approval. Obtain the Engineer's approval prior to making changes.

M. Grounding.

1. **General Requirements.**
   a. A component of the lighting system will be defined to be grounded when it is electrically bonded to a driven ground rod or a multiple

system of ground rods producing a resistance to ground of 25 ohms or less when installed and tested according to the contract documents.

b. Use ground rods and connections described in Article 4185.04 to ground major components of the lighting system, such as control stations, lighting units, and sign structures, and all metal duct work in exposed locations or installed on roadway bridges. Refer to the contract documents for details of these and other locations to be grounded.

2. Grounding Installations.

a. Whenever the ground rod installation does not have a resistance to ground of 25 ohms or less, couple additional rods to the first, and drive to the full depth until the required resistance is obtained. If a maximum depth of 50 feet (15 m) is reached, or if obstacles to further driving are encountered, install additional ground rods until the required resistance to ground is obtained.

b. Permissible grounding installations are as follows:

1) Ensure that in no case is any portion of the ground rod closer than 18 inches (0.5 m) to the finished earth surface. Drive all rods as nearly vertical as possible. Whenever possible, drive a full length ground rod.

2) When rock or other obstructions prevent driving the rod to full depth, two half-length sections may be driven, with the Engineer's approval. The two half-length sections are considered as a minimum length rod when additional rods are required to obtain the specified resistance to ground.

3) Where two half-length rods can not be driven to the required depth, place full length rods horizontally at a depth of no less than the adjacent trench depth.

4) The minimum horizontal clearance between all rods in a multiple ground installation is to be 6 feet (2 m).

N. Electrical Ducts.

1. General Requirements.

a. Refer to the contract documents for details of duct installations. Ensure the completed duct systems are watertight. Use expansion fittings where duct runs cross structural expansion joints and elsewhere as direct by the Engineer.

b. Thread metal conduit joints. Treat the mating threads with pipe joint compound. Treat all other threads with an approved rustproofing compound. For plastic conduits, use solvent welded, socket type joints.

c. After the duct runs are installed, demonstrate that the runs are clear by pulling an approved brush or conduit swab through the entire length of each run. Ensure no deleterious material remains in the duct. Securely cap terminal ends until cable is installed. Before the wire and cable is installed, fit terminal ends of metal conduit with threaded insulating bushings. Fit terminal ends of plastic conduit with socket type, bell end fittings.

d. Do not embed aluminum conduit in concrete.

2. **Underground Ducts.**
   a. **Lighting Circuit Ducts.**
   Fabricate lighting circuit ducts using Schedule 40 plastic conduit. As field conditions permit, install the runs to avoid adding bends or total bend angle to the design layout. Limit the total bend angle between pulling points to no more than 360 degrees.
   b. **Crossing Ducts.**
   Unless shown otherwise in the contract documents, use Schedule 80 PVC conduit for crossing ducts. If crossings are to be placed without disturbing the existing surface, install by jacking or boring methods approved by the Engineer. Do not use jetting.
   c. **Primary Service Ducts.**
   Apply installation requirements for lighting circuit and crossing circuit.

3. **Exposed Exterior Ducts.**
   a. Unless shown otherwise in the contract documents, use rigid steel conduits for all ducts for exposed installations.
   b. When not shown in the contract documents, support exposed ducts at intervals of 6 feet (1.8 m) or less. Anchor the hangers or clamps to be attached to concrete structures by means of expanding anchors in drilled holes. The use of driven or explosive set anchors will not be permitted.

O. Handholes.

1. Construct handholes of the size and type and at locations shown in the contract documents, unless the Engineer specifies otherwise. Do not construct handholes in the following areas:
   - Ditch bottoms,
   - Low areas where ponding of water may occur, or
   - Where they will be subject to normal vehicular traffic.

2. Provide access ducts for each general direction of the circuit branch run. Position them for ease of cable installation.

3. Position handholes so that the top is at the same inclination as the adjacent grade.

P. Junction Boxes.
Furnish junction boxes of the type specified and install as indicated in the contract documents.

Q. Wire or Cable.

1. Furnish and install wire or cable of the size and type specified. When installing wire or cable in a conduit system, provide equipment to demonstrate to the Engineer that at no time will a pulling tension of 0.008 pound per circular mil (70 N/mm^2) of conductor be exceeded.

2. Ensure unreeled wire or cable is not left on the ground surface or exposed to mechanical abrasion. Replace all wire or cable that is

stressed or damaged in any way at no additional cost to the Contracting Authority. Do not install wire or cable with dirt or any other abrasive material adhering to it.

3. Use a lubricant when pulling wire or cable. Use a UL listed lubricant designed for use with the specified cable and conduit. The use of graphite or petroleum lubricants will not be permitted. Ensure the pulling device is attached to each conductor and all wire or cable within a single duct is pulled simultaneously.

R. Connectors.
Furnish and install connectors of the type specified at the locations shown in the contract documents. Ensure connector assemblies are supplied with a disposable mounting pin, when required, and sufficient silicone compound to lubricate the metal parts and rubber housings. Ensure complete instructions are supplied with each connector.

S. Splices.
Use approved connector assemblies to make splices. Splices in the system will only be allowed in pole shafts, handholes, pull boxes, breakaway bases, and other specified locations.

T. Control Station.
Furnish the components specified and construct the control station as indicated in the contract documents.

U. Final Acceptance.

1. Perform electrical tests of all systems after the circuit installation work is complete, and at any other stage of construction when directed by the Engineer. Include the following tests:
- Insulation resistance measurement for all underground circuit cable,
- Voltage measurements, and
- Ground resistance test for each individual grounding installation.

2. Perform insulation resistance measurements with all lamps or ballasts disconnected from the circuit and all neutral lines properly grounded. Measure with a properly calibrated 500 volt megaohmmeter. Ensure insulation resistance is no less than 100 megaohms.

3. Measure and record the voltages in the cabinet from phase to phase and phase to neutral at no load and at full load. Measure and record the voltage readings at the last termination of each circuit.

4. Measure ground resistance with the ground rod, or system of ground rods as described in Article 2523.03, K, disconnected from the circuit neutral wire. Measure with a Wheatstone bridge type ground resistance tester according to the manufacturer's instructions. Ensure the ground resistance of each individual grounding installation is no greater than 25 ohms.

5. Perform electrical tests and demonstrate to the Engineer that the lighting system complies with requirements of the contract documents.

6. Provide the Engineer with a written report of all test results for a permanent record.

7. In the insulation resistance report, include measurements from each insulated line to ground, and between all combinations of lines in a given circuit or contained in a single duct.

8. In the voltage measurement report, include measurements for each cabinet and each circuit.

9. In the ground resistance report, include measurements for each grounding installation identified by a lighting unit number and at other grounding locations by a means approved by the Engineer.

10. All components of the lighting system shall be in satisfactory operation according to the ratings and requirements specified.

11. After satisfactory completion of required testing, the complete lighting system is to be placed in operation for a 30 calendar day trial period, and final approval of the installation will not be made until the trial period ends. During the trial period, service and maintain the installation and make all necessary adjustments or replacements as are required, at no additional cost to the Contracting Authority. The Contractor will not be required to pay for energy consumed by the system, and working days will not be charged, during this trial period.

12. Where the existing ground has been disturbed by the Contractor, reshape to original contours or as directed otherwise by the Engineer.

13. Final acceptance of all lighting installations will be based on:
    - Satisfactory results of electrical tests the Contractor has performed, and
    - Satisfactory completion of the 30 calendar day trial period.

2523.04 METHOD OF MEASUREMENT.

Measurement for the quantities of the various items involved in the construction of highway lighting will be as follows:

A. Lighting Poles.
By count.

B. Electrical Circuits.
Linear feet (meters) shown in the contract documents.

C. Handholes and Junction Boxes.
By count.

D. Control Cabinet.
By count.

E. Under Deck Lighting.
By count.

2523.05 BASIS OF PAYMENT.
Payment for the quantities of the various items involved in constructing highway lighting will be the contract unit price as follows:

A. Lighting Poles.

1. Each.

2. Payment is full compensation for materials, equipment, excavation, and installation of the pole, luminaire, mastarm, footing, base, ground rod, wiring within the pole, and connectors within the pole, according to the contract documents.

B. Electrical Circuits.

1. Per linear foot (meter).

2. Payment is full compensation for materials, equipment, excavation, and installation of the conduit and the wiring/cables between the connectors in the poles, including switches.

C. Handholes and Junction Boxes.

1. Each.

2. Payment is full compensation for materials, equipment, excavation, and installation of the handholes and junction boxes.

D. Control Cabinet.

1. Each.

2. Payment is full compensation for materials, equipment, excavation, meter socket, meter loop, control cabinet pole, and installation of control cabinet and all internal circuitry.

E. Under Deck Lighting.

1. Each.

2. Under Deck Lighting luminaires shall be complete including lamps, ballast, and mounting device.

Section 2524. Highway Signing

2524.01 DESCRIPTION.
Erect traffic signs and delineators according to the contract documents.

2524.02 MATERIALS.

A. Signing Materials: Apply Section 4186.

B. Wood Posts: Apply Section 4164.

C. Class A Crushed Stone: Apply Article 4120.04.

D. Concrete Footings: Apply the provisions of Section 2403.

2524.03 CONSTRUCTION.

Ensure all parts used in construction of traffic signs and delineators are able to withstand a wind load of 30 pounds per square foot (1.4 kPa) on the sign surface.

A. Fabrication of Signs.

1. Traffic Signs.

a. Except as modified by the contract documents, fabricate signs according to the standards established in the Standard Highway Signs, 2004 edition, as published by the U.S.D.O.T.

b. All traffic signs, except milepost markers and 6 inch by 6 inch (150 mm by 150 mm) route markers, are classified into two groups, Types A and B, as indicated in the contract documents.

1) Type A Signs.

a) Comply with the following:

- Aluminum, galvanized steel, or when specifically specified, plywood sheets mounted on wood or steel breakaway posts.
- Sign face material fabricated from reflective sheeting.
- Sign legends accomplished with either the direct or reverse silk screen process, or with black nonreflective sheeting that is direct applied.

b) Ensure the finished signs comply with the details specified in the contract documents.

2) Type B Signs.

a) Comply with the following:

- Extruded aluminum highway sign panels mounted on either wood or steel breakaway posts as specified in the contract documents.
- Sign face material fabricated from reflective sheeting.
- Sign legends accomplished through use of reflectorized or nonreflectorized letters, numerals, symbols, and borders that are direct applied.

b) Ensure the finished signs comply with the details specified in the contract documents.

c) Prior to fabrication, submit shop drawings for each Type B sign according to Article 1105.03. Each drawing is to be a scale drawing of the sign face, showing the size, arrangement, and spacing of all letters, numerals, symbols, and borders.

2. **Milepost Markers.**
   a. Comply with the following:
      - Green reflectorized sheeting on flat aluminum or galvanized steel sheets as for Type A signs.
      - Reflectorized white message applied directly to the face material.
      - Dimensions as specified in the contract documents.
   b. Mount milepost markers on posts of the type specified for delineators.

3. **Route Markers, 6 Inch by 6 Inch (150 mm by 150 mm).**
   Comply with the following:
   - Reflectorized sheeting on flat aluminum or galvanized steel sheets as for Type A signs.
   - Details as specified in the contract documents.

4. **Delineators.**
   a. Install a hermetically sealed, acrylic plastic, prismatic, reflex reflector, appropriately housed and contained on Materials I.M. 486.07.
   b. Mount above milepost markers on the same delineator post.

B. Erection of Signs, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.

1. **Type A and B Signs.**
   a. Accurately erect all Type A and B signs to comply with the dimensions and details shown in the contract documents. Obtain the Engineer's approval for all deviations from the contract documents before starting the work.
   b. After installation, modify each 4 inch by 6 inch (100 mm by 150 mm) wood sign post by field drilling holes as shown in the contract documents. All labor and equipment necessary for this modification is included in the price bid for the post and no separate payment will be made.
   c. Set wood posts in 12 inch (300 mm) diameter holes of the proper depth.
   d. Set posts to full depth at the required spacing. Align posts accurately both vertically and horizontally. Place backfill consisting of Class A crushed stone meeting the requirements of Article 4120.04 into the post holes. Place material in layers no more than 6 inches (150 mm) in depth. Thoroughly compact each layer taking care to preserve the alignment of the posts.
   e. Where steel breakaway posts are specified in the contract documents, carefully drill or dig footing holes to the required size at the proper location. Spread the excavated earth within the right-of-way to blend uniformly with the existing surface to the Engineer's approval.
   f. Immediately before placing concrete, remove all loose and uncompacted material from the bottom of the hole. Some of the holes will be located in the bottoms of drainage ditches. In these

cases conduct construction operations so that water will not enter excavated holes.

g. For the breakaway base, tighten all bolts to maximum using a 12 inch to 15 inch (305 mm to 308 mm) wrench to bed washers and shims, and to clean bolt threads. Loosen each bolt in turn and retighten in systematic order to the torque specified in the contract documents. For the fuse plate assembly, tighten fuse bolts to the torque specified in the contract documents.

h. Preposition stub posts and reinforcing to the proper depth as shown in the contract documents. Ensure stub posts and reinforcing are properly aligned and secured, complying with Article 2405.03, H, 3. Cast the footing to the elevation shown in the contract documents. Rod the concrete in place to fill all the voids. Form the exposed portion of the footing as shown in the contract documents. Shape the cap of the footing so that drainage is away from the base plate of the post. Apply the provisions of Section 2403.

i. After the concrete has developed the strength required by Article 2403.03, N, 2, attach the post and adjust for correct alignment and elevation. Remove all excess concrete from around the holes.

j. Erect extruded panels according to the details in the contract documents. Take necessary measures to prevent damage to sign faces. Repair (at no additional cost to the Contracting Authority) any mars, scratches, dents, or other damage to sign faces visible at a distance of 5 feet (1.5 m). Tighten locknuts on the post clip bolts by means of a torque wrench to 225 inch-pounds (25 Nm) when using dry, clean, unlubricated threads. Draw the nuts on panel bolts tight.

2. Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.

a. Drive the posts for delineators, milepost markers, and 6 inch by 6 inch (150 mm by 150 mm) route markers. Provide a suitable driving cap. Attach signs and delineators after driving.

b. Erect markers and delineators so that the signs and delineator reflectors will be at elevations called for in the contract documents. Ensure they are true to line and grade and are truly vertical. Where a milepost marker is designated, attach the marker in place of a delineator. Where a 6 inch by 6 inch (150 mm by 150 mm) route marker is designated, attach it above the milepost marker on the same post.

c. Ensure delineator posts for these signs are plumb and firm in the ground, spaced as shown in the contract documents, and driven to the required lines and grades. Ensure that after driving, the top of the post has substantially the same cross section dimensions as the body of the post. Battered heads will not be permitted. Remove from the site and replace (at no additional cost to the Contracting Authority) all posts which are bent or otherwise damaged to the extent that they are, in the Engineer’s opinion, unfit in the finished work.

C. Sign Positioning.
The glossy surface on sign faces may produce specular reflection. Position signs to eliminate or minimize specular reflection in the following manner:

1. Overhead Signs.
a. Adjust the sign face in the following manner, where the road grade approaching the sign is plus 2.0% or greater:
- Vertical axis to be parallel to a plumb line.
- Horizontal axis to be at right angles to the road.

b. Adjust the sign face in the following manner, where the road grade approaching the sign is less than plus 2.0%:
- Vertical axis inclined to face upward at the rate of 1/8 inch per foot (10 mm/m) of vertical sign surface for each 1% the road grade differs from plus 2.0%.
- Horizontal axis to be at right angles with the road.

2. Ground Installations.
a. Ground installations will be shown in the contract documents.
b. After installation of signs is complete, the signs will be inspected at night by the Engineer. If specular reflection is apparent on any sign, adjust its positioning to eliminate or minimize this condition.

D. Sign Identification.
Identify the signs as specified in Section 4186, with the following additions:

Sign No..... (Filled in by Sign Fabricator)
Erection Date..... (Filled in by Sign Contractor)

2524.04 METHOD OF MEASUREMENT.

Measurement for signing, satisfactorily erected according to the contract documents, will be as follows:

A. Type A Signs.

1. Calculated in square feet (square meters) of sign area completed in place based on the nominal dimensions of the signs.

2. The area of all regular, rectangular, triangular, octagonal, and circular shaped Type A signs will be measured from the nominal given dimensions. Cutouts for rounded corners, and so forth, will not be deducted. The area of all irregularly shaped Type A signs, such as U.S. and Interstate route markers, will be measured from the dimensions of a circumscribed rectangle around the route marker.

B. Type B Signs.
Calculated in square feet (square meters) on the basis of area of the vertical, front face of the signs specified in the contract documents. Measurement will not be made for area in excess of this area.

C. Wood Posts for Type A or B Signs.
Each to the nearest foot (0.3 m) for the various post sizes installed. When posts are placed to depths greater than the minimum depth specified, the measured length does not include any parts placed to depths greater than 1 foot (0.3 m) more than the specified minimum.

D. Steel Breakaway Posts for Type A or B Signs.

1. Each to the nearest 0.1 foot (30 mm) for the various post sizes installed.

2. Unless specified otherwise in the contract documents, the measured length of steel breakaway posts includes no more than 1 foot (0.3 m) over the length necessary to meet specified minimums.

E. Concrete Footings for Breakaway Posts for Type A or B Signs.
Each will be counted by the various sizes installed.

F. Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.
Each will be counted by the various types installed.

2524.05 BASIS OF PAYMENT.
Payment for signing, satisfactorily erected according to the contract documents, will be at the contract unit price as follows:

A. Type A Signs.

1. Per square foot (square meter) of sign area.

2. Payment is full compensation for furnishing, fabricating, and erecting the signs complete, including furnishing of the blank, application of reflective sheeting, application of the screened message, and all mounting hardware.

B. Type B Signs.

1. Per square foot (meter) of sign area.

2. Payment is full compensation for:
- Furnishing, fabricating, and erecting the complete signs, including furnishing aluminum extrusions or formed steel panel,
- Applying reflective sheeting,
- Furnishing and applying all letters, numerals, symbols, and border to the sign
- Applying the sign to the post,
- Furnishing all labor, and
- Furnishing all other details necessary to provide signs complete and erected in place, except for the required footings and posts.

C. Wood Posts for Type A or B Signs.

1. Per linear foot (meter).

2. Payment is full compensation for furnishing and erecting the posts, including treatment and other details necessary to provide the sign posts complete and erected in place.

D. Steel Breakaway Posts for Type A or B Signs.

1. Per linear foot (meter) for the various post sizes.

2. Payment is full compensation for furnishing, fabricating, and erecting the posts, including galvanizing and other details necessary to provide the sign posts complete and erected in place.

E. Concrete Footings for Breakaway Posts for Type A or B Signs.

1. Each for the various sizes.

2. Payment is full compensation for:
- Excavating the hole,
- Furnishing and placing concrete, stub post, reinforcing bars, and so forth,
- Finishing, and
- All other details necessary to provide a complete concrete footing.

F. Delineators, Milepost Markers, and 6 Inch by 6 Inch (150 mm by 150 mm) Route Markers.

1. Delineators and Milepost Markers:
a. Each for the various types.
b. Payment is full compensation for:
- Furnishing, fabricating, and erecting the delineators or milepost markers complete, including posts, reflector units, and frames for delineators, posts and milepost marker signs,
- Furnishing all necessary fittings and attachments, and
- All labor necessary to complete the work.

2. 6 inch by 6 inch (150 mm by 150 mm) Route Markers:
a. Each.
b. Payment is full payment for furnishing, fabricating, and erecting the route marker to a milepost marker post previously measured for payment, including all necessary fittings and attachments and all labor necessary to complete the work.

G. Excavation in Unexpected Rock.
Excavation in unexpected rock for wood posts for Type A or B signs, steel posts for Type A or B signs, concrete footings for Type A or B signs, delineators, and milepost marker posts will be paid for as extra work. Unexpected rock will be considered as rock encountered during post

erection, but neither visible from the roadway nor indicated in the contract documents.

Section 2525. Traffic Signalization

2525.01 DESCRIPTION.

Furnish all work, apparatus, and materials to construct, install, and place in operation, a complete traffic signal system as shown in the contract documents. Furnish and install all components of the system not furnished by the utility company serving the traffic signal system, including all incidental items appurtenant to the operation of the system.

2525.02 MATERIALS.

Furnish materials of new stock unless the contract provides for the relocation or the use of fixtures furnished by others.

A. Power Cable.
Comply with Article 4185.12. UL listed for type "USE".

B. Signal Cable.
Meet the requirements of IMSA Nos. 19-1 or 20-1.

C. Loop Detector Wire.
Single conductor meeting standard requirements for THHN. Meet the requirements of IMSA No. 51-5.

D. Detector Lead-In Cable.
Meet the requirements of the IMSA No. 50-2.

E. Tracer Wire.

1. Single conductor, stranded copper, Type THHN, with UL approval and orange colored jacket.

2. Splice tracer wires in the handholes, cabinet, and pole bases to form a continuous network.

F. Communications Cable (Conductive).
Meet the requirements of the IMSA No. 39-2 or 40-2.

G. Bare Copper Ground Wire.
Meet the requirements of Article 4185.12.

H. Conduit.

1. **General.**
Meet the requirements of Article 2523.10 and Article 4185.10.

2. **Rigid Steel Conduit.**
Use conduit fittings meeting the requirements of ANSI C80.4.

3. **Polyvinyl Chloride Conduit.**
Use rigid PVC conduit meeting the requirements of NEMA TC-2, Type 2, and applicable UL Standards.

4. **Innerduct.**
For innerduct conduit (IDC), use Schedule 40, high density polyethylene. Conduit shall provide nominal conduit size as indicated in the contract documents, be orange in color, and longitudinally ribbed on the inside wall. Conduit shall be purchased in continuous reel lengths to minimize splicing.

2525.03 CONSTRUCTION.

A. General.

1. Furnish equipment and materials of new stock unless the contract provides for the relocation or the use of fixtures furnished by others.

2. Submit to the Engineer, for review, a list of equipment and materials to be furnished before they are ordered. Replace, at no additional cost to the Contracting Authority, any part that fails in any manner by reason of defective materials within a period of 1 year from the date that the equipment was placed in operation and accepted. Provide the standard industry warranties for all equipment at the date of final acceptance of the work by the Engineer.

3. Shop drawings will be required for the poles and mastarms. Submit shop drawings according to Article 1105.03.

4. Prior to acceptance of the work, the Contractor will be required to furnish the Engineer with:
   - Five copies of the manufacturer's instructions for maintenance and operation of all signal equipment,
   - Wiring diagrams of the installation or system, and
   - A parts list sufficient for the ordering of parts.

B. Handholes.

1. Build handholes in place or furnish precast units. When forms are used, use forms that are set level and are of sufficient thickness to prevent warping or other deflections from the specified pattern. Provide a means for holding them rigidly in place while the concrete is being placed.

2. Use concrete meeting the requirements of Section 2403.

3. Extend the ends of all conduit leading into the handhole approximately 2 inches (50 mm) beyond the inside wall.

4. Construct a drain in the bottom of the handhole. Furnish frames and covers for handholes made of cast iron.

5. Furnish handhole covers with the words "TRAFFIC SIGNAL" cast on the top of the cover. Set them flush with the sidewalk or pavement surface.

6. When installed in an earth shoulder away from the pavement edge, install so the top surface of the handhole is approximately 1 inch (25 mm) above the surface of the ground. When constructed in unpaved driveways, install so the top surface of the handhole is approximately level with the surface of the driveway.

C. Conduit System.
Apply Article 2525.02, H.

1. Installation.

a. Accomplish change in direction of ducts by:
   - Bending the conduit uniformly to a radius which will fit the location (minimum radius 6 times the internal diameter of the conduit), or
   - The use of standard bends or elbows.

b. When it is necessary to cut and thread steel conduit, no exposed threads will be permitted.

c. Ensure all ducts and fittings are free from burrs and rough edges.

d. Use standard manufactured elbows, nipples, tees, reducers, bends, couplings, unions, and so forth of the same materials and treatment as the straight duct throughout the duct system. Tightly connect all fittings to the duct. Provide a bushing to all duct ends to protect the cable from abrasion, except for open ends of conduit being placed for future use. Cap or plug open ends intended for future use.

e. When the contract documents require that ducts be placed without disturbing the existing pavement, the term "pushed" is used. Place pushed conduit by jacking, pushing, boring, or any other means necessary to place the ducts without cutting or removing pavement.

f. Slope all ducts to drain. Furnish crushed stone drainage sumps at all handhole locations.

2. Excavation.

a. Excavate trenches to the depth necessary to provide 18 inches (0.5 m) of cover over the ducts. Remove all cinders, broken concrete, or other hard or abrasive materials. Do not use these materials as backfill materials. Ensure the trench is free of these materials before the conduit is placed.

b. Do not place ducts prior to the Engineer’s inspection of the trench. Place backfill material in all trenches as soon as possible after duct installation. Place backfill material in the trench in layers not to exceed 6 inches (150 mm) deep. Thoroughly compact each layer before placing the next layer.

c. Whenever excavation is made across parkways, driveways, or sodded areas, replace or restore the sod, topsoil, crushed stone, and gravel as nearly as possible in its original position. Leave the whole area involved in a neat and presentable condition.

d. Replace concrete sidewalks, pavements, base courses, and bituminous surfaces with new materials.

D. Wire and Cable.

Apply Articles 2525.02, A through G.

1. Install all cable runs so they are continuous from connections made in the handhole compartments of signal pole bases to the terminal compartment in the controller cabinet. Splicing will not be allowed. Install one signal cable from each signal head to the base of the pole. Use a 5-conductor cable in the poles for 2-section, 3-section, or 4-section signal heads. Use a 7-conductor cable for 5-section signal heads.

2. Install service cable runs so they are continuous from the service point to the terminal compartment on the controller cabinet. Connect loop detectors to the controller using a 14 A.W.G. 2-conductor shielded cable. Install these cables to be continuous from the terminal compartment in the controller cabinet to a splice made with the detector leads in the first handhole or pole base junction box provided adjacent to the detector.

3. Pull cables through conduit by means of a cable grip designed to provide a firm hold upon the exterior covering of the cable or cables, with a minimum of dragging on the ground or pavement. Use reels mounted on jacks or other suitable devices. Use frame mounted pulleys or other suitable devices to pull the cable out of conduit into handholes. Use lubricants which are approved for cable lubrication to facilitate the pulling of cable. Provide slack for each cable by the use of a 4 foot (1.2 m) loop in each handhole.

E. Controllers, Cabinets and Associated Equipment.

1. General Design Requirements.

a. Purpose.

The purpose sets forth minimum design and operating requirements for controllers, cabinet and associated equipment. Furnish controllers, cabinets, and associated equipment complying with NEMA TS-1, except as modified by the contract documents.

b. Cabinet.

1) Furnish controller units and associated equipment that are completely housed in a cabinet of clean-cut design and appearance. The cabinet shall be constructed from 5052-H32 sheet aluminum alloy which has a nominal 0.12 inch (3 mm) thickness.

2) Furnish a hinged door that meets the following requirements:

- Permits complete access to the interior of the cabinet.
- When closed, fits the gasketing material making the cabinet weather resistant and dust tight.
- Includes a strong Corbin #2 lock and key, or approved equal.

3) Ensure the outside of the main controller door includes a small, hinged and gasketed door-in-door that:

- Does not allow entrance to the controller mechanism or to exposed electrical terminals,
- Provides access to a small switch panel and compartment which contains a signal shutdown switch, manual/stop time, and a flash control switch, and
- Is equipped with a strong lock utilizing keys of a different design from those provided for the main cabinet.

c. Wiring.

1) Furnish panels that have mounted on them at least the following short circuit protection devices and suitably identified field terminals:

a) Terminals for the conductors of the signal light cable. One for each signal circuit.

b) Terminals for common return conductors of the signal light cable. At least one for each three signal circuits for which the controller is equipped.

c) Terminal grounded to the cabinet or an equipment grounding conductor.

2) The grounded side of the power service is to be carried throughout the controller in a continuous circuit, but do not ground it to the controller cabinet.

3) Furnish controllers that withstand without failure a high energy transient (1000 volts, both positive and negative, applied three times for each polarity at a rate of once every two seconds from a 15 microfarad oil filled capacitor) applied to the incoming power supply line.

d. Contacts.

For all contacts, meet the following requirements:

- Fabricated from coin or fine silver or material of similar conductivity,
- Sufficient cross section to perform their normal functions with minimum pitting or burning under maximum current, and
- No fine adjustment and readjustment required for satisfactory and continuous operation.

e. Mechanical Requirements.

Meet the following requirements:

1) All mechanism, motors, operating coils, bearings, contacts, relays, flashers, and similar components sufficiently large, rugged, and accessible to ensure reliability and minimum maintenance.

2) All equipment neatly and systematically arranged and mounted to allow thorough inspection while the controller is operating normally, and to permit easy removal of components without interfering with other portions of the controller.

3) Components securely fastened in place, if necessary to prevent accidental contact with moving parts or electrical power and to permit the cabinet door to be opened and closed without interference or damage to the controller and wiring.

4) The opening and closing of the flashing circuit accomplished in such manner as to avoid undue pitting or burning or other

damage of signal load switches at 10 amperes of tungsten lamp load at 120 volts, 60 hertz AC, for 50 million times.

a) Each equipped with additional terminals which are wired so that, by an interchange of jumpers, flashing operation may be arranged to display either flashing yellow or flashing red on each.

b) Cabinet constructed so that flashing operation can be obtained by operating the flash control switch even if the controller unit malfunctions or is removed from the cabinet.

c) Each cabinet equipped with adequate means to suppress or prevent radio interference from flashing of vehicular and pedestrian signal indications.

f. Uninterrupted Timing.

Ensure changes in operation of traffic control signal lights as described in Article 2525.03, E, 1, b, 2, and Article 2525.03, E, 1, e, do not interfere with the continued in-time operation of the cycle timer in each controller. A transfer from these special operations back to normal automatic operation is to immediately re-establish the normal cycle length and subsequently the in-time relation.

2. Preemption Features.

Furnish controllers equipped to provide special preemption sequences upon remote control from railroad track circuit, emergency vehicle preemption, mass transit equipment, or other similar device which may connect either through a master controller or directly to the interconnected controller.

3. Actuated Signal Controllers.

a. Description.

Furnish NEMA TS-1 or TS-2 controller units that:

- Are of completely solid state modular design,
- Incorporate digital timing, and
- Are capable of expanding to accommodate up to eight phases.

b. Electrical Requirement.

1) Over-current Protection.

Furnish controllers that contain a front-panel-mounted AC power input fuse of suitable size to provide adequate over-current protection.

2) Automatic Reorientation.

Furnish controllers that in the event of a power interruption are capable of automatic reorientation upon power resumption and require no manual initiation or switching.

c. Constancy of Intervals: Minimum Requirements.

Ensure the length of any interval or timing setting does not change by more than 100 milliseconds (±) so long as the voltage and frequency of the power supply and the ambient temperature inside the controller cabinet remain within the tolerances specified in these specifications.

d. Interval Sequence.

Ensure that at the end of the green interval of the terminating phase, if neither vehicle nor pedestrian memory indicates a need for the next traffic phase, the intervals which comprise that phase

are omitted from the interval sequence. This does not preclude the use of recall causing the phase to be displayed even though no detector actuations have been received.

e. Interval Setting and Functions.

1) Provision for Setting.

Furnish controls that meet the following requirements:

- Calibrated in seconds and fractions of seconds, when applicable.
- Provide a clear visual indication of the value of each interval or function.
- Timing and function values capable of being set without the use of special tools or wiring changes.

2) Location of Controls.

Furnish controllers with the interval and function controls located on the front of the controller and properly designated as to the function each control performs.

3) Interval and Function Indication.

a) Indication.

Furnish controllers with indication provided and appropriately labeled on the controller to facilitate the determination of operation and termination of the intervals and functions contained therein. Indication shall include, but not necessarily be limited to, the following:

- Phase(s) next.
- Phase(s) in service.
- Status indicators.
- Initial interval.
- Vehicle interval.
- Yellow change interval.
- Maximum/gap termination.

b) Call Indication.

Furnish controllers on which indication is provided to display presence of vehicle call, including memory and detector actuations and presence of a pedestrian call when pedestrian timing functions are included.

4) Vehicle Detector Non-Lock Memory Switch(es).

Ensure a switch is provided for each actuated vehicle phase which, when placed in the nonlock position, causes the vehicle detector memory circuit for that phase to be disabled.

f. Signal Circuits.

1) General.

Furnish cabinets with load switches, external to the controller, for closing and opening signal light circuits.

2) Closing and Opening of Circuits/Minimum Capacity.

Ensure closing or opening of signal circuits is positive without objectionable dark intervals, flickering of lights or conflicting signal indications. Ensure each switch has a capacity of no less than 10 amperes of incandescent lamp load at 120 volts AC.

3) **NEMA Triple Signal Load Switch(es).**
Furnish external jack-mounted load switches according to Part 5, "Solid-State Load Switches", Section TS-5.01, NEMA Traffic Control Systems Standards.

g. **Conflict Monitor.**
Furnish a separate external signal monitoring device complying with Part 6, NEMA TS-1 that monitors the occurrence of conflicting Green or Walk indications and causes the signals to go into flashing operation should such conflicts be sensed.

1) **Control of Flasher Mode.**
Meet the following requirements:
   a) Operation of flash mode from police panel does not interrupt operation of controller and associated units.
   b) An "auto-off-flash" mode switch is provided inside the cabinet.

2) **Flashing of Vehicular Signals.**
Meet the following requirements:
   a) Flashing of vehicular signal indications is obtained from one or more flashers, each of which is a self-contained device designed to plug into a panel in the controller cabinet.
   b) If the flashing is provided by two flashers, they are wired to assure that the flashing of all lenses on the same approach is simultaneous.

3) **Flashing of Pedestrian Signals (Pedestrian Clearance).**
When pedestrian interval timing functions are included, ensure means are provided to permit flashing of the DON'T WALK pedestrian signals during the pedestrian clearance interval.

4) **Solid State Flasher.**
Furnish solid state flashers that:
   - Contain no contact points or moving parts, and
   - Comply with Part 6, NEMA Traffic Control Systems Standards TS-1.

h. **Manual Control Enable.**
Ensure, when specified, manual commands:
- Place vehicle calls and pedestrian calls (when pedestrian timing is included in the controller's sequence of operation) on all phases and stop controller timing in all intervals except vehicle clearances, and
- Inhibit the operation of interval advance during vehicle clearances.

i. **Coordination.**

1) **Minimum Requirements.**
Furnish controllers with the means to permit its interconnection into a coordinated traffic signal system when coordinating devices are added. As a minimum, this should include the provision of Yield circuit or Hold circuit, accessible to interruption by command external to the controller.

2) **Coordination Requirements.**
Ensure controllers, in addition to the minimum coordination requirements specified above, contain the coordination

features for the applicable configuration included in NEMA Traffic Control Systems Standard TS-1.

j. Cooling/Heating Devices.

No heating or cooling devices other than standard vent fan(s) are required for proper operation of the controller.

k. Cabinet.

1) Size.

Furnish cabinets of a size to adequately house the controller, all associated electrical devices and hardware, and other auxiliary equipment herein specified.

2) Mounting.

a) Ensure the cabinet is arranged and equipped for mounting as shown in the contract documents. Also ensure sufficient clamps, nuts, hardware, etc., as required for the specified mounting type, are furnished with each cabinet.

b) Seal all conduit openings in the controller cabinet with a sealing compound that meets the following requirements:

- Readily workable, soft plastic,
- Workable at temperatures as low as 30ºF (-1ºC), and
- Does not melt or run at temperatures as high as 300ºF (150ºC).

c) Install the controller cabinet on preplaced caulking material on the concrete base. After the cabinet is installed in place, also place caulking material around the base of the cabinet.

3) Door Stop.

Ensure the controller cabinet door is provided with a stop and catch arrangement to hold the door open at angles of both 90 degrees and 180 degrees, ±10 degrees.

4) Mounting Shelves.

Furnish cabinets containing strong mounting facilities to:

- Accommodate the mounting of the controller and all auxiliary equipment, and
- Permit the controller and/or auxiliary equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting operation of the controller.

5) Mounting Screws.

Do not allow screws used for mounting shelves or other mounting purposes to protrude beyond the outside wall of the cabinet.

6) Outlet and Lamp.

Furnish and locate an electrical outlet with a Ground Fault Interrupter and lamp receptacle in an accessible place near the front of the cabinet.

7) Plastic Envelope.

Furnish a heavy-duty clear plastic envelope (minimum dimensions of 12 inches by 18 inches (300 mm by 450 mm)), securely attached to the inside wall of the cabinet or cabinet door, for stowing cabinet electrical prints, and so forth.

8) Ventilation.

a) Vents.

(1) Furnish cabinets containing a suitably designed rain tight vent or vents that:

- Are equipped with screens or filters, and
- Allow the release of excessive heat and/or any explosive gases which may enter the cabinet.

(2) Ensure when filters are utilized, positive retainment is provided on all sides to prevent warpage and entry of foreign matter around the edges.

b) Vent Fan.

Meet the following requirements:

- A thermostatically controlled vent fan is furnished to provide air circulation within the cabinet.
- The thermostat controlling the fan is manually adjustable to turn on between 90ºF and 150ºF (32ºC and 66ºC) with a differential of not more than 10ºF (6ºC) between automatic turn on and turn off.
- The fan is located with respect to the vent holes to direct the bulk of the air flow over the controller and auxiliary equipment.

9) Connecting Cables, Wiring, and Panels.

a) Connecting Cables.

Fabricate electrical connections from the controller (and auxiliary devices when included) to outgoing and incoming circuits in a manner that the controller (or auxiliary device) can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wires leading therefrom. This can be accomplished by means of a multiple plug, a spring connected mounting, or approved equivalent arrangement.

b) Panels and Wiring.

Furnish each cabinet with suitable, easily accessible wiring panel(s). Ensure all panel wiring is neatly arranged and firm, and all incoming cables are clearly identified by use of plastic numbered tags.

(1) Wiring Terminals.

Furnish terminals, as a minimum, for the following:

- Terminal with NEC approved cartridge fuse receptacle, fuse, power line switch, or magnetic circuit breaker, with integral power line switch, for the incoming power line,
- Terminal, unfused, for the neutral side of the incoming power line,
- Terminals and bases for signal load switches, flasher, and outgoing signal field circuits,
- Terminals for detector cables, and
- Terminals for all required auxiliary equipment.

(2) Clearance between Terminals.

Ensure adequate electrical clearance exists between terminals. Also ensure the controller, auxiliary

equipment, panel(s), terminals, and other accessories are arranged within the cabinet so that they will facilitate the entrance and connection of incoming conductors.

(3) **Signal Circuit Polarity.**
Ensure the outgoing signal circuits are of the same polarity as the line side of the power service, and the common return is of the same polarity as the grounded side of the power service.

(4) **Grounding Conductor Bus.**
Ensure an equipment grounding conductor bus is provided in each cabinet, and is grounded to the cabinet in an approved manner.

10) **Fusing and Surge Protection.**

a) **Incoming AC Line.**
Furnish suitable over-current protection, utilizing one of the methods described in Article 2525.03, E, 3, k, 9, b, 1.

b) **Lightning.**
Furnish suitable protection from lightning with lightning arresters, preferably of the gas filter type.

11) **Painting.**
Do not paint the aluminum exterior surface of the cabinet.

4. **Multi-Phase Traffic Actuated Controllers.**

a. **Operational Requirements.**

1) **Mode of Operation.**
Furnish controllers meeting the following requirements:
- Provide two to eight phase operation and are fully actuated with means for receiving actuations on all phases.
- Permit a nonactuated mode of operation on any of its phases by assertion of the vehicle recall function or pedestrian recall on the desired phase.

2) **Call to Nonactuated Mode.**
Furnish controllers that feature an input which, when asserted, permits the selection of nonactuated mode of operation on any of its phases.

3) **Operation with Auxiliary Functions/Devices.**
Furnish controllers capable of having their basic operation expanded or augmented by the addition of auxiliary functions or devices.

4) **Minimum Green.**

a) **Actuated Phase.**
The minimum green is to be the first timed portion of the green interval which is set in consideration of the storage of vehicles waiting between the sensing zone of the approach vehicle detector and the stop line.

b) **Nonactuated Phase.**
In the nonactuated mode of operation, the minimum green on the nonactuated phase is to be equal to the values described for Actuated Phases in the preceding

paragraphs or equal to a separately set Minimum Green function.

5) **Unit Extension.**
Ensure the actuation of a vehicle detector during the extendible portion of an actuated traffic phase having the right-of-way causes the retention of right-of-way by that traffic phase for one Unit Extension portion from the end of the actuation, but subject to the Maximum (extension limit).

6) **Maximum (Extension Limit).**
Ensure the Maximum (extension limit) determines the maximum duration of time the right-of-way can be extended for a phase having successive detector actuations spaced less than a Unit Extension portion apart.

7) **Initiation of Maximum or Extension Limit.**
   a) Ensure the timing of the maximum or extension limit commences:
      - With the first actuation or other demand for right-of-way on a traffic phase not having the right-of-way, or
      - At the beginning of the Green interval if an actuation or other demand for right-of-way has been previously registered on a traffic phase not having the right-of-way.
   b) Alternatively, the maximum may commence at the end of the Initial portion of the Green interval if an actuation or other demand has been previously registered on a traffic phase not having the right-of-way.

8) **Transfer of Right-of-Way.**
Ensure the actuation of any detector on a traffic phase not having the right-of-way causes the transfer of the right-of-way to that traffic phase at the next opportunity in the normal phase sequence, provided there has been an expiration of:
   - A Unit Extension portion with no continuing actuation, or
   - The Maximum (extension limit) timing on the preceding phase having the right-of-way.

9) **Rest in Absence of Actuation.**
Ensure in the absence of detector actuation or assertion of recall switch(es), the right-of-way indication remains (rests) on the traffic phase on which the last actuation occurred.

10) **Memory Feature.**
Unless precluded by the operation of the nonmemory feature, the following memory retention is to be provided in the controller:
   If the right-of-way is transferred by the operation of the Maximum or extension limit, the traffic phase losing the right-of-way is to again receive it without further actuation at the next opportunity in the normal phase sequence.

11) **Pedestrian Timing Operation.**
Ensure the following pedestrian function operation is provided:
   a) **Condition in Absence of Pedestrian Call.**

In absence of pedestrian actuation or assertion of pedestrian recall function, pedestrian signals remain in a DON'T WALK condition.

b) **Pedestrian Actuation Memory.**
Pedestrian actuations received by a phase during steady or flashing DON'T WALK indications of that phase are remembered and cause the controller to provide pedestrian timing functions for that phase at the next opportunity in the normal phase sequence.

c) **Nonextension of Pedestrian Intervals.**
Successive pedestrian actuations do not cause extension of the pedestrian intervals.

12) **Other Operations Features.**
Ensure, in addition to specified functions, the following additional features are provided:

- All phase detector inputs are supplied with detector delay disable capability.
- All signal load outputs are individually fused with 10 ampere fuses.
- Detector test switches and pedestrian (if specified) test switches are provided for each phase.
- The permissive and force-off features are fully conditionable.

b. **Functional Requirements.**
Ensure, in addition to the basic functional requirements specified above, the controller provides the functional features for the applicable configuration included in NEMA Traffic Control Systems Standard TS-1.

5. **Coordination of Traffic Actuated Controllers.**

a. **Requirements.**
Furnish controllers with a means to permit their interconnection into a coordinated traffic signal system when coordinated devices are added. As a minimum, this should include the provision of yield circuit or hold circuit accessible to interruption by commands external to the controllers.

1) **Hold Feature.**
Ensure controllers contain a hold feature which, when asserted for a particular phase, holds that phase in a rest condition. Upon release from hold, the phase is to immediately advance into the appropriate clearance interval or other unexpired portion of the Green, provided there is an actuation or an opposing phase.

2) **Force-off Feature.**
Ensure controllers contain a force-off feature which, when asserted, causes termination of the current phase, provided that phase is in the extension portion. In no case is assertion of force-off to cause termination in a clearance interval or during a minimum Green for vehicles or pedestrians.

3) **Additional Features.**

Ensure the controllers and coordination devices are capable of, but not limited to, the additional coordination features, including:

- Three cycles,
- Four splits per cycle,
- Three offsets per cycle,
- Four permissible periods per split,
- Four force-offs per split,
- One pedestrian permissive period per vehicular permissive period, and
- One dwell period per cycle.

b. NEMA Coordination Requirements.
Ensure, in addition to the coordination requirements specified above, controllers contain tab coordination features for the applicable configuration included in NEMA Standard TS-1.

6. Master-Secondary Controller.

a. Purpose.
The purpose sets forth functional requirements which apply to an interconnected actuated controller which is also equipped to serve as a master controller. For this, the master controller shall be located as designated in the contract documents.

b. Design Requirements.
The general design requirements in Article 2525.03, G, 1 and 2 apply, in addition to specific functional requirements described below.

c. Equipment.
Ensure the master-secondary controller consists of a complete interconnected controller equipped with the necessary apparatus to provide supervisory functions for operation of a system of interconnected actuated and pretimed controllers.

d. Supervisory Functions.
Ensure the master controller is equipped with a solid state programmable plug-in module or controller accessory unit with time-based coordination capabilities. This unit is to provide as a minimum, but not limited to, these capabilities:

1) Synchronization pulse generation for offsets.
2) An offset interrupter or equivalent device for decreasing the disruption to interval timing caused by large offset changes.
3) Hand operated flash control switch for transfer of traffic control signal lights at each interconnected controller to give flashing indications.
4) Complete compatibility with actuated controller coordination units specified in Article 2525.03, E, 3.
5) Programming capability as a minimum, but not limited to, time of day, day of week, week of year, with daylight savings selection.

F. Inductive Loop Vehicle Detector.
Provide wiring and schematic diagrams, descriptive parts lists, and instruction and maintenance manuals for all items furnished under these

specifications. Equipment or unit modifications as approved shall be accompanied by revised diagrams with the first shipment of the modified units. Provide tables, charts, or equations for use in designing loops of various sizes and configurations. Provide five complete sets of diagrams, manuals, and so forth to the Engineer with each order.

1. Design Requirements.

Meet the following requirements:

a. Operation.

1) General.

a) Detectors shall be designed to meet requirements of NEMA Traffic Control Systems Standard TS-1.

b) The detector shall provide reliable detection and maintain an output indication for a period of not less than 3 minutes for a vehicle that causes a 0.02% change in the total inductance of the loop and lead-in system, as measured at the detector loop input terminals.

c) The detector shall provide operation as above with a loop system having any or all of the following characteristics:

(1) A shunting resistance of 10,000 ohms or greater to a common or circuit ground bus.

(2) A loop system quality factor (Q) of not less than 5.0, when connected to the detector being tested. Q is defined as the ratio of the resonant operating frequency over the half-power band width.

(3) A total or equivalent inductance within the range of 40 microhenrys to 700 microhenrys at the detector loop input terminals.

d) A sensitivity adjustment or selector is to be provided to allow selection of a high, medium, or low sensitivity adjustment. Increments are to include: High, 0.02%; Medium, 0.06%, 0.01% (±); Low, 0.125%, 0.025% (±).

2) Loop Energizing and Detector Sensing Circuits.

a) The detector is to:

- Provide reliable detection of licensed motor vehicles,
- Provide an output (switch closure) only when vehicles are passing or stopped over the loop,
- Detect all vehicles passing over the loop at speeds up to 80 mph (130 km/h).

b) When first turned on, while tuning or being tuned, the detector shall provide a continuous output pulse (switch closure), plus a visual indication, in both the presence and pulse modes of operation. On power failure, or loop failure that would cause the inductance to exceed the tuning range, the detector shall place a continuous call.

c) To prevent mutual interference "cross-talk," the detectors shall be provided with a three-position frequency mode switch on the front panel.

d) The detector is to be designed to be initially tuned to the loop and provide for automatic drift compensation.

e) The operation of the detector shall not be affected by changes in the inductance of the loop caused by environmental changes, such as rain, hail, snow,

temperature, and humidity, nor is the sensitivity to be markedly affected.

3) Accuracy.
The detector shall be able to detect all licensed vehicles, including motorcycles, accurately.

b. Detector Output.
The detector output (switch closure) to the associated traffic control equipment shall be provided by means of a relay. The relay shall have a mechanical life of at least 1,000,000 operations. The contacts are to have a rating of at least 1.0 ampere at 120 volts AC or DC.

c. Power Supply.
The primary of the power supply transformer shall be fused with a 1/4 inch (6 mm) diameter, 1 1/4 inch (32 mm) long, 250 volt fuse of suitable current rating. Provide an extractor-post fuse holder. The fuse rating shall be marked by the fuse holder.

d. Visual Indicator.

1) A LED shall be used to provide a visual indication of each vehicle detection. The indication shall be readily visible in indirect sunlight.

2) The LEDs are to have a minimum design life of 20,000 hours at rated voltage.

e. Dielectric Strength.
The detector shall withstand a dielectric strength test of 1250 volts, 60 hertz, AC applied between the 120 volt AC line-supply circuit and the terminals for the external loop, for a period of 1 minute.

f. Interchangeability and Design Life.
All modules and components of the same type shall be interchangeable. The design life of all components, under conditions of normal operation, is to be no less than 5 years.

g. Marking.
Each detector is to be marked with the manufacturer's name, model, catalog, or type number, and serial number. The electrical input rating (voltage, frequency, and wattage) is to be included in the marking.

2. Input/Output Receptacle.

a. Function Assignment.
Complete input and output connections for the detector to a type MS-3102-A-18-1P box receptacle using 10 male contacts. Place a plastic cover on the receptacle. Assign the pin positions of the input/output connector as follows:

Pin No.	Function
A	120 vac (-)
B	Output Relay Common
C	120 vac (+)
D	Input from Loop
E	Input from Loop
F	Output Relay N.O.
G	Output Relay N.C.
H	Chassis Ground
I	Spare

J Spare

b. Plug and Cable.

Furnish a plug, type MS-3108-B with type 18-1S insert, with 10 female contacts, wired with leads of No. 18 AWG stranded, color-coded wire with 300 volt insulation. Furnish a type MS-3057-10 cable clamp and boot for strain relief. Fabricate the leads to be 10 feet (3 m) long, with the first 16 inches (0.4 m) of leads, from the plug, enclosed in cotton braiding. No terminals are required on the leads.

3. Components.

a. Inductors and Transformers.

Ensure all inductors and transformers have their windings insulated and are impregnated to exclude moisture. Ensure all wire leads are color coded.

b. Resistors and Capacitors.

Ensure all resistors and capacitors are insulated and marked with their resistance or capacitance value. Resistance and capacitance values may be indicated by the Radio Electronics Television Manufacturer's Association (RETMA) color codes. Ensure all electrolytic capacitors are marked to indicate polarity and voltage.

c. Printed-Circuit Boards.

Ensure the following:

- All printed-circuit boards are at least 1/16 inch (1.5 mm) thick and made of glass-cloth silicone NEMA type G-10 glass epoxy, or equivalent.
- The conductor material is copper, 0.0027 inch (70 µm) thick, having a weight of 2.0 ounces per square foot (610 g/m^2), with a protective solder coating.
- All printed-circuit board connectors (male and female) are gold plated over the copper base.
- The printed circuit-boards are securely mounted to prevent flexing or bending of the boards, and are easily removable for servicing or replacement.

d. Wiring.

Use No. 22 AWG, or larger, insulated interconnecting wires, suitable for 180ºF (82ºC) operation.

e. Solid State Circuitry.

1) Meet the following requirements:

a) Transistors, integrated circuits, or semiconductor diodes shall be used for all amplifying, detecting, rectifying, counting logic, and regulator circuits. No vacuum or gas tubes are to be used except for pilot lights. Transistors, integrated circuits, and diodes are to be marked with their type number and are to be types listed by the RETMA.

b) No electro-mechanical timers, synchronous motors, or relays shall be employed, except as specified in Article 2525.03, A.

c) All electronic and electrical components shall be of standard manufacture and available from a source other than the manufacturer of the loop detector unit.

2) No modifications to the circuit, parts substitutions, or changes in the function or form from the original equipment list will be allowed without prior approval of the Engineer.

4. Detector Loop Installation.

a. Insert the detector loop wire into a flexible plastic tubing for the full length of the wire from the point of splicing. Prefabricated loops installed under new paving consist of loop wiring encased in a watertight plastic tubing assembly. The field loop conductors installed in the pavement are to run continuously from the terminating service box or base with no splices permitted. At the time of placing the loop wire in the sawed slots, seal the ends of the tubing to prevent moisture from entering the tubing.

b. Twist all lengths of loop wires and tubing not imbedded in the pavement with at least 5 turns per foot (16 turns per meter), including lengths in conduit and service boxes.

c. Solder the electrical splice between the loop and lead-in cable to the controller and the loop wire using resin core solder. Furnish a water tight protective covering for the spliced wire, the shielding on the loop lead-ins and the end of the tubing containing the loop wires. Using an open flame to heat the wire connection will not be permitted. Use a soldering iron, gun, or torch equipped with a soldering tip. Complete the splice using the following method:

1) Remove all lead-in cable coverings leaving 4 inches (100 mm) of insulated wire exposed.

2) Remove the insulation from each conductor of a pair of lead-in cable conductors and scrape both copper conductors with knife until bright.

3) Remove the plastic tubing from the loop wires for 1.5 inches (40 mm).

4) Remove the insulation from the loop wires and scrape both copper conductors with knife until bright.

5) Connect conductors by a soldered “Western Union” type splice, wrapped with water proof tape and coated with a water tight protective covering.

6) Cover the exposed shielding, ground wire and end of any unused loop lead-in where the sheathing was cut with liquid silicone rubber. Apply Butyl Rubber Polymer Tape sealant between the wires and completely cover the silicone rubber. 3M Company Scotchcast Kit, or approved equal, is an acceptable alternate for splices.

d. Mark the location of each loop on the pavement with crayon or spray paint. Obtain the Engineer’s approval prior to cutting the saw slots.

e. Use a saw equipped with a depth gage and horizontal guide to assure proper depth and alignment of the slot. Use a blade for the saw cut that will provide a clean, straight, well defined 3/8 inch (10 mm) wide saw cut, without damage to adjacent areas. Make cuts 1.5 inches to 2 inches (40 mm to 50 mm) deep. Where the loop changes direction, overlap the saw cuts to provide full depth at all corners. Do not use right angles or corners less than 90 degrees.

f. Before installing the loop wire, check the saw cuts for the presence of jagged edges or protrusions. If they exist, remove them. Clean and dry the slots to remove cutting dust, grit, oil, moisture or other contaminants. Clean by flushing with a stream of water under pressure, followed by an air blast using oil free compressed air.

g. Install loop detector conductor using a nominal 0.2 inch (5 mm) thick wood paddle. If the wire does not lie close to the bottom of the saw cut, hold it down using a material such as tape or doubled over pieces of the plastic tubing.

h. Coil each loop clockwise (or according to the manufacturer's recommendations) and band the beginning conductor in the terminating handhole or base with a symbol "S" to denote the start of conductor. Use durable tags to further identify each loop by phase or function as shown in the contract documents.

i. Connect the “S” conductor of the loop to the unbanded conductor of the adjacent loop for situations where multiple loop configurations, spliced to a single lead-in loop, are to be connected in series.

5. Detector Loop Sealing.

a. After obtaining satisfactory test results, seal the loop with a flexible embedding sealer listed in Materials I.M. 491.18. Use the sealer according to the manufacturer's instructions.

1) Pour the sealer into the slot to half depth.

2) When both the loop and lead-in slots are half filled, check for air bubbles and material pileup, and then proceed to fill the slots to roadway level. The sealer, when poured into a saw cut, should completely surround the wires, displace all air and completely fill the area of the slot, except for that portion filled with the wire hold down material.

3) Remove excess sealant using a squeegee. Ensure neither a trough or a mound remains.

4) Allow sufficient time for the sealer to harden, according to manufacturer's instructions, before allowing traffic to move over the area.

b. After completion of the sealing, test the loop individually at the handhole and as a group at the control cabinet. The completed sealed loop is required to pass continuity, inductance, and resistance testing prior to being accepted.

6. Detector Loop Testing.

Test all loops and document by using the following procedures:

a. Determine the insulation resistance of the loop wire using a "megaohmmeter" with 500V applied to either loop wire to earth ground. The resistance is to be greater than 100 megohms.

b. Determine the inductance of the loop using a loop inductance meter.

G. Signals.

1. General.

a. Furnish traffic signals manufactured in polycarbonate sections that are interchangeable and fit so they can be combined in a tier.

Follow the requirements as shown in the contract documents for mounting devices, lens indications, and other modifications. Ensure the reflector is parabolic in design and made of specular alzak aluminum. Other parts of the optical system, including the lens, lamp socket, reflector, and reflector holder, are to be manufactured as a whole system so as to eliminate the return of outside light rays which enter the unit.

b. During the course of construction and until the signals are placed in operation, cover signal faces or turn them away from approaching traffic. When ready for operation, secure them in position facing toward approaching traffic.

c. Ensure the optical assembly of the vehicle signals is in substantive compliance with the latest version of ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads.

d. Apply one prime coat of metal primer and two coats of high quality Federal yellow enamel to mounting accessories. Dipping will not be permitted for any part of the enameling process. Ensure mounting accessories for mast-arm mounted signal fixtures are galvanized in accordance with the latest revision of ASTM A 123. The body of the signal sections is to be Federal yellow, and the door, backplate, if required, and visors are to be dull black. The color shall be completely impregnated in the polycarbonate material, and scratches are not to expose uncolored material.

2. Vehicle Signals.

Meet the following requirements:

a. All lenses shall be of the prismatic, long range type. The lenses shall have a nominal diameter of 12 inches (300 mm). All lenses shall be made of vandal resistant polycarbonate or acrylic plastic meeting the light transmitivity and chromaticity standards established by latest version of ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads.

b. Each signal lens, with the exception of lenses for optically programmed sections, shall have a visor of a type normally described as a tunnel visor, which encloses 75% of the lens circumference for the entire length of the visor. Cut-a-way type visors shall be provided for each lens of optically programmed sections only where specifically required as indicated in the contract documents.

c. Mastarm mounted vehicle heads shall be equipped with a backplate. The backplate shall provide a minimum of 5 inches (125 mm) of black field around the assembly.

3. Pedestrian Signals.

Meet the following requirements:

a. Pedestrian signals shall consist of two signal sections with rectangular lenses and mounting attachments as shown in the contract documents. The upper section shall display a DON'T WALK symbol, and the lower shall display a WALK symbol. The two sections are to be of such design and construction as to fit rigidly and securely together with or without a spacer. Any space

shall be no more than 0.5 inch (13 mm) thick. These signals are intended to operate with incandescent lamps.

b. The lenses shall be either sanded or prismatic lenses of nominal 9 inch or 12 inch (225 mm or 300 mm) size, as indicated in the contract documents. The lenses shall be made of vandal resistant polycarbonate or acrylic plastic. The symbols on these lenses shall be designed to produce maximum legibility both day and night. The WALK symbol shall be Lunar White, and the DON'T WALK symbol is to be Portland Orange. Both messages shall be screened on the lenses with a material which will not crack or peel. The background or field around both messages is to be black.

c. Each signal lens shall be equipped with a visor which encloses the top and both sides of the lens.

4. Traffic Signal Lamp.

All traffic signal lamps shall have a standard, medium brass screw base and a clear glass envelope. The light center length (L.C.L.), or the dimension, in inches (millimeters), from the center of the filament to the tip of the base, is to be in compliance with the following design requirements:

a. 67 Watt series (9 inch (225 mm) pedestrian heads)

- Light center length 2-7/16" (62 mm)
- Rated life hours 8000 hours
- Rated initial lumens 665 lumens
- Minimum initial lumens 595 lumens
- Rated voltage 120 volts

b. 150 Watt series (for 12 inch (300 mm) traffic and pedestrian heads)

- Light center length 3" (75 mm)
- Rated life hours 6000 hours
- Rated initial lumens 1950 lumens
- Minimum initial lumens 1745 lumens
- Rated voltage 130 volts

5. Optically Limiting Signals.

a. General.

Ensure the signal permits the visibility zone of the indication to be determined optically without a need for hoods or louvers. The projected signal may be visible or selectively veiled anywhere within 15 degrees of the optical axis. No indication is to result from external illumination, nor is one indication to illuminate a second.

b. Optical System.

Meet the following requirements:

1) The components of the optical system are to consist of:

Lamp
Circlet Reflector
Optical Limiter-Diffuser
Objective Lens

2) The lamp shall be a nominal 150 watt, 120 volt AC, three prong, sealed beam having an integral reflector and an average rated life of 6,000 hours.

3) A circlet reflector with a specular inner surface is to mate the lamp to the diffusing element.

4) The optical limiter-diffuser combination shall provide an imaging surface, at focus on the optical axis for objects 900 feet to 1,200 feet (270 m to 370 m) distance. It is also to permit an effective veiling system to be variously applied as determined by the desired visibility zone. The optical limiter-diffuser shall be provided with positive indexing means and to be composed of heat resistant glass.

5) The objective lens shall be a high resolution planar incremental lens, hermetically sealed within a flat laminate of weather resistant acrylic. The lens shall be symmetrical in outline and may be rotated to any 90 degree orientation about the optical axis. Lens colors shall comply with ITE transmittance and chromaticity standards.

c. Castings.
Ensure cast aluminum parts comply with ITE alloy and tensile requirements and have a chromate preparatory treatment. The exterior of the signal case, lamp housing, and mounting flanges shall be finished with a high quality flat black enamel prime and finish system. The lens cover and the interior of the case shall be optical black. Hinge and latch pins shall be stainless steel. All access openings shall be sealed with weather resistant rubber gaskets.

d. Visors.
Ensure visors are 9 1/2 inch (240 mm), cut-a-way visors, are optical black, and are attached to all optically limiting signals for this project.

e. Installation.
Install, direct, and veil the signal according to published instructions and the Engineer's approval. Mask each section of the signal as required with prescribed materials in an acceptable and competent manner.

6. Pedestrian Push Button Detectors.
Furnish pedestrian push button detectors of the direct push contact type without levers, handles, or toggle switches. Meet the following requirements:

a. Each detector shall consist of a removable contact assembly mounted in a durable metal case.

b. The contacts shall be entirely insulated from the case and operating button with terminals for making connections.

c. The case shall have one outlet for 0.5 inch (13 mm) pipe.

d. The operating button is to be made of brass or other nonrusting metal alloy and be of sturdy design.

e. This button shall be weatherproof and is not to protrude out from the case.

f. The entire assembly shall be weather tight, secured against electrical shock and of such construction to withstand continuous hard usage.

g. The contacts shall be normally open, with no current flowing except at the moment of actuation.

H. Signal Supports (Single Tubular Mastarms and Poles).

1. General.

Meet the following requirements:

a. Furnish mastarms and support poles that are continuous tapered, round steel poles of the anchor base type as shown in the contract documents. The poles and mastarms shall be fabricated from one length of steel sheet with one continuous arc welded vertical seam, unless approved otherwise by the Engineer.

b. Unless specified otherwise, the poles and mastarms shall be fabricated from low carbon steel (maximum carbon, 0.30) of U.S. standard gage The base and flange plates shall be of structural steel complying with AASHTO M 183 (ASTM A 36/A 36M) and cast steel complying with ASTM A 27/A 27M, Grade 70-36 or better.

c. When specifically required, the poles and mastarms shall be fabricated from corrosion resistant steel meeting requirements of ASTM A 595, Grade C, and A 606, Type 4 sheets (with minimum chemical requirements of ASTM A 588/A 588M, Grade D). The base and flange plates shall be fabricated from A 588/A 588M structural steel.

d. After manufacture, poles and mastarms shall have a minimum yield strength of 48,000 psi (330 MPa).

e. It may be permissible to fabricate poles and mastarms by welding two sections together. The method used for connecting the sections shall result in a smooth joint and be factory welded.

1. Longitudinal butt welds, except within 1 foot (0.3 m) of a transverse butt-welded joint, shall have a minimum 60% penetration for plates 3/8 inch (10 mm) and less in thickness, and a minimum of 80% penetration for plates over 3/8 inch (10 mm) in thickness.

2. Longitudinal butt welds on poles and arms within 1 foot (0.3 m) of a transverse butt-welded joint shall have 100% penetration.

3. Transverse butt welds for connecting sections shall have 100% penetration achieved by back-up ring or bar.

4. Transverse butt welds and all specified 100% penetration longitudinal butt welds on poles and mastarms shall be examined 100% by ultrasonic inspection.

f. In addition, welding, fabrication, and inspection shall comply with Article 2408.03, B.

g. Personnel performing nondestructive testing are required to be qualified according to the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A and applicable Supplements B (Magnetic Particle) and C (Ultrasonic). The welding consumables used shall comply with Materials I.M. 559.

h. The poles and mastarms shall be designed to support traffic signals, luminaires, and/or signs as shown in the contract documents. They shall be certified by the fabricator that the poles and mastarms are capable of withstanding winds up to 100 mph (160 km/h) without failure.

i. The poles and mastarms shall be galvanized inside and out according to ASTM A 123.

j. Erect all poles vertically, unless otherwise specified.

1) Securely bolt bases to the cast-in-place concrete foundations.
2) Perform leveling using two nuts on each anchor bolt. One nut shall be turned on each anchor bolt and the pole placed in position on these nuts. The top nut shall then be turned into place loosely and the pole adjusted to the vertical position by adjusting both the upper and lower nuts.
3) After leveling the poles, trowel mortar between the pole base and the foundation. Use expansive type mortar. Neatly finish exposed edges of mortar.
4) Ground each pole by installing a No. 6 AWG bare copper ground wire between the pole and the ground rod according to Article 2523.03, M.
5) Perform electrical tests according to Article 2523.03, U.

2. Concrete Bases for Poles.

a. For the forms, use material of sufficient thickness to prevent warping or other deflections from the specified pattern.

b. Set the forms level, and provide means for holding them rigidly in place while the concrete is being deposited.

c. Rigidly install all conduit, ground rods, and anchor rods in place before concrete is deposited in the forms.

d. Place anchor bolts according to Article 2405.03, H, 3. Set anchor bolts for the signal poles in place by means of a template constructed to space the anchor bolts according to the manufacturer's requirements.

e. The center of the template and the center of the concrete base are to coincide.

f. For concrete, apply Section 2403.

g. Finish the top of the base to be level and round the top edges with an edger having a radius of 0.5 inch (13 mm).

h. Set the top of pole bases flush with the sidewalk or pavement surface. When installed in an earth shoulder away from the pavement edge, set the concrete base so the top is approximately 4 inches (100 mm) above the surface of the ground. Finish the exposed surface of the base with a wood float.

3. Hardware.

Ensure mastarms and poles are equipped with all necessary hardware, shims, and anchor bolts to provide for a complete installation without additional parts. The fabricator shall submit drawings for anchor bolts and base design. All hardware shall be steel, hot-dipped galvanized according to ASTM A 153, Class C, or shall have an electro deposited coating of the same coating thickness, and so designed for this purpose.

a. Anchor Bolts.

- Full-length, full-body diameter, hot-dip galvanized meeting the requirements of ASTM F 1554, Grade 105 (724 MPa).
- Threaded a minimum of 6 inches (150 mm) at one end, with a 4 inch (100 mm) long, 90 degree bend at the other end.
- Unified Coarse Thread Series with Class 2A tolerance.

- The end of each anchor bolt shall project from the concrete color coded in red to identify the grade.

b. Nuts.

- Heavy hex meeting the requirements of ASTM A 563, DH.
- Galvanizing according to ASTM A 153, Class C, or ASTM B 695, Class 50.
- May be over-tapped according to the allowance requirements of ASTM A 563.

c. Washers.

Meet the requirements of ASTM F 436.

4. Aluminum Traffic Signal Pedestal.

Meet the following requirements for the pedestal shaft:

a. Fabricated from tubing with a wall thickness of no less than 0.125 inches (3 mm).

b. Equipped with a cast aluminum base with a handhole. The size of the handhole shall be at least 4 inches by 6 inches (100 mm by 150 mm). It shall be equipped with a cover which can be securely fastened to the shaft with the use of hand tools.

c. The top of the shaft shall have an outer diameter of 4.5 inches (115 mm).

I. Testing of Signal Equipment.

1. After the project is open to traffic, notify the Engineer in writing of the date the signal or signal system will be ready for testing. Upon concurrence of the Engineer, place the signal or signal system in operation for a consecutive 30 calendar day test period. If the signal is to operate independently of other signals or signal systems, test it as a single installation. If the signal is part of a system, do not start the test period until all signals in the system are ready to be tested. Test a system as a unit. Correct all failures or malfunctions of the equipment during the test period at no additional cost to the Contracting Authority. The Contractor will not be required to pay for energy consumed by the system, and working days will not be charged during this testing period.

2. Secure the services of an authorized factory representative of the controller manufacturer to check out the system and to make all necessary adjustments at the time the equipment is turned on in order to get all specified functions of the equipment working properly. The factory representative shall have on hand, at the time the equipment is turned on, the necessary tools, test equipment, spare modules, spare detector amplifiers, and other miscellaneous parts and equipment to check out the system and make all necessary adjustments. Notify the Engineer at least two business days prior to turn on so the Engineer may be present at the turn on.

J. Certification of Equipment.

Supply certification from the manufacturers of all electrical equipment, signal supports, conduit, and cable stating the materials comply with the specifications.

K. Documentation.

1. With each signal system, provide file documentation packages which consist of the following:
   - **a.** Complete schematic diagram, accurate and current for units supplied.
   - **b.** Complete physical description of units.
   - **c.** Controller printout or equal documentation of initial controller settings installed in the field or in the office.
   - **d.** Complete installation procedure and performance specifications, both electrical and mechanical, for loop detector amplifier units.
   - **e.** Complete maintenance and trouble shooting procedures.
   - **f.** Standard industry warranties on units supplied.
   - **g.** Complete parts list identifying full names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA, or EIA.
   - **h.** Pictorial of components layout on chassis or circuit board.

2. Include at least one full package in each controller cabinet and provide the Engineer with one full package.

2525.04 METHOD OF MEASUREMENT.
None. Plan quantities are for estimating purposes only, and these quantities will not be paid for separately.

2525.05 BASIS OF PAYMENT.

A. Payment for Traffic Signalization will be made at the lump sum contract price.

B. Removal of the existing traffic signal installation will be paid for at the lump sum price for Removal of Traffic Signalization. The lump sum price for Removal of Traffic Signalization will be full payment for the removal of all traffic signal poles, signal pole footings, overhead wires, handholes, and controllers. Removal of underground wire, cable, and conduit will not be required.

Section 2526. Construction Survey

2526.01 DESCRIPTION.
Perform survey for construction projects.

2526.02 MATERIALS.
None.

2526.03 SURVEY.

A. Furnish all survey necessary for construction of the project before work begins in the area. Do not apply the provisions of Article 1105.06 to this work, except to preserve the original stakes set by the Engineer. If, in the

opinion of the Engineer, the Contractor has destroyed or disturbed any of the original survey stakes or benchmarks, the cost of replacing will be charged to the Contractor. Bring design errors discovered to the Engineer's attention for review prior to staking. Construction survey includes qualified personnel, equipment, and supplies required for, but not limited to, the following items:

1. Project Control.

a. Primary Control Monuments.

A primary control monument is a survey point the Contracting Authority establishes prior to project commencement. These are shown in the contract documents. The point will be established by placing a monument in the ground.

b. Secondary Control Monuments.

A secondary control monument is a survey point the Contractor establishes on grading or other projects specified in the plans, and preserves on all other projects.

1) The Engineer will provide monuments, similar to those the Department uses for Global Positioning System (GPS) control.

2) Place secondary permanent horizontal control monuments, under the Engineer’s direction, at locations likely to survive project construction and at intervals not to exceed 2640 feet (0.8 km). Place the monuments in the ground along the project corridor. Place at higher elevations along the corridor to provide a view of the immediate project topography and to provide for visible clear line of sight to the nearest secondary permanent control monument in either direction. Primary project monuments may be substituted if appropriate.

3) Plant secondary control monuments 1 to 4 inches (25 mm to 100 mm) below existing ground. Drive a metal fence post within 1 foot (0.3 m) to mark their location.

4) Carefully determine project coordinates relative to the nearest primary project control monument using project coordinate values the Engineer has provided. Ensure the resulting error radius of the secondary monument does not exceed 0.10 feet (30 mm) ±2 ppm relative to the primary control. Provide the Engineer with all the field data of the survey. The data may be either unedited printed or electronic formatted field data, or both. Provide the Engineer with an ASCII comma delineated file of the coordinates formatted as (Point Number, Northing, Easting, Elevation, Point Description, Feature).

5) Perform an independent traverse check between the secondary control monuments by observing distance and angular measurements or by use of GPS. Provide the Engineer with all the field data for the traverse check. The data may be either unedited printed or electronic file, or both. Provide the Engineer with a diagram indicating horizontal ground distances to nearest 0.01 foot (3 mm) and angles to at least the nearest 10 seconds between each secondary control monument. Ensure inverses between the coordinate pairs as determined in the previous paragraph do not exceed 0.10 feet (30 mm) of the direct measurements.

6) Replace secondary control monuments disturbed during construction activities using procedures outlined above, at no additional cost to the Contracting Authority.

c. Durable Physical Objects.

1) Using measurements to the nearest 0.10 foot (30 mm), reference each control monument to a minimum of three durable physical objects located 20 to 100 feet (6 m to 30 m) away from the monument. Durable physical objects could include trees, poles, fence posts, station marks in new roadway pavement, or metal fence posts.

2) Provide the Engineer with either a printed or electronic reference image (for example JPEG, TIFF, etc), or both, including each reference and project coordinate.

d. Benchmarks.

1) Establish permanent vertical control benchmarks at all bridges and reinforced concrete box culverts within the project. Use an Iowa DOT brass plug on bridge barrier rail or headwall of reinforced concrete box culvert to indicate the benchmark. If the Engineer approves, a sawn “X” on bridge barrier rail or headwall of reinforced concrete box culvert may be used.

2) Transfer all benchmark elevations from construction plan benchmarks to the permanent benchmarks using the three-wire method or by trigonometric leveling. Use temporary benchmarks of reasonable stability to preserve the plan benchmarks.

3) Provide the Engineer with all field benchmark elevation data. The data may be either unedited printed or electronic formatted, or both. Provide the Engineer with the project x and y coordinates of all benchmarks along with an ASCII comma delineated file of the coordinates formatted as (Point Number, Northing, Easting, Elevation, Point Description, Feature).

4) Ensure benchmark level loops do not exceed an error of 0.05 feet (15 mm) times the square root of the loop’s length in miles (kilometers). Distribute the error equally along the loop on all intermediate traverse/benchmark points.

2. Grading.

a. Survey right-of-way line between permanent right-of-way corners at 100 foot (20 m) intervals, or less if needed, including borrows, temporary easements, and right of entry. Mark these points by placement of a metal pin or wood hub, flat, and lath at the same location as the slope stakes. Clearly mark the flat with the station number, distance from centerline, and elevation (cut or fill) to subgrade.

b. Set slope stakes at 100 foot (20 m) intervals, or less if needed, for all embankment and excavation work including roadway, channel changes, and borrow areas. Interpolations may be necessary to match the cross-sections. Set the stakes at the toe of the foreslope or the top of the backslope, or both. Mark slope stakes with a flat and lath. Clearly mark the flat with the station location, distance, slope, and cut/fill information.

c. Set grade check stakes at 100 foot (20 m) intervals for bottoms of subgrade treatments. Set the stakes on centerline for two-lane roads and in the median for four-lane roads. Mark grade check stakes with a lath. Clearly mark the lath with the station location and cut or fill information.

d. Set finish grade stakes (blue tops) at 100 foot (20 m) intervals, or less if needed. Set the blue tops at each shoulder line and at each point where there is a change in cross slope. Mark blue tops with a wood hub and a stake chaser or similar type tassel.

e. Take original and final elevations of all borrows. Provide original and final graphical cross sections at 100 foot (20 m) intervals, or less if needed, suitable for use by the Engineer to calculate excavation quantities.

f. Set bridge berm slope stakes to establish all transitions, including the face of the berm. Set finish grade stakes (blue tops) on all roadway shoulder lines and roadway centerlines to project down the face of the bridge berm at the top, midpoint, and toe.

g. When Class 12 excavation is an item, take cross section elevations at 100 foot (20 m) intervals, or less if needed, and plot cross sections for use by the Engineer to calculate the excavation quantities.

h. Use a lath to locate, on each side of roadway at the right-of-way line, agricultural drain tile shown in the contract documents. Clearly mark lath to show station location, distance from centerline, tile size and type, and flowline elevation.

3. Bridges.

a. Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark flat with the pier/abutment station location, design number, and offset distance from centerline of the approach roadway.

b. Establish a minimum of three temporary benchmarks.

c. Mark location of test pile with a wood hub.

d. Perform an independent check of the above stakes.

e. Submit elevations of all completed substructure beam seats to the Engineer for review prior to installation of bearings and superstructure elements.

f. Take elevations of beams as erected. Provide the elevations to the Engineer for computation of finish elevations for deck construction. Locations for determining beam elevations are to be according to the plans.

g. Provide the Engineer with a copy of the staking diagram prior to commencing work.

4. Reinforced Concrete Box Culverts.

a. Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, design number, cut/fill elevation, and offset distance from the centerline of the culvert and back of parapet.

b. Perform an independent check of the above stakes.

c. Provide the Engineer with a copy of the staking diagram prior to commencing work.

d. Report to the Engineer questionable flow lines and alignments that do not match existing drainage.

5. Pipe Culverts.

a. Mark locations and elevations with metal pin or a wood hub, flat, and lath. Clearly mark the flat with the station location, cut/fill elevation, and offset distance to both ends or centerline of pipe.

b. Report to the Engineer questionable flow lines and alignments that do not match existing drainage.

6. Sanitary and Storm Sewers.

Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, pipe number, cut/fill elevation, and offset distance to centerline of pipe.

7. Water Mains.

Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, pipe number, cut/fill elevation, and offset distance to centerline of pipe.

8. Intakes and Utility Accesses.

Mark locations and elevations with metal pin or tack in a wood hub, flat, and lath. Clearly mark the flat with the station location, intake or utility access number, cut/fill elevation (including bottom of well and form grade), and offset distance to the Station Location.

9. Pavements (PCC & HMA).

a. Mark locations and elevations with metal pin or tack in a wood hub (only tack one side), flat, and lath. Mark elevations on both sides of the pavement at 50 foot (10 m) intervals on straight and level sections and at 25 foot (10 m) intervals on horizontal and vertical curves. Clearly mark the flat with the station location, cut/fill information, and offset distance to the edge of pavement. Include pavement cross slope information in superelevated curves.

b. Take elevations of pavement centerline and both edges at bridges and existing pavement at 10 foot (3 m) intervals for 100 feet (30 m). Submit final elevations to the Engineer for approval.

c. When a new profile grade is not included in the contract documents:

1) Obtain elevations of the existing shoulders and/or pavement as stated in Article 2526.03, A, 9.

2) Design a smooth profile grade line based on these elevations to provide the required pavement or shoulder thickness as detailed in the contract documents. This grade line shall tie into existing bridges, adjacent pavement and ramps, and provide the required pavement crown. Submit this proposed grade line to the Engineer for approval.

10. Pavement Overlays (PCC and HMA)

a. Reference and preserve existing control points located at each Point of Intersection (P.I.).

b. Obtain the Engineer's approval for the method used to reference points.
c. Reset Control Points after the work is complete.

11. Structural Walls.
a. Survey requirements for structural walls includes the following work types:
1) Mechanically Stabilized Earth (MSE) Walls.
2) Cast in Place (CIP) Retaining Walls.
3) Soil Nail Walls.
4) Tie Back Walls.
5) Noise Walls.
6) Modular Block Retaining Walls.
7) Segmental Retaining Walls.
b. Mark locations and elevations with a metal pin or a wood hub, flat, and lath. Clearly mark the flat with the station location, cut/fill elevation, and offset distance to face of wall.

B. Submit the method used to preserve project control to the Engineer for approval. Format the survey work documentation in a manner acceptable to the Engineer. Ensure survey work is completed by a Professional Engineer licensed in the State of Iowa in responsible charge or a Professional Land Surveyor licensed in the State of Iowa in responsible charge, according to the provisions of Chapter 542 B, Code of Iowa. Submit a resume to the Engineer identifying the field survey personnel and their capabilities to perform the intended requirements.

C. Obtain the Engineer's approval for the method of determining alignments and elevations and the method of preserving control points. This approval does not act to relieve the Contractor of the responsibility for the correctness of the survey work. Do not use plan cross-sections for vertical or horizontal control.

D. The Engineer will provide bench mark elevations, right-of-way corners, and reference control points on the original survey as shown in the contract documents. A GeoPak alignment will be provided if available.

E. Check tie-ins with existing roadways for correctness of alignment prior to construction staking.

F. When survey work is done under traffic, detail sheets in the contract documents will establish the required signing.

G. The Engineer will locate and determine elevations of settlement plates.

H. Replace land corners and permanent reference markers unless stated otherwise in the contract documents.

I. All survey work documentation becomes the property of the Contracting Authority. The work of this specification will be considered finished when the documentation is furnished to and accepted by the Engineer.

J. For the purpose of subcontracting, this item will be considered a specialty item.

2526.04 METHOD OF MEASUREMENT.
None. Lump sum item.

2526.05 BASIS OF PAYMENT.

1. Payment for Construction Survey will be paid for at the lump sum contract price.

2. Payment is full compensation for the survey work required for the project as let, including any interpolations that may be necessary between cross-section and field staking.

3. Payment for revisions after the letting will be paid for according to Article 1109.03, B.

Section 2527. Pavement Marking

2527.01 DESCRIPTION.

A. Furnish, install, maintain, and remove permanent or temporary pavement markings, temporary delineators, and raised pavement markers, such as for:

1. Diversions and on site detours where the need for this work is anticipated as part of the traffic control plan to accommodate traffic during construction.

2. Replacing markings obliterated during construction activities on roads open to public traffic.

3. Changing markings on roads open to public traffic where the necessary changes result from staged construction.

4. Replacing markings that are obsolete.

5. Marking completed pavement surfaces.

B. Permanent pavement markings are those intended to remain in place after the project is completed. Temporary markings are those that are designated for removal, those that will be obliterated during construction, or those that require changes during construction.

C. Diversions are installations or modifications for the transfer of traffic on four lane or wider roadways to lanes which would normally carry traffic in the opposite direction. Diversions provide for continuous but restricted traffic flow from both directions for divided highways. Diversions usually include crossovers.

D. On site detours are temporary roadways specifically constructed to accommodate traffic during construction.

2527.02 MATERIALS.

A. Use pavement marking materials that provide markings readily visible when viewed in daylight and with vehicular headlights at night.

B. The marking materials used for temporary pavement marking include removable marking tape, traffic paint, temporary delineators, and raised pavement markers. Unless specified otherwise, the marking materials used for permanent pavement marking include regular marking tape, traffic paint, and preformed polymer pavement marking material.

C. Other marking materials, such as: epoxy, polyester, or thermoplastic, etc.; may be specified in the contract documents.

D. Materials for pavement markings are described below:

1. Removable Marking Tape.

a. Meet the requirements of Article 4183.06, A. and prequalified for use according to Materials I.M. 483.06.

b. Complying with the following:

1) Nominal width of 4 inches (100 mm).

2) Yellow or white, weather and traffic resistant film, precoated on one side with a pressure sensitive adhesive.

3) Flexible and formable.

4) Capable of remaining in place during its useful life.

5) Easily removed from the pavement at any time.

2. Traffic Paint.

a. General.

1) Use painting equipment complying with the following:

a) Capable of placing two lines simultaneously with either line in a solid or intermittent pattern in yellow or white.

b) Capable of applying glass beads at the required rate.

c) All guns in full view of the operator at all times.

d) Equipped with a metering device to register the accumulated length for each gun, each day.

e) Designed so that the pressure gages for each proportioning pump are visible to the operator at all times during operation to monitor fluctuations in pressure.

2) Apply reflectorizing spheres meeting requirements of Section 4184 to the painted lines. Apply the paint without dilution using mechanical equipment intended for that purpose. Apply the reflectorizing spheres immediately to the wet paint with a pressurized system.

b. Waterborne and Solvent-based Paint.

1) Meet the requirements of Section 4183 for fast dry paint.

2) Use the nominal application paint and glass bead rates shown in Tables 2527.02-1 and 2527.02-2:

Table 2527.02-1: Waterborne Paint

Line Width	Wet-Film Thicknes s	Paint	Spheres
4 1/2" (115 mm)	14 mils (0.35 mm)	305.5 ft. of solid line per gallon of paint. (24.60 m of solid line per liter of paint.)	9.0 lb./gal. (1.08 kg/L)
4" (100 mm)	14 mils (0.35 mm)	343.7 ft. of solid line per gallon of paint. (27.68 m of solid line per liter of paint.)	9.0 lb./gal. (1.08 kg/L)

Table 2527.02-2: Solvent-based Paint

Line Width	Wet-Film Thickness	Paint	Spheres
4 1/2" (115 mm)	16 mils (0.41 mm)	267.4 ft. of solid line per gallon of paint. (21.53 m of solid line per liter of paint.)	9.0 lb./gal. (1.08 kg/L)
4" (100 mm)	16 mils (0.41 mm)	300.8 ft. of solid line per gallon of paint. (24.22 m of solid line per liter of paint.)	9.0 lb./gal. (1.08 kg/L)

c. Durable Paint Pavement Markings.

1) Meet requirements of Article 4183.04.

2) Provide the Engineer with a copy of the manufacturer's recommendations for applying the marking material. Install the marking material according to the product manufacturer's recommendations. Use the same binder thickness as applied on the National Transportation Product Evaluation Program (NTPEP) deck with a tolerance of 10%. The bead application rate, bead gradation, and bead coating is at the discretion of the Contractor. Use an appropriate bead package to consistently meet or exceed the minimum retroreflectivity requirements.

3) Demonstrate to the Engineer at the start of the project the ability to meet the retroreflectivity requirements of these specifications when tested according to Materials I.M. 483.04. The Engineer may also require the Contractor to demonstrate the ability to meet the initial retroreflectivity requirements if there is a change in equipment, materials, or a delay of more than 2 months in completing the project.

4) Final acceptance will be based on compliance with these specifications. Ensure the markings meet the following retroreflectivity requirements.

	Specific Luminance (mcd/sq.ft./ft.-cdl.) (lux•m^2)
White line, symbols, and legends	300
Yellow line	200

3. Regular Marking Tape.

a. Meet the requirements of Article 4183.06, B. and prequalify regular marking tape for use according to Materials I.M. 483.06.

b. Comply with the following:

1) Nominal width of 4 inches (100 mm).

2) Yellow or white, weather and traffic resistant film on a conformable, metallic foil backing precoated with a pressure sensitive adhesive.

3) Flexible and formable, and following application, remains conformed to the texture of the pavement surface.

4. Temporary Delineators.

Meet the requirements of Article 4186.07. Mount on posts meeting the requirements of Article 4186.10 for delineator posts.

5. Raised Pavement Markers.

a. These markers are intended for temporary use to provide retro-reflective pavement markings. Place in addition to other pavement markings, when specified. Use markers for which the reflective surface or surfaces:

- Have a minimum area of 1/2 square inch (320 mm^2),
- Are of the color required, and
- Provide reflectance from approaching headlights.

b. Ensure markers that will be continually exposed to traffic, when installed, do not extend more than 3/4 inch (20 mm) above the pavement surface. Use markers that comply with Materials I.M. 483.07.

6. Channelizer Markers.

Use channelizer markers that comply with Materials I.M. 483.08.

7. Preformed Polymer Tape.

a. Use preformed polymer tape that:

- Consists of glass beads imbedded in a white or yellow polymer film,
- Is precoated with a pressure sensitive adhesive, and
- Has a nominal width of 4 inches (100 mm).

b. The contract documents will specify precut symbols and legends or tape to be made of preformed polymer marking material.

c. Use marking material that:

- Is capable of adhering to asphalt and PCC surfaces,
- Meets the requirements of Article 4183.06, C., and
- Is prequalified as a preformed polymer tape according to Materials I.M. 483.06.

8. Removable, Nonreflective, Preformed Tape.

Comply with the following:

a. Nominal width of 6 inches (150 mm).

b. Dark grey or black, weather and traffic resistant film.

c. Precoated on the bottom with a pressure sensitive adhesive.

d. The top of the tape embedded with skid resistant particles.

e. Flexible and conforming to the pavement surface.
f. Capable of remaining in place during its useful life.
g. Easily removed from the pavement at any time.
h. Does not damage or discolor the underlying pavement or pavement markings.

9. Profiled Pavement Marking Tape.

a. Use profiled pavement marking tape that:

- Consists of reflective beads imbedded in a white or yellow polymer film, which is precoated with a pressure sensitive adhesive,
- Is capable of adhering to asphalt and PCC surfaces,
- Meets the requirements of Article 4183.06, E., and
- Is prequalified as a profiled pavement marking tape according to Materials I.M. 483.06.

b. This marking tape has raised profiles which gives the tape higher initial retroreflectivity than the preformed polymer marking in Article 2527.02, D, 6.

c. The contract documents will specify precut symbols and legends or lane stripes to be marked with profiled pavement marking tape. Use lane stripes with a nominal width of 4 inches (100 mm).

10. Intersection Marking Tape.

a. Use intersection marking tape that:

- Consists of reflective beads and ceramic anti-skid particles embedded in a polymer film that is precoated with a pressure sensitive adhesive,
- Is capable of adhering to asphalt and PCC surfaces,
- Meets the requirements of Article 4183.06, E., and
- Is prequalified as a profiled pavement marking tape according to Materials I.M. 483.06.

b. This marking tape is intended for use in high wear and high shear areas such as cross walks, gore lines, and turn symbols at intersections.

c. The contract documents will specify precut symbols and legends or lane stripes to be marked with intersection marking tape. Use lane stripes with a nominal width of 4 inches (100 mm).

2527.03 CONSTRUCTION.

A. General.

1. The contract documents will specify the quantity, locations, and type of pavement markings required.

2. Table 2527.03-1 shows the minimum atmospheric and surface temperatures for application of pavement markings. Follow the manufacturer's written recommendations for other details of application.

Table 2527.03-1: Minimum Atmospheric and Surface Temperatures

Type of Marking	Oct. 23 to Apr. 7	Apr. 8 to Apr. 22	Apr. 23 to Oct. 7	Oct. 8 to Oct. 22
Waterborne Paint	not allowed	45°F (4°C)	45°F (4°C)	45°F (4°C)
Low Temperature Waterborne Paint with Rohm & Haas XSR Resin	35°F (2°C)	35°F (2°C)	35°F (2°C)	35°F (2°C)
Solvent Based Paint	no restrictions	no restrictions	(a)	no restrictions
(a) Solvent-based paint may be used only if temperature requirements can not be met.				

3. Follow the manufacturer's temperature restriction recommendations for tape and durable paint.

4. For all pavement markings, ensure the pavement surface is dry and free from dirt, dust, oil, curing compound, and other contaminates which may interfere with markings properly bonding to the surface. Ensure the clean surface is at least 1 inch (25 mm) wider than the anticipated marking. Shoot an air blast on the pavement surface immediately prior to placing the new marking. The air blast is not intended to remove large amounts of dust, but only a very small amount of residue that might be left from the removal and cleaning operation.

5. Ensure the following for all painted and taped pavement markings:
- Uniform thickness,
- Uniform distribution of glass beads throughout the line width,
- Line widths as specified, with a tolerance of ± 1/4 inch for 4 inch (± 6 mm for 100 mm) lines and ± 1/2 inch (13 mm) for wider lines, and
- Markings have sharp edges and cutoffs at the ends.

6. For tape products, follow the manufacturer's recommendations for surface dryness, primers, adhesives, and other surface preparation requirements. Unless specified otherwise by the tape manufacturer, meet the following test for determining surface dryness before applying the tape:
- **a.** In an area of direct sunlight where the tape will be applied, place an 18 inch x 18 inch (450 mm x 450 mm) piece of polyethylene (a green or black garbage bag may be used). There should not be any holes or tears in the polyethylene.
- **b.** Tape down all the edges of the polyethylene sheet to seal all the edges and not allow any air movement to get under the polyethylene.
- **c.** Firmly tamp the tape using the tamper cart or by foot tamping.
- **d.** Allow 20-25 minutes for the polyethylene to be exposed to the direct sunlight.

e. Remove the polyethylene from the road surface. If no moisture is present on the under side of the polyethylene or on the road surface, the tape can be applied.

f. If any moisture is present, allow another hour to pass and repeat the test until no moisture is found.

B. Traffic Control.

Apply the provisions of Section 2528 to traffic control for removing and placing painted and taped pavement markings, along with the following additional requirements:

1. Place traffic control devices on the roadway before removal operations have commenced. Leave traffic control devices in place through the completed curing time of the newly applied pavement markings.

2. Do not close any longer length of lane than can be adequately removed and replace in a single working day.

3. For painted pavement markings, do not remove traffic control devices until the newly applied pavement markings are tack free.

C. Removal of Pavement Markings.

1. Promptly remove, on the same day new lines are placed, all existing pavement markings in the newly marked traffic lanes that are confusing, conflicting, or misleading to traffic. The Engineer may designate other pavement markings for removal to maximize the effectiveness of the traffic control plan.

2. Upon completion of the project, remove all new pavement markings which are applied according to this specification and would change the color or placement of existing standard pavement markings. Removal may also be required during progress of the work if lines that are no longer needed cause confusion in traffic delineation.

3. Remove existing painted pavement markings so that 90% or more of the pavement is visible. Tightly adhering markings may remain in the bottom of the tining and other depressions on the pavement surface but shall not be visible to the motorist during daytime or night time. Remove tape markings according to the manufacturer's recommendations. Ensure removal processes do not cause functional damage to the transverse or longitudinal joint sealant materials.

4. Conduct pavement marking removal operations in a manner so that the finished pavement surface is not damaged or left in a pattern that may mislead or misdirect the motorist. When the operations are completed, power broom the pavement surface. Remove all marking removal debris from the pavement surface before the pavement is open to public traffic.

5. Perform pavement marking removal to a width no less than the width of the existing or new pavement markings plus 1 inch (25 mm). When

symbols or legends are removed, remove the entire area of the existing symbol or legend.

6. Removal will not be required prior to being covered by a construction process unless specified in the contract documents. Removal of pavement markings may be by vacuum blasting, vacuum dry grinding, wet grinding, shot blasting, or high pressure water blasting. Open abrasive blasting or dry grinding without containment will not be allowed.

7. In lieu of physical removal, existing pavement markings may be covered by removable, nonreflective, preformed tape that is prequalified according to Materials I.M. 483.06 and meets the requirements of Articles 2527.02, D, 7, and 4183.06, D.

8. Ensure pavement marking removal equipment:
- **a.** Operates without the release of dust,
- **b.** Recovers all removed material, and
- **c.** Includes a waste collection and transfer system and for dry wastes, ensure the system incorporates HEPA methods and equipment.

9. Removal operations may be halted if the process and final result is not acceptable to the Engineer.

10. Remove collected material and dispose of according to applicable Federal and State regulations.

11. Remove temporary delineators, posts, and raised pavement markers when their need no longer exists or when directed by the Engineer.

D. Pavement Marking Requirements.
Apply the following marking material placement requirements for permanent and temporary standard pavement markings:

1. Edge Lines.
Solid white lines (solid yellow line for the inside edge line for a multi-lane divided highway, including ramps and crossovers). Place approximately 3 inches (75 mm) from the edge of the pavement.

2. Center Lines for Two Lane, Two Way Highways.
Single, dashed yellow lines 10 feet (3 m) long with 30 foot (9 m) gaps between dashes.

3. Center Lines for Multi-lane, Undivided Highways.
Solid yellow lines spaced 10 1/2 inches (270 mm) apart between the inside edges of the lines.

4. Lane Lines for Multi-lane Highways (Divided and Undivided).
Single, dashed white lines 10 feet (3 m) long with 30 foot (9 m) gaps between dashes.

5. **No Passing Zone Lines.**
   a. Solid yellow lines. For PCC surfaces, place 3 inches (75 mm) outside a 4 1/2 inch (115 mm) center line or 3 1/4 inches (85 mm) outside a 4 inch (100 m) center line. For asphalt surfaces, place 10 1/2 inches (270 mm) from the adjacent center line or no passing zone line.
   b. Where there are two no passing zone lines, the center line is to be omitted, and the no passing zone lines are spaced 10 1/2 inches (270 mm) apart between the inside edges of the lines.
   c. It is intended that only the two outside paint nozzles be used for painting center lines and no passing zone lines on asphalt surfaces. Painting equipment should be equipped to change from solid line to a dashed line on the two outside paint nozzles.
6. **Dotted Lines.**
   Dotted lines are usually single, white dotted lines 2 feet (0.6 m) long with 4 foot (1.2 m) gaps between dots.

7. **Transverse Marking.**
   Transverse marking will be shown in the contract documents.

8. **Symbols and Legends.**
   Symbols and legends will be shown in the contract documents. Each of the following is a complete unit:
   a. Each RxR marking for railroad and highway grade crossing.
   b. Each SCHOOL legend (one lane or two lane).
   c. Each STOP, X-ING, ONLY, BUS, LANE.
   d. Each arrow (straight, left, right, combination, or ramp).

9. **Solid White Barrier Lines.**
   Solid white barrier lines may also be required in the contract documents.

E. Permanent Pavement Marking.

1. When permanent marking is required, place:
   - Center lines, lane lines, no passing zone lines, and edge lines,
   - Barrier lines and transverse lines,
   - Symbols and legends, and
   - Other markings required by the contract documents or by the Engineer.

2. Permanent marking will normally be required, according to this specification, for all projects on which public traffic is allowed during construction.

3. Accurately place all lines to a close tolerance using a guide extending at least 3 feet (1 m) ahead of the machine. The location of edge lines may be referenced to the pavement edge. The locations of other longitudinal lines may be referenced to accurately located longitudinal joints. Where such references do not exist or are not reliable, locate the lines as follows:

a. For straight or nearly straight lines, reference the locations to a stringline set between marking line points.
b. For curves, reference the locations to closely spaced marking line points. For sharp curves, a spacing of 10 feet (3 m) may be required.
c. Other equally effective systems the Engineer approves.

F. Temporary Pavement Marking.
The location of temporary pavement marking will be shown in the contract documents or as directed by the Engineer. Temporary pavement marking includes:

1. Diversions.
Temporarily mark roadways as follows:
a. Mark the traffic lane or roadway for traffic that is not diverted with a continuous yellow inside edge line in the approach taper, continuing as a no passing zone line through the diversion along the existing lane line.
b. For traffic that is to be diverted:
1) Place a continuous yellow line as a left edge line through both crossovers, continuing as a no passing zone line through the diversion.
2) Place a white edge line on the right pavement edge through the diversion and both crossovers.

2. On Site Detours.
a. Mark on site detours for two way traffic with two continuous no passing zone lines near the center of the roadway and two continuous white edge lines, one at each pavement edge.
b. Mark on site detours for one lane traffic with two continuous white edge lines, one at each pavement edge.

3. Marking Changes Resulting from Stage Construction.
On all sections of Primary Road open to traffic during construction activities, place center lines, lane lines, no passing zone lines, and edge lines necessary for the construction stage as shown in the contract documents or as directed by the Engineer.

4. Temporary Delineators.
Erect temporary delineators (when required) as shown in the contract documents. If not shown, space them at intervals described in Section 3D-5 of the MUTCD. Temporary delineators will usually be single, white reflectors which are to be placed:
- 2 feet (0.6 m) beyond the outside edge of the shoulder, and
- 4 feet (1.2 m) above the edge of the pavement on delineator posts.

5. Raised Pavement Markers.
a. Place raised pavement markers parallel to the line being marked at that location. Place according to the manufacturer's recommendations, subject to the Engineer’s approval.
b. For pavement crossovers, supplement the white and yellow edge line with raised pavement markers, spaced at 10 feet (3 m) on

center, from the beginning of the lane reduction taper through the reverse curves of the crossover.

G. Markings Obliterated during Construction.

1. On sections of pavement open to traffic, place pavement markings where operations have obliterated existing markings.

2. Replace pavement markings before the lane or road is opened to traffic in the following situations:

a. Multi-Lane Roads:

1) Divided.

a) Lane lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated for 50 feet (15 m) or more.

2) Undivided (Three or More Lanes) or Road with Continuous Two-Way Left-Turn Lane.

a) Lane lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated for 50 feet (15 m) or more.

c) Center lines obliterated for 50 feet (15 m) or more.

b. Two Lane Roads:

1) Paved Shoulder More Than 2 Feet (0.6 m).

a) Center lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated for 50 feet (15 m) or more.

c) No Passing Zone lines obliterated.

2) Paved Shoulder 2 Feet (0.6 m) or Less.

a) Center lines obliterated for 50 feet (15 m) or more.

b) Edge lines obliterated on curves with a radius of 1,000 feet (300 m) or less.

c) Edge lines obliterated at bridge approaches, or other obstructions within 3 feet (1 m) of the roadway, for 300 feet (90 m) or more.

d) No Passing Zone lines obliterated.

3. Within 3 working days from the day the pavement and shoulder work are completed for the project, place edge lines that are not required to be placed before the lane or road is opened to traffic. Place remaining pavement markings within 3 working days from the day the road work is completed for the project.

4. Place symbols and legends within 5 working days from the day the road is open to traffic.

H. Defective Pavement Markings.

1. Markings that are low on initial retroreflectivity up to 20% may, at the discretion of the Engineer, be accepted with a price adjustment.

2. Repair, at no additional cost to the Contracting Authority, all pavement markings which, after application and curing, the Engineer determines to be defective and not in conformance with these specifications. Remove the defective markings completely and clean to the underlying pavement surface according to the requirements of Article 2527.03, C.

Remove the defective area plus all adjacent marking material extending 1 foot (300 mm) in any direction. After surface preparation work is complete, finish the repair by reapplying new marking material over the cleaned pavement surface according to the requirements of these specifications.

I. Grooving for Pavement Markings.

1. When specified, place pavement markings in a groove cut into the pavement surface. Dry or wet cut the groove in a single pass, using stacked diamond cutting heads mounted on a floating head with controls capable of providing uniform depth and alignment. If dry cutting, use equipment that is self vacuuming. Use the equipment according to the manufacturer's recommendations.
2. Ensure the groove meets the following specifications:
   a. **Groove width.**
      Tape width plus 1 inch (25 mm) minimum.
   b. **Groove depth.**
      For profiled marking tape, a grooved depth of 0.080 inches + 0.010 inches (2.0 mm + 0.03 mm). For all other markings, a groove depth as recommended by the pavement marking manufacturer.
   c. **Groove length.**
      Full length of tape plus 3 inches (75 mm) minimum grooving transition on either end. Do not use a continuous groove for dash markings.
   d. **Groove position.**
      Minimum of 2 inches (50 mm) from edge of the longitudinal joint.
   e. **Finished surface.**
      The bottom of the groove should have a fine corduroy-like texture. The maximum allowable rise between the high and low points across the width of the groove is 0.010 inch (0.25 mm).
   f. **Groove cleaning.**
      Vacuum and broom dry cut grooves using a high pressure air blast for the final cleaning. If wet cutting is used, immediately flush the groove with water and recover the removed material. Allow the surface to dry to a visibly dry condition. Ensure the surface to receive the tape is free from dust, dirt, or other contaminates that may interfere with the tape properly bonding.

J. Limitations.

1. When pavement markings are required, coordinate their application with other construction work and associated traffic control changes.

2. Use removable tape for temporary pavement markings which extend diagonally across a final traffic lane.

3. When the installation of preformed polymer pavement marking material or profiled pavement marking tape is in conjunction with placement of HMA, inlay the tape by positioning it on the HMA prior to the final rolling. Perform the installation of the tape according to the manufacturer's

recommendations. If grooving is specified, do not inlay the tape into hot HMA.

4. When pavement markings are placed on newly completed PCC pavements, remove the existing curing compound film from horizontal surfaces in these locations. Curing compound film need not be removed from curbs or other vertical surfaces. Remove the curing compound in a manner that does not damage the underlying PCC pavement.

5. Complete the placement of pavement markings before the lane, road, on-site detour, or diversion is open to traffic.

6. If unavoidable circumstances result in not being able to complete the pavement marking placement or removal specified for that day, provide traffic control until the pavement marking placement or removal work is completed.

K. Maintenance.
Maintain in good condition all pavement markings, symbols and legends, temporary delineators, and raised pavement markers for which the Contractor is responsible. Replace, if necessary, for the period of their intended use. Their condition is subject to review by the Engineer.

2527.04 METHOD OF MEASUREMENT.

A. Measurement for pavement markings, symbols and legends, temporary delineators, and raised pavement markers, satisfactorily placed or approved, will be as follows:

1. **Painted Pavement Markings.**
Stations (meters) of the type specified placed with traffic paint. This includes both permanent and temporary pavement marking.

2. **Permanent Tape Markings.**
Stations (meters) placed of the type specified in the contract documents.

3. **Removable Tape Markings.**
Stations (meters) placed. Removing removable tape will not be measured separately for payment.

4. **Painted Symbols and Legends.**
By count for the type specified complete as a unit placed with traffic paint.

5. **Precut Symbols and Legends.**
By count for each complete unit placed with the marking tape specified in the contract documents.

6. **Temporary Delineators.**
By count.

7. **Raised Pavement Markers.**
By count.

8. **Pavement Markings Removed.**
Stations (meters). Pavement markings obliterated during construction, that are of removable marking tape, or removed by the Contractor on the Contractor's own accord, will not be measured separately for payment.

9. **Symbols and Legends Removed.**
By count. Symbols and legends obliterated during construction or removed by the Contractor on the Contractor's own accord, will not be measured separately for payment.

10. **Removable, Nonreflective, Preformed Tape.**
Stations (meters) of Removable, Nonreflective, Preformed Tape placed. Removal of the tape will not be measured separately for payment.

11. **Grooves Cut for Pavement Markings.**
Stations (meters). This quantity will be equivalent to the number of stations (meters) measured for the Pavement markings. Additional width and transition length will be incidental.

12. **Grooves Cut for Symbols and Legends.**
By count for grooves cut for profiled marking tape. Each symbol or legend groove will be counted as a complete unit.

B. The Engineer will measure the number of stations (meters), based on a single 4-inch (100 mm) width, or painted, taped, and/or removed line. The length of each type of markings will be determined using beginning and ending points, and adjusting for breaks at side roads, median crossings, station equations, or other locations shown in the contract documents. The measurement for dashed and dotted lines will be adjusted to exclude skips. Measurement of lines wider than 4 1/2 inches (115 mm) will be adjusted by the quantity factor to a 4 inch (100 mm) line.

2527.05 BASIS OF PAYMENT.

A. Payment for pavement marking, symbols and legends, temporary delineators, and raised pavement markers, satisfactorily placed or removed, will be at the contract unit price as follows:

1. **Painted Pavement Markings.**
Per station (meter) of the type specified, placed with traffic paint, including both temporary and permanent marking.

2. **Permanent Tape Markings.**
Per station (meter) placed for the type of marking tape specified in the contract documents.

3. **Removable Tape Markings.**
   a. Per station (meter) placed.

b. Payment includes removing the removable marking tape, when required.

4. Painted Symbols and Legends.
Each.

5. Precut Symbols and Legends.
Each.

6. Temporary Delineators.
Each.

7. Raised Pavement Markers.
Each.

8. Pavement Markings Removed.
Per station (meter).

9. Symbols and Legends Removed.
Each.

10. Removable, Nonreflective, Preformed Tape.
a. Per station (meter) placed.
b. Payment includes removal of the tape and repairing damage to the existing pavement markings caused by the tape.

11. Grooves Cut for Pavement Markings.
Per station (meter).

12. Grooves Cut for Symbols and Legends.
Each.

B. Payment is full compensation for:
- Cleaning and surface preparation,
- Application of temporary and permanent pavement markings, symbols and legends,
- Maintenance of pavement markings,
- Removal of pavement markings or symbols and legends,
- Installing or removing temporary delineators,
- Installing or removing raised pavement markers, and
- Furnishing all materials, equipment and labor, and disposal of material generated from the removal operations.

Section 2528. Traffic Control

2528.01 DESCRIPTION.

A. General.

1. This section describes various materials, equipment, and procedures involved in traffic control during construction. The Contractor and the

Contracting Authority have certain responsibilities, whether public traffic is allowed or is prohibited during construction. Apply Article 1107.09.

2. The contract may include an item for traffic control. In this case furnish, erect, operate, maintain, move, and remove all traffic control devices required by the contract documents.

3. The contract may indicate that traffic control is incidental. In this case the Contracting Authority will furnish all signs and traffic control devices, except pilot car and flaggers' signs, and all Type III barricades, and associated mounting devices. Furnish all other traffic control devices required. Erect, operate, maintain, move, and remove all traffic control devices. Signs and barricades to be furnished by the Contracting Authority will be made available at a nearby maintenance site. Return the signs and barricades when no longer needed.

4. The contract documents may specify orange mesh safety fence be used in conjunction with other traffic control devices as part of the project traffic control requirements. Use orange mesh safety fence meeting the requirements of Article 4188.03. Securely support the fence so it is in a vertical position without any sagging. Locate and place the safety fence supports so they are not a safety hazard.

5. Ensure all traffic control complies with the current edition of the MUTCD, Part VI as adopted by the Department.

6. On Interstate and Primary Road projects, use Category I and Category II traffic control signs and devices that meet NCHRP Report 350. Category I devices are defined as low mass, single-piece traffic cones, tubular markers, single-piece drums, and delineators. In order for these devices to meet the Category I limitations, no lights or signs may be attached to them. Category II devices are defined as vertical panels, Type I, II, and III barricades, and moveable skid mounted sign stands.

7. Provide the following to the Engineer for the purpose of documenting the crashworthiness of Category I and Category II traffic signs and control devices:
   a. The vendor’s self-certification for Category I devices.
   b. FHWA NCHRP Report 350 approval memos for Category II signs and devices.

8. A list of approved Category II traffic control devices is found on the World Wide Web at the following URL: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/wzd/.

9. Gender specific signs, such as FLAGMAN and MEN WORKING, will not be allowed. Use neutral gender signs, for example FLAGGER, or equivalent symbol signs.

B. Monitoring With Incident Response.

1. Provide 24 hour per day continuous monitoring of traffic control devices and incident response for emergency situations on projects during complex traffic situations as defined in the contract documents. The contract documents will identify projects requiring monitoring with incident response. Ensure a vehicle and operator traverses the project throughout the entire traffic control zone at all times, except for refueling and short rest breaks no greater than 15 minutes in duration.

2. Furnish this work according to the contract documents any time that signs, barriers, barricades, or other traffic control devices are in place during complex traffic situations.

3. Provide a vehicle and operator for this work as follows:

a. Equipment.

1) Meet the following requirements:

a) 3/4 ton (or metric equivalent) pickup truck or another similar vehicle.

b) Contractor's insignia on the vehicle.

c) Adequate weight and power and suitably equipped to move stalled automobiles or pickup trucks.

d) Equipped with an amber revolving light or amber strobe light visible in all directions and a cellular telephone or similar type of mobile phone.

e) Capable of carrying traffic signs, tools, traffic control devices, and other necessary equipment.

2) When used on projects where more than one lane in one direction is maintained at all times, ensure this vehicle is also be equipped with a Type C arrow panel as described in Article 2528.03, G, mounted to be visible to traffic approaching from behind.

b. Operation.

1) Furnish an operator for the vehicle. Ensure the operator re-erects, repairs, or replaces defective devices immediately upon discovery.

2) Have the operator:

a) Be available to assist persons with vehicle problems and move automobiles, pickup trucks and other obstructions so as to keep all travel lanes and shoulders available for public traffic.

b) Continue assistance to motorists and involvement with obstructions until they are no longer an impediment to traffic and further assistance can be provided safely by others.

c) Assist motorists or remove obstructions promptly and safely when a vehicle or anything else is obstructing a travel lane or shoulder intended to be clear.

d) Summon further assistance if needed.

e) Keep a report of any events that restrict the normal traffic flow during complex operations, including responses to

emergency situations, on forms provided by the Engineer. Provide the Engineer with a copy of this report daily.

3) The Engineer may request to operate project related Portable Changeable Message Signs (PCMS) according to Article 2528.03, B, for advance traffic notification and warning. Authority to operate PCMS units will be under the direction of the Engineer according to the contract documents. Only the Engineer may add or modify any preprogrammed messages. The Contractor may only operate the CMS to display one of the preprogrammed messages.

4) During anticipated peak traffic times, the Engineer may direct the Contractor to provide additional monitoring personnel for PCMS operation and other traffic monitoring functions.

C. Traffic Quality Control.

1. Maintain a Traffic Control Technician on staff, even though the traffic control portion of the contract may be subcontracted. The Traffic Control Technician is required to have attended and passed the exam in an ATSSA Traffic Control Technician or IMSA Work Zone Traffic Control training class. This Traffic Control Technician is responsible for overall management of the Contractor's quality control program for traffic control.

2. On a daily basis as the project is constructed, perform the following quality control work associated with monitoring and documenting traffic control conditions:

a. Review all traffic control operations for compliance with contract documents and maintain a project traffic control daily diary in a format provided by the Contracting Authority. Submit this diary to the Engineer. It will become a part of the Contracting Authority's permanent project records. The Engineer may require submission of completed portions of the daily diary at routine intervals during construction of the project. In the diary include:

- Listing and station location of traffic control used each day referenced to the appropriate Standard Road Plan, project plan sheet, etc.,
- All reviews of traffic control devices and operations, whether satisfactory or unsatisfactory, and corrections made,
- Approved changes to the contract document’s traffic control,
- Incidentals affecting the efficiency and safety of traffic, and
- A daily list of trained flaggers used, including hours worked.

b. Monitor traffic operations and submit proposed Traffic Control Plan changes to the Engineer for approval.

c. Coordinate all changes to the Traffic Control Plan.

d. Coordinate all traffic control operations, including those of subcontractors and suppliers.

2528.02 MATERIALS.

Use materials meeting the requirements of Part 6 of the MUTCD and Division 41 for the respective traffic control signs and devices.

2528.03 SIGNS AND DEVICES.

A. Signs.

1. Furnish signs that are of the size and type shown in the contract documents and use retroreflective sheeting meeting the requirements of Article 4186.03.

2. For Interstate and Primary projects, furnish diamond shaped warning signs that are 48 inches (1200 mm) by 48 inches (1200 mm) unless specified otherwise in the contract documents.

3. For traffic control zones in duration for 4 calendar days or more, mount signs on fixed posts.

4. Signs for traffic control zones in duration for less than 4 calendar days may be mounted on moveable skids or fixed posts.

5. Meet the following requirements for fixed post mounted signs:
- **a.** Sign sheeting applied to rigid wood or metal.
- **b.** Mounted at a height of at least 7 feet (2.2 m), measured from the bottom of the sign to the near edge of the pavement. A secondary sign on the same post may be mounted 1 foot (0.3 m) lower than specified above.
- **c.** A clear distance 2 feet (0.6 m) behind a curb or beyond the edge of the shoulder.

6. Meet the following requirements for moveable skid mounted signs:
- **a.** Flexible roll-up sheeting or other skid mounted sign systems that meet NCHRP 350 requirements.
- **b.** Mounted at a height of at least 1 foot (0.3 m) above the roadway.

7. Ensure mounting devices are not so substantial as to be a hazard to vehicles. Meet the following requirements for posts mounted in existing soil:
- **a.** Wood sign supports meeting the materials requirements of Article 4164.04.
- **b.** 3.0 pounds per foot (4.5 kg/m) U-shaped rail steel posts.
- **c.** 2 1/4 or 2 1/2 inch (60 mm or 65 mm) square 12 gage perforated steel tubing.

8. Dual-post and triple-post configurations using these sign supports are acceptable provided that no more than two posts occupy any 8 foot (2.4 m) wide path. Bracing of these posts will not be permitted. Posts exceeding these requirements shall have breakaway features approved by the Engineer.

9. Ensure signs are in a condition so they are effective for the intended purposes when viewed from a vehicle. For nighttime installations, ensure the reflectance is adequate so that the message is clearly readable. Ensure signs are maintained in a near vertical position.

10. When indicated in the contract documents, use supplemental sign flags in conjunction with work zone signing. Use sign flags 16 inches (400 mm) square and sheeted with red Type III or Type IV retroreflective sheeting meeting requirements of Article 4186.03.

11. On projects where two new lanes are being constructed adjacent to an existing two lane highway, place TWO WAY TRAFFIC (W6-3) signs. Place them off the right shoulder of mainline: 1) after each public side road for each direction of travel for traffic that may enter from all intersecting side roads; or 2) at 1/2 mile (0.8 km) intervals, whichever is less. Install these signs when grading activities start and leave in place until the entire four lane divided highway is opened to traffic. If the pavement is constructed under a separate contract, leave these signs in place after the grading contract is completed. They become the property of the Contracting Authority. The paving contractor then takes over these signs and removes them when the four lane divided highway is opened to traffic. Payment will be according to Article 2528.05, A.

12. When directed by the Engineer, cover or remove permanent signing that conveys a message contrary to the message of the temporary signing and not applicable to the working conditions.

13. The END ROAD WORK (G20-2) sign may be eliminated for mobile or short duration (less than 1 hour) temporary traffic control zones.

B. Portable Changeable Message Signs

Furnish, place, operate, and maintain PCMS at the locations shown on the plans. The Contractor maintains possession of the PCMS upon completion of the project.

1. Sign Design.

a. Trailer mounted signs. Message panel mounted at a height of at least 7 feet (2.2 m), measured from the bottom of the sign to the near edge of the pavement. Sign presents a level appearance. Sign is capable of displaying three lines of up to eight characters at one time. Character height is 18 inches (450 mm) and configured using a 7 pixel tall by 5 pixel wide font.

b. Message panel visible from 1/2 mile (800 m) under both day and night conditions. Letters legible from 750 ft (225 m). Message sign shall include automatic dimming for nighttime operation and a power supply capable of providing continuous 7 days (24 hours per day) service.

c. Message panel consisting of a line matrix or full matrix design controlled by an onboard computer capable of:

- Storing a minimum of 99 programmed messages for instant recall.

- Being programmed to accept messages created by the operator via an alpha-numeric keyboard.
- Being programmed by remote.

d. Physical access to the onboard computer protected by a padlock (using a key). Electronic access to the onboard computer protected by a username and password.

2. Operation of Signs.

a. Provide preventive maintenance efforts necessary to achieve uninterrupted service. If service is interrupted and not restored within 24 hours, the Engineer will cause such work to be performed as may be necessary to provide this service, at no additional cost to the Contracting Authority.

b. The Engineer may request the Contractor to operate PCMS for advance traffic notification and warning. Authority to operate PCMS will be under the direction of the Engineer. The Contractor may only operate the PCMS to display messages authorized by the Engineer.

c. Promptly program and/or reprogram the computer to provide the messages as directed by the Engineer.

d. Provide the Engineer with the username and password and two keys.

3. Internet Operation for Long Term Duration.

a. This section describes Internet operations for use of PCMS for long term duration. PCMS hardware and software that are required for Internet operation under this article will be considered extra work according to Article 1109.03, B.

b. Communication equipment at the sign, a web server at a central communications hub, and communications from the sign to the Internet are required.

c. Make an Internet web page available as the method for the Engineer to control the sign from the office. Choose software to control the signs that is not required to be installed on the Engineer's computer. Ensure the Internet web page performs the following functions:

- Displays the name of the sign.
- Shows the current display on the message board.
- Puts up a message using free text.
- Puts up a message by calling the onboard library of stored messages.
- Removes the current message.
- Displays the current voltage of the sign's batteries (if solar).

C. Channelizing Devices.

1. Use Channelizing Devices that are of the type shown in the contract documents. Use reflective sheeting meeting the requirements of Article 4186.03.

a. Barricades.

1) A 2 foot (0.6 m) minimum length barricade may be used when Type I or Type II Barricades are furnished as one of the options for channelizing devices in lieu of vertical panels, 42 inch (1050 mm) channelizers, cones, or drums.

2) Ensure Type III barricades have a minimum length of rail of 6 feet (1.8 m). When traffic is permitted in each direction around a Type III Barricade, ensure the Type III Barricade used has fully reflectorized faces on both sides of the rails.

3) Erect barricades in essentially a horizontal position perpendicular to the direction of approaching traffic. Ballast them so as not to cover any striped rail.

b. Cones, Vertical Panels, 42 Inch (1050 mm) Channelizers, Drums, and Tubular Markers.

1) Ensure cones, vertical panels, 42 inch (1050 mm) channelizers, drums, and tubular markers meet the current requirements of the MUTCD, and Section 4188.

2) When used to separate two way traffic, separate temporary no passing lines approximately 16 inches (400 mm), with the marker to be installed between these lines.

3) Ensure tubular markers meet the following:

a) Between 28 inches (710 mm) and 34 inches (865 mm) in height.

b) Diameter facing traffic at least 2 inches (50 mm) in width.

c) Completely faced with reflectorized white and orange sheeting that is in two bands 4 inches (100 m) wide with 6 inches (150 mm) between bands, with the top band no more than 2 inches (50 mm) from the top of the tubular marker.

4) Cones may be used as channelizing devices in tapers and along lane lines during daylight hours only.

2. Channelizing devices may be placed up to 2 feet (0.6 m) beyond centerline or lane line at specific locations where actual work activity is taking place. Return channelizing devices to the original position when the work activity has passed.

3. Individual channelizing devices may be omitted during working hours in areas where placement interferes with the work. Channelizing devices on tapers are required at all times.

4. Do not intermix channelizing devices of different types.

D. Pilot Cars.

1. Pickup trucks or automobiles displaying the Contractor's company insignia, equipped with G20-4 signs reading: PILOT CAR - FOLLOW ME. Ensure two signs are mounted on the vehicle so as to be clearly visible from both directions of traffic. Mount the signs so the bottoms are at least 1 foot (0.3 m) above the top of the vehicle's roof.

2. Operate pilot cars such that they maintain a uniform speed through the work area, no greater than 40 miles per hour (65 km/hr).

E. Temporary Barrier Rail.

Use temporary barrier rail as shown in the contract documents. Unless shown otherwise, use precast concrete units. Tie the units together as specified or as approved by the Engineer.

F. Modular Glare Screens.

1. When specified in the contract documents furnish, install, and maintain a modular glare screen system on the top of concrete barrier rail according to the contract documents and the modular glare screen system manufacturer's instructions. Furnish a system consisting of modular base units attached to the top of concrete barrier rail with blades evenly spaced and securely mounted to the base units. Ensure the following:
   - Modular base units and glare screen blades are compatible so the base unit and blades can be securely attached to each other.
   - Base units and blades supplied are manufactured by the same manufacturer.
   - The length of individual modular base units is no longer than the nominal length of individual temporary concrete barrier rail sections.
   - The width of the modular base units is no wider than the top width of the concrete barrier rail.
   - Glare screen blades are FHWA highway green in color and made of impact resistant non-metallic high density plastic material.
   - Blade height is from 24 inches to 30 inches (600 mm to 750 mm) and width is from 6 inches to 9 inches (150 mm to 225 mm).
   - The same uniform sized blades are used throughout the work.
   - The modular glare screen system is manufactured by a company on the approved manufacturer’s list in Materials I.M. 486.06, Appendix A.

2. Install the modular glare screen system according to the manufacturer's instructions and the approval of the Engineer. Install the system so that:
   - It is centered along the longitudinal axis length of the top of the concrete barrier rail.
   - The overhang of the base units, blades, and associated assembly over the edges of the top of the concrete barrier rail is kept to a minimum.
   - The modular base units are flush with the top of the concrete barrier rail and they do not extend over the joints between concrete barrier rail sections.

3. Install glare screen blades so the combination of blade width and spacing provide for a minimum 22 degree sight cut-off angle.

4. At 10 foot (3 m) intervals along the glare screen installation, apply (appropriate to the direction of traffic) 3 inch by 6 inch (75 mm by 150 mm) yellow or white strips of Type III or IV retroreflective sheeting

meeting the requirements of Section 4186 to the appropriate glare screen blades. Apply each strip at the vertical midpoint of the glare screen blade and to the side of the blade nearest to traffic. Apply the strip with the longer dimension vertical.

5. Maintain the modular glare screen throughout the work. Replace or repair damaged parts of the modular glare screen system, as soon as practical, at no additional cost to the Contracting Authority.

6. When moving temporary barrier rail with a modular glare screen system, the Contractor may temporarily remove base units and glare screen blades, if necessary, to assist in the moving. Reinstall the removed base units and glare screen blades as soon as the temporary concrete barrier rail has been moved to its new location.

7. Perform final removal of the modular glare screens from the concrete barrier rail when directed by the Engineer. Upon removal, ensure there are no protrusions on the top of the concrete barrier rail.

8. Upon completion of the work, the Contractor retains ownership of the modular glare screen system.

G. Lighting Devices.

1. Furnish lighting devices as required by the contract documents. Type A barricade warning lights will normally be required for nighttime installations. Type B warning lights will normally be required for 24 hour operation.

2. Use barricade warning lights that comply with the ITE Standard for Flashing and Steady Burn Barricade Warning Lights and are identified as such. In addition, use Type A barricade warning lights that:

- Operate on a 12 volt battery system, unless the ITE identification specifically indicates that the rating is based on a different system, and
- Are visible to both directions of traffic.

3. When arrow displays are used, furnish Type C arrow displays described in the current edition of the MUTCD, Part 6, and operate them in a sequential chevron mode when indicating a lane change.

H. Temporary Traffic Signals.

1. General.

a. Set up and operate temporary traffic signals as shown in the contract documents. Ensure the temporary traffic signal system meets the physical display and operational requirements of conventional traffic signals as specified in Part 4 of the MUTCD. Unless stated otherwise in the contract documents, either a span wire or trailer mounted temporary traffic signal system may be provided.

b. In the event any part of the temporary traffic signal system malfunctions or a continuous red flash mode is encountered, furnish flaggers on a 24 hour/7 day a week basis until repairs are

made and the signals are fully functional. For temporary traffic signals at intersections, install stop signs on all approaches until the signals are fully operational, at no additional cost to the Contracting Authority.

2. Equipment.

a. Trailer or Span Wire Mounted Systems.

1) Furnish actuated signal controllers complying with NEMA and ITE standards. Ensure the temporary traffic signal system complies with the following:

a) Includes a solid state digital traffic signal controller capable of operating the signals according to MUTCD requirements and NEMA Standard TS1. A copy of the manufacturer's certificate of compliance is to be posted in the control cabinet (in a weatherproof folder) and made available to the Engineer upon request.

b) Has conflict monitoring complying with NEMA Standard TS1 and the following:

- Detects the presence of conflicting signal indications, absence of proper voltages, and proper operation of the controller.
- Upon detection of a conflict or loss of communication, all signals enter into flashing red mode.

2) Apply Article 2525.03, E, 4, with the following exceptions for one lane two way traffic control:

a) Green Revert.
If during an All Red clearance interval a call occurs on the phase losing the right-of-way prior to a call on any other traffic phase, the right-of-way reverts to the previous traffic phase, initiating the initial green interval. The transfer is to be immediate without completing the All Red clearance interval.

b) Rest in Absence of Actuation.
In the absence of detector actuation of assertion or recall switch(es), the right-of-way indication dwells in All Red.

3) Comply with the following:

a) Clearance for overhead wiring is a minimum of 18 feet (5.5 m).

b) A detection area is located near the stop line with the downstream edge positioned 6 feet (2 m) from the stop line. A second detection area is located 100 to 150 feet (30 to 45 m) in advance of the stop line. The size of detection areas is 6 feet by 10 feet (2 m by 3 m). A single above-ground detector may be used to provide detection for both areas.

c) Signal heads have 12 inch (300 mm) lenses and comply with ITE Specification "Vehicle Traffic Control Signal Heads". All signal heads are equipped with visors and back plates. The backplate provides a minimum of 5 inches (125 mm) black field around the signal assembly and has a dull black finish.

d) A minimum of two traffic signal heads per approach. All signal heads mounted over the road surface are mounted a minimum of 15 feet (4.6 m) from the bottom of the signal head to the top of the road surface. One signal head mounted over the center of the travel lane. All far right signal heads mounted a minimum of 8 feet (2.45 m) from the bottom of the signal head to the top of the ground surface. Required signal heads for through traffic on any one approach located no less than 8 feet (2.4 m) apart measured horizontally perpendicular to the approach between the centers of the signal faces.

b. Trailer Mounted Systems.
Provide a system consisting of two or more self-contained trailer mounted units each containing two signal heads.

c. Span-Wire Mounted Systems.
Ensure posts meet the requirements of Article 2528.03, A.

3. Operational Requirements.

a. Locate signals, stop bars, and signs exactly as identified in the contract documents. Secure and level temporary traffic signal installations in a manner approved by the Engineer.

b. Program all temporary traffic signals for red flash upon startup, conflict, or power failure. Program the temporary traffic signal system to dwell in All Red.

c. For one lane two way traffic control operations, when an additional phase is used for a side road movement, only one long all red interval is to be used between active phases on each side of the work area.

d. Set signal timing as identified in the contract documents.

4. Equipment Crossings.

a. For equipment crossings, use a signal operator to control the signal system. Position this operator with good sight distance for both the mainline and haul road.

b. Program the signal system with fixed yellow and all red time periods so the operator can only activate the beginning of the yellow interval for mainline traffic.

c. When the equipment crossing is not in use, set the signal to yellow flash mode. If hauling operations are suspended for more than one week, cover the signal heads, or if portable trailer units are used, remove the trailers.

I. Temporary Floodlighting.

1. Ensure floodlighting is installed and in service before work is started that requires nighttime traffic control by the traffic control plan.

2. Ensure temporary floodlighting meets the following:

a. Pole-mounted luminaire or a luminaire mounted on portable equipment.

b. Mounting height of luminaires is no less than 35 feet (11 m) above the roadway, and as shown in the contract documents. Pole length

determined by field measurement to obtain specified mounting height.

c. Clearance for overhead wiring a minimum of 18 feet (5.5 m). Auxiliary poles used to furnish power to floodlighting offset 30 feet (9 m) from the traveled way unless there are right-of-way restrictions.

d. Poles placed outside the normal shoulder line at the approximate locations shown in the contract documents.

e. Above ground lighting circuits are aluminum or A.C.S.R. triplex.

f. Underground lighting circuits are type U.S.E. or U.F.

3. Meet the following requirements for luminaires used for floodlighting:

a. Standard roadway types with totally enclosed refractors.

b. IES glare control rating of "cut off".

c. The lamps with an initial output rating of 19,000 lumens or greater.

d. Photoelectric controlled for dusk to dawn operation.

e. Approval of the Engineer.

4. Exercise reasonable care to avoid interruptions during the hours of darkness, promptly repair damage to the system, and replace all burned out lamps as soon as possible.

J. Temporary Crash Cushions.

Apply Section 2551.

K. Flaggers.

1. Prior to flagging operations, ensure the flaggers are trained in safe flagging operations that comply with Iowa DOT Flagger's Handbook, Part 6 of the MUTCD, and the Standard Specifications. Ensure training of flaggers includes the following:

a. Issuing and reviewing the current Iowa DOT Flagger's Handbook,

b. Presentation of the current Iowa Professional Flagging Video,

c. Issuing flagger training cards including the information below. Ensure the flaggers carry their flagger training card at all times and show it upon request.

1) Employee name,

2) Date of training,

3) Name of Instructor, and

4) Expiration date of December 31 of the year following the training date.

2. Maintain a list of the flaggers trained and the date of the training.

3. Training is not required for short time, emergency, or relief assignment of employees to flagging operations. Payment will not be made in accordance with Article 2528.05, I.

4. Ensure flagger operations, equipment, and apparel comply with the current Iowa DOT Flagger's Handbook.

5. When nighttime flagging is required, provide auxiliary lighting to illuminate the flagging stations according to the current Iowa DOT

Flagger's Handbook. Set up this lighting in such a manner to minimize glare to motorists. The cost of furnishing nighttime flagging stations is included in the lump sum price bid for Traffic Control.

L. Limitations.

1. Use sandbags to anchor all traffic control devices subject to movement by wind.

2. When a two way road is open to public traffic during contract work, do not control one way traffic through the work area by means of a carry through flag or other token, except during equipment failure or emergency. Use other means when voice or signal communication between flaggers at control points is difficult or not effective because of distance, sight, or noise. Other means may be two way radio, pilot cars, or traffic signals.

3. Use pilot cars when the normal work area exceeds 1/4 mile (0.4 km) on Primary projects. Where necessary for short durations, the distance may be extended to 1/2 mile (0.8 km) for better sight distance or to clear intersections or other safety considerations with approval of the Engineer, provided a two way radio is used for communication between flaggers.

4. During non-working hours, remove, cover, or turn down traffic control devices intended for working hours only, unless a drop-off or physical obstruction remains within 15 feet (4.5 m) of a lane open to traffic. Signs or barricades are not required for work beyond 15 feet (4.5 m) of a lane open to traffic. When traffic control devices are no longer needed, remove them.

5. All personnel in the highway right-of-way are required to wear ANSI 107 Class 2 apparel at all times when exposed to traffic or construction equipment.

6. The Engineer may require traffic control devices to be recleaned by washing. Use a brush and water, and detergent or solvent as necessary. Include the entire target area or sign face, supplemental or auxiliary signs, if any, all reflectors, and faces of warning lights which are part of that device.

7. Ensure entry to and exit from work areas is in the direction of public traffic and does not cross open traffic lanes at other than designated locations.

8. During hours of darkness, operate equipment in the traffic control zone facing in the direction of traffic flow unless specified otherwise in the Traffic Control Plan. Darkness will include the period from sunset to sunrise and other times when conditions such as fog, snow, sleet or rain provide insufficient lighting to clearly identify persons and vehicles on the highway at a distance of 500 feet (150 m) ahead.

9. Unless stated otherwise in the traffic control plan, provide for a minimum of 2 miles (3 km) between traffic control zones on rural roadways. The Engineer will determine minimum distances between traffic control zones on urban roadways.

10. Submit Traffic Control Plan modifications to the Engineer for review and approval prior to any changes being made. The Engineer may modify sign spacing to meet existing field conditions or to prevent obstruction of the motorist's view of permanent signing.

2528.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Traffic Control.
Lump sum.

B. Portable Changeable Message Signs.
The Engineer will count the number of days each PCMS is required to be in a location to display potential messages to the traveling public.

C. Temporary Barrier Rail.
The Engineer will calculate the length of temporary barrier rail used based on count and the nominal length of each unit. The length of temporary barrier rail measured will be the length required per setup. Measurement will also be made for temporary barrier rail moved within, or added to, an existing setup when required by the contract documents. Measurement of temporary barrier rail, after its initial placement, will not be made unless it is required by the contract documents to be moved.

D. Modular Glare Screen.
Measurement for Modular Glare Screen System will be in liner feet (meters).

E. Temporary Crash Cushions.
Article 2551.04 applies.

F. Temporary Traffic Signals.
By count for each group installation of temporary traffic signals operated by a common control unit. A group installation is normally four signal heads at the same traffic conflict area.

G. Temporary Floodlighting Luminaire.
By count.

H. Pilot Cars.

1. By count for the number of days each pilot car was used.

2. For a pilot car to be counted:

a. Use of the pilot car is necessary and it is used as part of preplanned work that is started that day and is intended to proceed for a major part of the day. If used less than 4 hours in a calendar day, the operation will be counted as a half-day. If a pilot car is

used for more than 16 hours in a calendar day, the pilot car will be counted as 2 days.

b. Use of other pilot cars is necessary and they are used for at least 1 hour during the day, perhaps intermittently, and this shall be the primary duty of the employee. If used less than 4 hours in a calendar day, the pilot car will be counted as a half-day.

3. Short time, emergency, or relief assignment of employees to pilot car operations will not be counted separately.

I. Flaggers.

1. By count for the number of days each flagger was used.

2. For flaggers to be counted:

a. Use of the flaggers is necessary and they are used as part of preplanned work that is started that day and is intended to proceed for a major part of the day. If used less than 4 hours in a calendar day, the flagger will be counted as a half-day.

b. Use of other flaggers is necessary and they are used for at least 1 hour during the day, perhaps intermittently, and this shall be the primary duty of the employee. If used less than 4 hours in a calendar day, the flagger will be counted as a half-day. If a flagger is used for more than 16 hours in a calendar day, the flagger will be counted as 2 days.

3. Short time, emergency, or relief assignment of employees to flagging operations will not be counted separately.

J. Monitoring with Incident Response.

Calendar days based on the contract quantity. Additional personnel required by the Engineer to provide additional traffic monitoring of CMS operation will be measured in calendar days per person needed.

2528.05 BASIS OF PAYMENT.

Payment will be at the contract unit price as described below. When the Engineer requires recleaning of reflectorized surfaces of traffic control devices, payment will be made as extra work according to Article 1109.03, B. All traffic control devices furnished by the Contractor remain the Contractor's property at the completion of the work and are to be removed from the site when no longer needed.

A. Traffic Control.

1. Lump sum when there is a contract item for Traffic Control.

2. Payment is full compensation for:

- Erecting, maintaining, moving, and removing all traffic control devices required by the contract documents, including warning lights,
- Furnishing all materials, labor, and equipment, and
- Traffic quality control.

B. Portable Changeable Message Signs.

1. Payment will be the contract unit price per calendar day for each PCMS that is required to be in a location to display potential messages to the traveling public.

2. Payment is full compensation for furnishing, placing, operation, and maintenance of PCMS. Payment includes the cost of communication, software, hardware, and power supply.

C. Temporary Barrier Rail.

1. Linear feet (meters) of Temporary Barrier Rail measured.

2. Maintenance of temporary barrier rail is incidental to Temporary Barrier Rail.

D. Modular Glare Screen.

1. Per foot (meter) of Modular Glare Screen System measured.

2. Payment is full compensation for:

- Material,equipment, and labor to furnish and install the system on the top of the temporary concrete barrier rail,
- Furnishing and applying retroreflective strips,
- Maintenance of the system,
- Repairing or replacing damaged parts of the system,
- Removing and reinstalling the system if necessary when moving the concrete barrier rail, and
- Final removal of the system from the top of the concrete barrier rail.

E. Temporary Crash Cushions.
Section 2551.05, A, applies.

F. Temporary Traffic Signals.

1. Each, for individual group installations operated by a common control unit, normally four signal heads at the same traffic control area.

2. Payment is full compensation for furnishing, installing, maintaining and servicing the controller, signal heads, traffic detection system, signal operator, costs for electrical energy, and the cost of removing temporary traffic signal materials from the construction site. The Contractor shall supply their own breaker box and power meter and shall not connect to existing Contracting Authority owned circuits to supply power for temporary traffic signals.

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G. Temporary Floodlighting Luminaire.

1. Each.

2. Payment is full compensation for:
- Furnishing, installing, maintaining and servicing the temporary floodlighting units,
- All costs for electrical energy,
- The cost of removing all lighting materials from the construction site, and
- The Contractor shall supply their own breaker box and power meter and shall not connect to existing Contracting Authority owned circuits to supply power for temporary floodlighting.

H. Pilot Cars.
Predetermined contract unit price per day for the number of days each pilot car was operated.

I. Flaggers.

1. Predetermined contract unit price per day for the number of days each flagger was used.

2. Payment is full compensation for providing trained flaggers according to Article 2528.03, K.

J. Monitoring with Incident Response.

1. Per calendar day for the number of calendar days used.

2. This payment is full compensation for:
- Furnishing the necessary vehicle (including operation, maintenance, and supplies),
- Furnishing the operator,
- Documentation of any events that restrict the normal flow of traffic including responses to an emergency situation,
- Re-erecting, repairing, or replacing traffic control devices,
- Providing assistance to persons with vehicle problems,
- Moving stalled vehicles, and
- Summoning further assistance when needed.

3. Payment for the number of calendar days that additional personnel, such as for CMS operation required by the Engineer, will be the contract unit price per calendar day. Payment is full compensation for furnishing the required personnel and necessary support vehicles.

Section 2529. Full Depth Finish Patches

2529.01 DESCRIPTION.

A. Remove pavement in areas designated by the Engineer to be patches. Restore the subbase and/or subgrade and furnish and place subbase aggregate, furnish and place patching material, and restore the shoulder area. Construct a new finished traffic surface in the patch area.

B. Work under this specification may include the types of patches listed below. Generally, the patch type will be consistent with the existing pavement.

1. Full depth HMA finish patches.

2. Full depth PCC finish patches, without dowels.

3. Full depth PCC finish patches, without dowels, composite section.

4. Full depth PCC finish patches, with dowels.

5. Full depth PCC finish patches, with dowels, composite section.

6. Full depth PCC finish patches, continuously reinforced.

7. Full depth PCC finish patches, continuously reinforced, composite section.

2529.02 MATERIALS.

A. Hot Mix Asphalt Mixture.
Unless stated elsewhere in the contract documents, use HMA meeting or exceeding Section 2303 requirements for a 300,000 ESAL surface mixture with a PG 64-22 Performance Graded asphalt binder.

B. Portland Cement Concrete.
It is the intention to obtain concrete with a high early strength for early opening to traffic. Meet the requirements of the current Materials I.M. 529 with the following modifications:

1. Slump.

a. Slump, measured according to Materials I.M. 317 prior to addition of calcium chloride solution, is to be between 1 inch (25 mm) and 2 1/2 inches (65 mm) as a target range, allowing a maximum of 3 inches (75 mm). If calcium chloride solution is not to be added, the slump is to be between 1 inch (25 mm) and 3 inches (75 mm) as a target range, allowing a maximum of 4 inches (100 mm).

b. When a Type A Mid Range water reducing admixture is used, the slump, tested prior to the addition of calcium chloride, is to be between 1 inch (25 mm) and 4 inches (100 mm) as a target range, allowing a maximum of 5 inches (125 mm).

2. Air Entrainment.
The entrained air content of the unconsolidated concrete will be determined according to Materials I.M. 318, prior to addition of calcium chloride if it is to be added. The air entrainment shall be as follows:

a. When calcium chloride is to be added: 5.0%, with a tolerance of ± 2.0%.

b. When no calcium chloride is to be added: 6.5%, with a tolerance of ± 1.5%.

3. Temperature.
Refer to Paragraph 4 below for temperature requirements of Full Depth Portland Cement Concrete patching material, as delivered to the job site. Heat the water or aggregate, or both, if necessary to meet this requirement. The cost of heating is incidental to patching.

4. Cement.
For Class M mixes, meet the requirements of Section 4101. Table 2529.02-1 lists cement types and maximum allowable substitution rates. The maximum substitution for Type IS shall not exceed 25%.

Table 2529.02-1: Cement Types and Maximum Allowable Substitution Rates

Patch Type	Cement Type	Maximum Allowable Substitution	Minimum Mix Temperature
5 Hour	Type I, Type II Type IS	0% Fly Ash 0% Fly Ash	75ºF (24ºC) 80ºF (27ºC)*
10 Hour	Type I, Type II Type IS	10% Fly Ash 0% Fly Ash	65ºF (18ºC) 70ºF (21ºC)*
* When a Type A Mid Range Water reducing admixture is used, limit the minimum mix temperature to that required when Type I/II cement is used.			

5. Calcium Chloride.

a. When calcium chloride is required, furnish it in water soluble form and add it to the mixture at the job site. Use a commercial 32% calcium chloride solution, or equivalent, prepared according to Table 2529.02-2:

Table 2529.02-2: Proportions for 32% Calcium Chloride Solutions

Type of Solid Calcium Chloride	Pounds (Grams) of Solid per Gallon (liter) of Water	Solution Produced per Gallon (Liter) of Water
Type 1 – Regular Flake (77% material)	7 (840)	1.35
Type 2 – Concrete Flake or Pellets (94% material)	5 (600)	1.18

b. Add the solution at the rate of 2.75 gallons per cubic yard (13.6 L/m^3) of concrete. The Engineer may approve alternate calcium chloride solutions of different concentrations provided appropriate adjustments in the total concrete composition are made.

c. Agitate the mixture until the calcium chloride is completely in solution. Continue agitation, as necessary, to maintain uniformity. The calcium chloride will crystallize out of a 32% solution at 20°F (-

7°C), so the solution shall be maintained at a higher temperature at all times.

d. Except when using continuous mixing equipment described in Article 2001.20, E, ensure the calcium chloride solution is present in the mix for at least 2 minutes of mixing.

6. Water Reducer.
A Type A Mid Range water reducing admixture may be used. Use one listed in Materials I.M. 403, at the manufacturer's recommended dosage.

7. Aggregate Durability.
Unless specified otherwise, use coarse aggregate of the proper class of durability as defined in Article 4115.04.

8. Transit Mix Concrete.
Use a mix from a plant from which the concrete can be delivered and placed within 60 minutes from the time of mixing. The time may be extended to 90 minutes when a retarding admixture, used according to Materials I.M. 403 including temperature dosage guidelines (and at no additional cost to the Contracting Authority), is added at the plant. Continuous mixing equipment using volumetric proportioning may be used according to Article 2001.20, E. Place the concrete within 30 minutes after introduction of calcium chloride.

9. Concrete Mixtures.
For PCC patches, use Class M mixtures with calcium chloride. The Engineer may waive the use of calcium chloride on patches cured longer than 10 hours.

10. Dowel Bars and Tie Bars.
Use epoxy coated dowel bars meeting the requirements of Article 4151.02, C. Use tie bars cut from epoxy coated reinforcing bars as specified in Article 4151.03, C.

C. Joint Sealing Material.
Use joint sealer and backer rod meeting the requirements of Article 4136.02, A, 1. When joint or crack sealing or filling is a part of the contract, use only hot pour material.

D. Tack Coat Bitumen.
As specified in Article 2303.02, E.

E. Subbase.
Meet the requirements of Section 4121.

2529.03 CONSTRUCTION.

A. General.

1. The contract documents will include a tabulation of patches showing location and approximate area. This tabulation is intended primarily for

estimating purposes. The actual patch location and size will be determined by the Engineer. The patch thickness and type of patch material may be included. The contract documents will identify the existing pavement type, thickness, and reinforcement, and may identify the coarse aggregate classification. A detail, typical of each type of patch, will be shown.

2. When the contract documents include reconstruction of gore areas, this work may be done as a separate operation. For PCC patches in gore areas, mixtures with calcium chloride will be allowed. Cure the concrete as specified for the mixture used.

3. When the contract documents include joint and crack sealing, perform joint sealing of the patches as part of that work.

B. Full Depth Patch Thickness.

If full depth patch thickness is not shown in the contract documents, establish thickness as follows:

1. HMA Patches.

Interstate and Primary pavement: the thickness of the HMA pavement, but no less than 9 inches (230 mm) or more than 15 inches (380 mm).

2. PCC Patches.

a. PCC pavements on Interstate and Primary Roads: the thickness of the pavement but no less than 9 inches (230 mm) or more than 12 inches (300 mm).

b. County roads: thickness no less than 6 inches (150 mm) or more than 12 inches (300 mm).

3. Composite Patches.

PCC pavements which have been resurfaced with HMA: patch materials and thickness the same as the existing pavement except the PCC portion of the patch is not to be less than 9 inches (230 mm) or more than 12 inches (300 m) unless specified otherwise in the contract documents. If the HMA resurfacing exceeds 4 1/2 inches (120 mm) (nominal) place an HMA patch, unless specified otherwise in the contract documents.

C. Pavement Removal.

1. General.

Remove pavement for full depth patch construction according to the following requirements:

a. When repairing PCC pavement, even though it may have been resurfaced, remove the material for the full pavement depth, unless designated otherwise. Excavation will be required for the patch thickness and, if required, for the granular subbase.

b. The contract documents will include an estimate of the number of anchor lugs to be removed. When an anchor lug is encountered within an area to be patched:

- Break the anchor lug down to approximately 6 inches (150 mm) below the bottom of the pavement,

- Remove all exposed anchor lug reinforcing, and
- Replace the concrete with granular subbase aggregate, compacted as required, to the elevation of the bottom of the patch.

c. Remove reinforcement from the patch area, and to approximately 1 inch (25 mm) or less from the concrete that is to remain, except for continuously reinforced pavements.

d. Unless shown otherwise in the contract documents, construct all patches to be full lane width. The length of each patch, measured parallel to the center line, will not be less than 6 feet (1.8 m) on Interstate pavements and 4 feet (1.2 m) on other pavements except continuously reinforced full depth finish patches. Continuously reinforced patches will not be less than 8 feet (2.4 m) in length.

e. Perform pavement removal according to Article 2510.03, A.

2. Full Depth HMA Finish Patches.

Except where an existing longitudinal or transverse joint forms an edge of the patch, construct the patch edge by sawing full depth of the patch. Use a saw, a concrete cutter, or other equipment that will result in a reasonably vertical edge. For patches in HMA pavement, a 15 inch (380 mm) deep saw cut will be considered full depth. After sawing, a drop hammer, hydrohammer, or other heavy equipment may be used. Do not damage pavement that will remain.

3. Full Depth PCC Finish Patches, With or Without Dowels.

This applies to PCC finish patches for jointed PCC pavement, including composite sections of resurfaced PCC pavement.

a. Patches With Dowels.

Saw the edges of proposed patches to full depth with a blade saw.

b. Patches Without Dowels.

1) Saw the transverse edges of proposed patches to a depth of 1 1/2 inches (40 mm) with a blade saw. Sever the pavement by a full depth cut with a saw or concrete cutter approximately 1 1/2 inches (40 mm) inside the original 1 1/2 inch (40 mm) transverse saw cut. Saw the edges at center lines and lane lines with a blade saw.

2) After severance is made, pavement in removal areas may be broken by use of a drop hammer, hydrohammer, or other heavy equipment. Perform this work in a manner to not damage concrete that is to remain. Do not use heavy equipment adjacent to new concrete until the specified curing is completed.

3) Complete the preparation of patch edges using equipment no heavier than a 15 pound (7 kg) air chisel. A 30 pound (14 kg) air chisel may be used if its use does not result in significant undercutting of the pavement. The finished transverse edge shall be sawed to 1 1/2 inches (40 mm) as specified above. Remove the ledge at the bottom of the 1 1/2 inch (40 mm) saw cut to the bottom of the pavement at a uniform constant taper towards the patch interior. Limit the removal to within 0 to 1 1/2 inches (0 mm to 40 mm) from vertical. Roughen the surface to promote interlock. Avoid undercutting. If spalling at the top

edge or undercutting continues, the Engineer may withdraw permission to use equipment heavier than a 15 pound (7 kg) air chisel.

4. **Full Depth PCC Finish Patches, Continuously Reinforced.**
This method applies to PCC finish patches for continuously reinforced PCC pavement, including composite sections of resurfaced PCC pavement, where the continuous reinforcement is to be restored.
   a. Construct the transverse edges of the patch with a blade saw to a nominal depth of 1 1/2 inches (40 mm). Avoiding cutting longitudinal reinforcement. Saw the edges at center lines and lane lines with a blade saw through existing tie bars.
   b. Within the patch area, sever the pavement transversely by a full depth cut with a blade saw inside the 1 1/2 inch (40 mm) saw cut to a depth through the existing reinforcing. Locate this severance so as to leave a minimum of 20 inches (500 mm) of longitudinal steel protruding into the patch area.
   c. Break the pavement in such a manner not to damage concrete that will remain. Do not use heavy equipment adjacent to new concrete until the specified curing is completed.
   d. Use jackhammers or other hand equipment to remove pavement between the 1 1/2 inch (40 mm) saw cut and the severance. Complete the edge of the patch at the 1 1/2 (40 mm) inch saw cut using equipment no heavier than a 15 pound (7 kg) air chisel. A 30 pound (14 kg) air chisel may be used if its use does not result in significant undercutting of the pavement. Remove the shoulder at the bottom of the 1 1/2 inch (40 mm) saw cut. Ensure the edge below the saw cut is reasonably vertical, tapered to the interior of the patch, and has a rough surface to promote interlock. Work with the air chisel should continue until the taper at the bottom of the pavement is approximately within 0 to 1 1/2 inches (0 mm to 40 mm) from vertical. Avoid undercutting. If necessary, reconstruct the saw cut so the top edge at the pavement surface is not frayed or spalled. If spalling at the top edge or undercutting continues, the Engineer may withdraw permission to use equipment heavier than a 15 pound (7 kg) air chisel.
   e. Break or remove pavement in such a manner that protruding longitudinal steel is not unduly disturbed. Preserve a 20 inch (500 mm) length of longitudinal steel. Do not bend the steel more than the minimum necessary for concrete removal and subgrade or subbase compaction.

5. **Full Depth Composite Patches.**
When an existing PCC pavement has been resurfaced with 4 1/2 inches (120 mm) of HMA or less, construct the patch according to Section 2212, PCC Full Depth Repair Patches and HMA Surface Patches to result in a composite patch, unless specified otherwise in the contract documents. Lightly tack the PCC area and edges of the patch, and place the hot mixture in the remaining depth and compact, while hot, to provide a dense, smooth riding surface.

D. Restoring Subbase or Subgrade for Full Depth Finish Patches.

1. When subbase is required by the contract documents or by the Engineer, remove the exposed subbase or subgrade, or both, to a depth of 6 inches (150 mm) below the bottom of the new patch. Replace with subbase. When unstable material or excessive moisture is encountered in the subgrade, the Engineer may order an additional thickness of subbase, if necessary, to ensure drainage.

2. When the existing subgrade, base, or subbase is damaged during removal operations and subbase placement is not required, perform repairs at no additional cost to the Contracting Authority. Overdepth removal may be replaced with granular subbase material or the patching mixture. When the granular subbase material cannot be properly drained, replace the overdepth removal with the patching mixture.

3. Place subbase material with a field optimum moisture content established by the Engineer. Place it in lifts not exceeding a nominal compacted thickness of 6 inches (150 mm). Compact the material by a minimum of four complete coverages using a vibratory compactor, with additional coverages as necessary to ensure maximum consolidation. The compaction procedure for subbase normally will be established by the Engineer using the initial area as a trial section.

4. Compact the exposed subgrade or subbase by a minimum of four complete coverages using a plate type vibratory compactor with a manufacturer's certified force rating of 6,000 pounds (26 kN).

E. Restoring Reinforcement for Portland Cement Concrete and Continuously Reinforced Concrete Finish Patches.
Cut off existing tie bars. Replace when required by the contract documents. Place new tie bars in predrilled holes using epoxy grout, as provided in Article 2301.03, E. When there is a common line for patching, a bent bar may be placed in a keyway and later straightened.

1. PCC Finish Patches without Dowels.
Restoration of reinforcement is not required, except for tie bars as described above.

2. PCC Finish Patches with Dowels.

a. When dowels and/or tie bars are required at the transverse edges of the patch, the contract documents will show details of the placement. Place individual dowels or tie bars in predrilled holes using epoxy grout, according to Article 2301.03, E. Control the drilling alignment using a suitable jig designed for that purpose. Coat the dowels extending into the patch area with a bond breaker. Do not coat reinforcing bars.

b. When CD joints are required, the contract documents will show details of the placement of dowel assemblies. Locate these joints to meet joints or cracks in the adjacent lane. Use dowel assemblies meeting the requirements of Article 4151.02, C. Place the dowel

assemblies and secure in proper position before the concrete is placed, according to Article 2301.03, E.

3. PCC Finish Patches, Continuously Reinforced.

a. After the subbase, if required, is in place and compacted, set new reinforcement. Make the protruding longitudinal reinforcement ends as true as practical. Clean them of loose concrete and concrete which would interfere with close placement of new reinforcement.

b. Restore longitudinal reinforcement using bars of the same grade, size, and spacing as in the original pavement. The contract documents will describe the reinforcement in the existing pavement.

c. Set new longitudinal reinforcement to connect the longitudinal reinforcement across the repair area, lapping the protruding reinforcement at the same elevation. Wire tie at least twice. Furnish bars (maximum length 20 feet (6 m)) in appropriate lengths to minimize the number of splices.

F. Subdrains.

When subbase material and longitudinal subdrains are required by the contract documents or the Engineer, place the subbase as backfill material to drain to the longitudinal subdrain.

G. Placing Full Depth Hot Mix Asphalt Finish Patches.

1. After removal of the old pavement, lightly tack the edges of the old pavement and the adjacent 1 foot (0.3 m) of subgrade.

2. Deposit the HMA patch mixture in layers. Deposit the upper 5 inches (125 mm) in at least two layers, with the top layer not exceeding 2 inches (50 mm) in thickness when compacted. Lifts should be at least 3 times the mixture size. Thoroughly compact each layer, while hot, by rolling or compacting with a vibratory compactor to provide a dense compacted surface. Succeeding layers may be placed as soon as the preceding layer has been properly compacted. Smooth the final layer with a steel tired finish roller meeting requirements of Article 2001.05, B or F. A roller meeting requirements of Article 2001.05, F, may be a small roller suitable for this type of operation.

3. The Engineer may require test cores for density and depth be taken, at no additional cost to the Contracting Authority, to verify that the construction method used is satisfactory.

4. Ensure the final compacted surface is level with, or not more than approximately 1/4 inch (5 mm) above the surrounding pavement surface. Cut off patch material which extends beyond the edge of the pavement.

5. Do not open the patch to traffic until the mixture has cooled to provide stability; however, on two lane highways, do not leave barricades in place overnight. If the patch becomes distorted for any reason, smooth

the surface the next working day by blading, scraping, filling, or by other approved means.

6. Prior to final acceptance, the patch shall be level with, or no more than 1/8 inch (3 mm) above, the adjacent pavement, and have a smooth riding surface.

H. Placing Full Depth Portland Cement Concrete Finish Patches.

1. Use forms on all exposed edges and also along the center line for patches that extend into an adjacent lane. Wood forms may be used in lieu of steel by using 2 inch (50 mm) nominal dimension lumber the full depth of concrete. Where old pavement has a curb, extend the forms from the bottom of the patch to the top of the curb. Stake all wood forms to hold the forms in place and in proper alignment.

2. Place, consolidate, finish, and cure of the concrete as provided in Section 2301, except as follows:

a. Moisten the subbase or subgrade or cover with a single layer of plastic film meeting requirements of Section 4107.

b. Except for preplanned joints, place the patch in a continuous manner until placement is completed. When a delay of 45 minutes can not be avoided, construct an appropriate DW joint.

c. Dump or convey the concrete into the patch areas to avoid segregation of the aggregates and cement. Spread it into place and vibrate with a mechanical vibrator. Smooth the concrete and finish it to the elevation of the adjacent PCC surface. Avoid excessive vibrating.

d. Finish full lane width patches over 25 feet (10 m) long flush with the adjacent pavement. Use a finishing machine that has at least one vibrating screed. To ensure a smooth riding surface, straight edge all patches finished flush with adjacent pavement. Texture patches by finishing with a burlap, carpet drag, or rake, to approximately match the texture of the adjacent surface.

e. Check the patches with a 10 foot (3 m) straightedge before the concrete has set. Correct spots that are 1/8 inch (3 mm) high or low, as shown by the straightedge. The existing pavement crown shall be maintained.

f. Finish all edges and ends of patches with an edging tool.

g. Construct lane edges and the ends of patches to a depth of approximately 1 1/8 inches (30 mm), leaving an opening of at least 3/8 inch (10 mm) to provide a reservoir for joint sealer. The reservoir may be constructed by hand methods or may be sawed. When white pigmented curing compound is used, protect the reservoir with tape or other suitable material.

h. On patches finished flush with the pavement surface, stamp two numerals indicating the year of placement 2 feet (0.6 m) from the outside edge, facing outward to be read from the near shoulder.

3. After the concrete has been finished and surface water has disappeared, cure the concrete. Place curing materials no later than 20 minutes after completing finishing operations. Cure concrete by

completely covering it with an insulating blanket-type cover consisting of a layer of closed cell polystyrene foam protected by at least one layer of plastic film, rated by the manufacturer with a minimum R-value of 0.5 (0.08805 for metric units). Cover the blanket-type cover completely with insulation board having the following properties: cellulosic fiber sheathing with a nominal 3/4 inch (19 mm) thickness. The board may be wrapped with plastic film to protect it from rain. Place the board over the patch and adjacent surface and hold it tightly in place with weights to retain all possible heat in the concrete.

4. Cure PCC patches placed on multi-lane sections for a minimum of 10 hours before opening to traffic. Cure PCC patches placed on two-lane sections a minimum of 5 hours before opening to traffic. These restrictions may be modified in the plans or by the Engineer for specific sections.

5. Replace patches that are damaged in any manner during the curing period at no additional cost to the Contracting Authority.

6. Saw C and CD joints. Timing is critical for this operation. Perform sawing as soon as possible without excessive raveling of the saw cut edges.

7. For patches finished flush with the adjacent pavement, and not to be covered with HMA, seal C and CD joints and the edged reservoir formed by edging or sawing according to Article 2301.03, P, except sand cleaning will not be required.

I. Smoothness.

Apply Section 2316 to smoothness of full depth finish patches (except when the contract includes an overlay or pavement surface repair by diamond grinding or milling within the patch area) with the following modifications:

1. Profilometer testing and evaluation is required for each patch with a length of 50 feet (15 m) or more. Perform the testing near the center of the traffic lane after the patch is placed. For each patch added by the Engineer that is greater than 50 foot (15 m) long, the Contractor will be paid $500 in addition to the appropriate unit prices involved. This is to compensate for additional smoothness requirements.

2. Patches 50 feet to 100 feet (15 m to 30 m) in length:

- **a.** Test the patch length, and the existing pavement in that lane, for a distance of three times the patch length on both ends of the patch. If a patch occurs near a bridge, an intersection, and so forth, where the proper distance can not be tested, make up the required total on the other end of the patch. If interference occurs on both ends, test only to the points of interference.
- **b.** Establish one Average Base Index (ABI) of the pavement for both ends of patch.
- **c.** Calculate a new index for the entire length.
- **d.** Compare the new index with the ABI.

1) If the new index does not exceed the ABI, the work is acceptable and no correction is required.

2) Corrective action is also not required if the new profilometer index is equal to or less than 12 inches per mile (190 mm/km), regardless of the ABI.

3) If the new profilometer index is greater than 12 inches per mile (190 mm/km) and less than 30 inches per mile (470 mm/km) and is also within 2 inches per mile (32 mm/km) of the ABI, corrective action is not required.

4) If the new profilometer index is greater than 30 inches per mile (470 mm/km), corrective action is required to reduce the new index at least to the ABI.

e. Corrective action involves correction of bumps and dips exceeding a vertical height of 0.5 inch (13 mm) in a 25 foot (7.6 m) span in the patch, if identified from the trace, plus appropriate surface correction within the patch and existing pavement, or both, on either end of the patch within the limits tested.

3. Patches 100 feet to 250 feet (30 m to 75 m) in length: Article 2529.03, I, 2, above applies, except the length tested is the patch length, and the existing pavement in that lane for a distance of 300 feet (90 m) on both ends of the patch.

4. Patches over 250 feet (75 m) in length: Apply the requirements for Chart B pavement, Section 2316.

J. Area Restoration.

When the patch is completed, remove the forms and place backfill material in the trench. If a form is necessary on a longitudinal joint, temporarily fill the space between the patch and the adjacent traveled lane with suitable material until the adjacent patch can be constructed. Fill the excavated space along the outside pavement edge with material similar to that in the existing shoulder. Thoroughly compact, as directed by the Engineer, before the section is opened to traffic.

K. Limitation of Operations.

1. Conduct all operations with minimum inconvenience to traffic. Maintain traffic during construction operations unless the road is closed.

2. On two-lane roads, conduct patching on only one lane at a time when traffic is maintained.

3. For roads with multiple lanes each direction, the work area may include one lane each direction or as allowed by the traffic control details.

4. Place Stop Sign Rumble Strips, when included in the plans, prior to opening roadway sections to traffic.

5. When conditions permit, patch areas may extend up to 2 feet (0.6 m) into an adjacent lane. When this encroachment is not tabulated in the contract documents, it shall be approved by the Engineer prior to

beginning work. A flagger will be required at these locations. Work in an adjacent lane shall be completed and opened to traffic the same day using PCC (Class A or B) or HMA to match the normal patch area material.

6. When HMA patches on two-lane roadways and PCC patches with calcium chloride are constructed, adjust the work schedule so all equipment and obstructions are removed from the travel lanes and shoulders from 30 minutes before sunset to 30 minutes after sunrise.

7. When PCC patches without calcium chloride are constructed, place two drums meeting the requirements of Article 2528.03, C, in front of each patch location where there is a possibility of turning into or returning to the closed lane. Additional drums need not be placed for patches spaced closer than 150 feet (45 m).

8. If unforeseen difficulties should result in excavated areas being left overnight, assign a sufficient number of flaggers to warn and direct traffic until the areas are complete. No extra payment will be made for the necessary flaggers.

9. Limit full depth sawing to patch areas scheduled to be constructed the following work day. The Engineer may limit advance sawing.

10. Do not reconstruct pressure relief joints within patch areas. When these joints extend into adjacent lanes, construct a full depth patch in the adjacent lane as directed by the Engineer.

11. Joints and edges of PCC patches to be sealed may be cleaned and sealed as soon as the vertical surfaces appear dry by visual examination. Complete sealing within 5 working days after the patch is placed. For PCC patches to be covered by HMA, cover them with HMA during the working day the curing is completed.

12. When other work is included in the contract, sequence the operations in an area in the following order:
- **a.** Undersealing,
- **b.** Longitudinal subdrains,
- **c.** Patching,
- **d.** Milling,
- **e.** Installation of retrofit load transfer, and then
- **f.** Crack and joint sealing.

13. If a DW joint becomes necessary, fill the area following the joint with a suitable temporary hot or cold paving mixture or stable granular material, as directed by the Engineer.

2529.04 METHOD OF MEASUREMENT.

Measurement for the various items involved in satisfactory construction of full depth pavement patches will be as follows:

A. Full Depth Finish Patches.

1. By count. Patches in each traffic lane will be individually counted.

2. By area. The areas of full depth finish patches will be computed in square yards (square meters) to the nearest 0.1 square yards (m^2) from measurements of the areas of pavement removed and replaced, except that each patch which is less than 2.0 square yards (2.0 m^2) in area will be counted as 2.0 square yards (2.0 m^2). The length will be measured parallel to the center line. Includes areas associated with anchor lug removal.

3. Tie bars and dowel bars at the patch edges, when required, will not be measured for payment.

B. CD Joint Assembly and CT Joint.
By count for joints properly installed of each type respectively, when CD Joint Assemblies or CT Joints are required within the patch area. Each joint is for one lane width. Partial lane width joints will be counted as one lane width for payment purposes.

C. Hot Mix Asphalt (Composite Section).
Tons (megagrams), computed or estimated, of HMA placed on PCC surfaces for patches. Asphalt binder will not be measured for pay.

D. Subbase (Patches).

1. Where subbase aggregate is placed in patch areas, as required by the contract documents or the Engineer, the Engineer will compute in square yards (square meters) the areas of subbase placed as provided in Paragraph A, above. Excludes areas associated with anchor lug removal. The Engineer will not measure subbase aggregate used for special shaping at longitudinal drains or subbase used at the Contractor's option.

2. The Engineer will separately compute areas in square yards (square meters), where subbase was directed to be placed to a depth greater than that originally specified.

E. Removal of Anchor Lugs.
By count for anchor lugs removed in each traffic lane.

2529.05 BASIS OF PAYMENT.

For construction of the various items measured for pavement patches, the Contractor will be paid as follows:

A. Full Depth Finish Patches.
When joint and crack sealing is included in the contract, joint sealing of the patches will be paid for as part of that work.

1. **Full Depth Finish Patches, by Count.**
   a. Each. The type or types of patches to be counted will be identified by the following types and tabulated in the contract documents.
      1) Full Depth HMA Finish Patches.
      2) Full Depth PCC Finish Patches, Without Dowels.
      3) Full Depth PCC Finish Patches, Without Dowels, Composite Section.
      4) Full Depth PCC Finish Patches, With Dowels.
      5) Full Depth PCC Finish Patches, Composite Section.
      6) Full Depth PCC Finish Patches, Continuously Reinforced.
      7) Full Depth PCC Finish Patches, Continuously Reinforced, Composite Section.
   b. Payment is full compensation for all sawing or cutting necessary and for furnishing and installation of dowel bars at patch edges.

2. **Full Depth Finish Patches, by Area.**
   a. Per square yard (square meter) to the nearest 0.1 square yards (m^2).
   b. Payment is full compensation for:
      - Removal of the old pavement,
      - Restoring the subgrade or subbase,
      - Furnishing and installation of tie bars,
      - Restoring longitudinal reinforcement for continuously reinforced patches, and
      - Furnishing and placing the patching material, including the asphalt binder, tack coat, curing, joint sealing, and placing backfill material in the disturbed area.
   c. When the average thickness of the existing pavement at any one patch location varies from the thickness shown in the plans, the square yard (square meter) patching quantity will be adjusted per Table 2529.05-1. Quantities will be increased when pavement thickness is greater than shown in the plans and decreased when less than shown in the plans.

Table 2529.05-1: Patching Quantity Adjustment

% Change of Thickness	% Change of Quantity
0 to 10	0
> 10 to 20	10
> 20 to 30	15
> 30	20

B. CD Joint Assembly and CT Joint.
Each, for the type of joint.

C. Hot Mix Asphalt (Composite Sections).

1. Per ton (megagram).

2. Payment includes full compensation for placement and compaction, the asphalt binder in the HMA mix, and tack.

D. Subbase (Patches).

1. For the number of square yards (square meters) of subbase furnished and placed, the Contractor will be paid the contract unit price per square yard (square meter).

2. Payment is full compensation for:
- Furnishing and installing subbase,
- Additional excavation necessary for this placement and the removal of excavated material,
- Construction of transverse subdrains, and
- Placing backfill material in the disturbed shoulder area.

3. When subbase has been placed to a greater depth than specified in the contract documents, at the Engineer's direction, payment per square yard (square meter) for those areas will be increased by 20% for each inch (30 mm) of increased depth. This increased payment is full compensation for additional excavation and subbase material, associated compaction, and if so ordered, additional depth for the transverse subdrain.

E. Removal of Anchor Lugs.

1. Each.

2. Payment is full compensation for removal and for furnishing and placing subbase material, as specified. If removal of anchor lugs is not a bid item in the contract documents, payment will be paid $600 per lane in which an anchor lug, or portion of anchor lug, is removed.

3. When a PCC finish patch is required to be finished low and covered with HMA, but a patch of composite section is not so identified in the contract documents, the additional associated cost will be paid for as extra work.

4. When reconstruction of gore areas is required as a part of the contract documents, this reconstruction will be measured and paid for as specified in the contract documents.

Section 2530. Partial Depth Finish Patches

2530.01 DESCRIPTION.

A. Remove pavement in areas designated in the contract documents or by the Engineer to be patches. This includes furnishing and placing patching material to provide a new traffic surface, and restoring the adjacent shoulder as shown in the contract documents. This work is in areas where the size, shape, and depth of patch depends on the extent of pavement deterioration and shall be determined during the removal operation.

B. Partial depth finish patches may be identified and constructed as one of the following types:

1. Partial Depth PCC Finish Patches.
These patches are square or rectangular in shape. Saw the edges. Removal may be by milling or other equipment. This type of patch will be identified by tabulation in the contract documents. The size and location for each lane will be shown.

2. Partial Depth Regular HMA Finish Patches.
These patches are in the shape of a square or rectangle. They have square corners and straight edges to allow almost all of the removal by a milling machine. An air hammer or saw may be necessary to complete removal along edges and at corners. This type of patch will be identified by tabulation in the contract documents. The size and location in each lane will be shown.

3. Partial Depth Irregular HMA Finish Patches.
These patches are not square or rectangular in shape. They have at least one side that is not straight or one corner that is not square which will prohibit complete removal by a milling machine. Other equipment such as an air hammer or saw may be necessary to accomplish the removal. This type of patch will be identified by tabulation in the contract documents. This tabulation will be an estimate of the number of patches per lane mile, and the estimated total area of patch.

2530.02 MATERIALS.

Meet the requirements for the type of material specified.

A. Hot Mix Asphalt Patching Material.
Unless stated elsewhere in the contract documents, use HMA meeting or exceeding Section 2303 requirements for a 300,000 ESAL 3/8 or 1/2 inch (9.5 mm or 12.5 mm) surface mixture with PG 64-22 Performance Graded asphalt binder.

B. Portland Cement Concrete Patching Material.
Meet one of the requirements below. When patching encroaches on an adjacent lane which is open to traffic or when there is patching on two lane pavements or other locations where overnight closures are not permitted, use Class A or Class B patching material. On pavements with three or more lanes and where overnight closure is permitted, use Class C patching material.

1. Class A Patching Material.

a. Use a modified Portland cement type manufactured to provide rapid set and high early strength. Meet the requirements of Materials I.M. 491.20.

b. When a mortar is furnished, add the manufacturer's recommended quantity of coarse aggregate.

2. Class B Patching Material.

a. Use high early strength rapid set (5 hour) PCC meeting the requirements of Materials I.M. 529 and the following requirements:

Use Class M mixture patching material with calcium chloride. Class M mixtures with calcium chloride are not to contain fly ash. When calcium chloride is used in a mixture, place the concrete within 30 minutes after the introduction of the calcium chloride. For coarse aggregate, meet the requirements of Section 4115 and Gradation No. 5, Aggregate Gradation Table, Appendix A.

b. When Class B patching material is furnished for partial depth patches, it may also be furnished for full depth patches.

3. Class C Patching Material.

a. Use a PCC mixture with an early set that will allow time of opening to traffic in 24 hours to 36 hours as directed by the Engineer. For coarse aggregate, meet the requirements for Class B patching material. Use Class M mixture meeting the requirements of the current Materials I.M. 529 without the addition of calcium chloride.

b. When Class C patching material is furnished for partial depth patches, it may also be furnished for full depth patches.

4. Modifications to Mixtures for Class B and Class C Patching Material.

Apply the following modifications to the PCC mixtures for Class B and Class C patching material:

a. Slump.

1) Slump, measured according to Materials I.M. 317 prior to addition of calcium chloride solution, is to be between 1 inch and 2 1/2 inches (25 mm and 65 mm) as a target range, allowing a maximum of 3 inches (75 mm). If calcium chloride solution is not to be added, the slump is to be between 1 inch and 3 inches (25 mm and 75 mm) as a target range, allowing a maximum of 4 inches (100 mm).

2) When a Type A Mid Range water reducing admixture is used, the slump, tested prior to the addition of calcium chloride, is to be between 1 inch (25 mm) and 4 inches (100 mm) as a target range, allowing a maximum of 5 inches (125 mm).

b. Air Entrainment.

The entrained air content of the unconsolidated concrete will be determined according to Materials I.M. 318, prior to addition of calcium chloride if it is to be added. When calcium chloride is to be added, air entrainment is to be 5.0%, with a tolerance of ± 2.0%. When no calcium chloride is to be added, air entrainment is to be 6.5%, with a tolerance of ± 1.5%.

c. Temperature.

The temperature of Class B patching material, as delivered to the job site, is to be as required in Article 2530.02, B, 4, d below. Ensure the temperature of Class C patching material, as delivered to the job site, is greater than 65°F (18°C). Heating the water, aggregate, or both, may be necessary to meet this requirement. The cost of heating is incidental to patching.

d. Cement.

1) For Class M concrete mixtures, meet the requirements of Section 4101.

2) Refer to Table 2530.02-1 for cement types and maximum allowable substitution rates. The maximum substitution for Type IS is not to exceed 25%.

Table 2530.02-1: Cement Types and Maximum Allowable Substitution Rates

Patch Class	Cement Type	Maximum Allowable Substitution	Minimum Mix Temperature
B	Type I, Type II Type IS	0% Fly Ash 0% Fly Ash	75ºF (24ºC) 80ºF (27ºC)*
C	Type I, Type II Type IS	10% Fly Ash 0% Fly Ash	65ºF (18ºC) 70ºF (21ºC)*
* When a Type A Mid Range water reducing admixture is used, limit the minimum mix temperature to that required when Type I/II cement is used.			

e. Calcium Chloride.

1) Where calcium chloride is required, furnish it in water solution form and add it to the mix at the job site. Use a commercial 32% calcium chloride solution, or equivalent, prepared according to Table 2530.02-2:

Table 2529.02-2: Proportions for 32% Calcium Chloride Solutions

Type of Solid Calcium Chloride	Pounds (Grams) of Solid per Gallon (liter) of Water	Solution Produced per Gallon (liter) of Water
Type 1 – Regular Flake (77% material)	6 (720)	1.3
Type 2 – Concrete Flake or Pellets (94% material)	4.5 (540)	1.2

2) The Engineer will check the solution concentration using a hydrometer according to Materials I.M. 373. Add the solution at the rate of 3.0 gallons per cubic yard (14.8 L/m^3) of concrete. Calcium chloride solutions of different concentrations may be approved by the Engineer, provided appropriate adjustments in the total concrete composition are made.

3) **Caution.** Agitate the mixture until the calcium chloride is completely in solution, and continue agitation, as necessary, to maintain uniformity.

4) Except when using continuous mixing equipment described in Article 2001.20, E, ensure the calcium chloride solution is present in the mix for at least 2 minutes of mixing.

f. Water Reducer.
A Type A Mid Range water reducing admixture may be used. Use one listed in Materials I.M. 403, at the manufacturer's recommended dosage.

g. Aggregate Durability.
Unless specified otherwise, use coarse aggregate of the proper class of durability, as defined in Article 4115.04.

h. Transit Mix Concrete.
Use a mix from a plant from which the concrete can be delivered and placed within 60 minutes from the start of mixing. The time may be extended to 90 minutes when a retarding admixture, used according to Materials I.M. 403 including temperature dosage guidelines (and at no additional cost to the Contracting Authority), is added at the plant. Continuous mixing equipment using volumetric proportioning may be used according to Article 2001.20, E.

i. Prepackaged Mixture.
A prepackaged mixture, proportioned as specified above for Class B or Class C matching material, may be furnished as a Class B or Class C patching material with the Engineer's approval. The coarse aggregate for prepackaged mixtures is limited to that meeting the requirements of Article 4115.05. Mix prepackaged mixtures in an on-site paddle type mixer or proportion and mix with continuous mixing equipment using volumetric proportioning according to Article 2001.20, E.

C. Joint Boards.
Comply with the following:

1. Joint boards for recreating joints and cracks: use a resilient filler, cellulosic fiber, paraffin coated cardboard, or other compressible material of the proper shape to recreate the joint during placement of the patch material.

2. Boards for recreating transverse joints: one piece, so as to have no horizontal joints.

3. Boards for recreating longitudinal joints: one piece. One piece boards will not be required in lengths exceeding 4 feet (1.2 m).

4. Joints and open transverse cracks: use a board with a nominal width of 1/4 inch (5 mm). Metal strips may be used for narrow cracks.

5. Extend boards and metal strips into the pavement to the bottom of the patch.

6. Use of a bond breaker on board surfaces is encouraged.

D. Joint Sealer.
Use joint sealer and backer rod meeting the requirements of Section 4136. Unless specified otherwise, use only hot poured joint sealer.

E. Tack Coat Bitumen.
For HMA patches, use tack coat bitumen as specified in Article 2303.02, E.

2530.03 CONSTRUCTION.

A. Equipment.

1. Remove existing surface material using a milling machine, jack hammers, or similar equipment. Hand equipment may be necessary to achieve a vertical edge and the designated shape.

2. Sawing equipment is required at edges from a milling operation.

3. The following additional equipment is required for PCC patches:
   - **a.** Sandblasting equipment for cleaning of the prepared patch area on PCC pavements.
   - **b.** 15 pound (7 kg) (or less) air chisel to complete patch area preparation. A 30 pound (14 kg) air chisel may be used if its use does not result in significant damage to the patch area and edges.
   - **c.** Air compressor that emits oil and moisture free air for cleaning the prepared area.
   - **d.** On-site paddle type concrete mixer for mixing Class A patching material or other prepackaged mixtures.

B. Partial Depth Finish Patch Construction.

1. **General.**
   - **a.** The tabulations for partial depth finish patches shown in the contract documents are for estimating purposes only. The Engineer will designate the location and limits of these patches.
   - **b.** The shape and depth may be irregular so that hand operated equipment may be necessary for all or some of the removal.
   - **c.** Remove the existing pavement material within the designated area to sound concrete as determined by the Engineer. All material removed not designated for salvage becomes the property of the Contractor and shall be removed according to Article 1104.08.

2. **Hot Mix Asphalt Patches.**
   Construct partial depth HMA finish patches as follows:
   - **a. Preparation of Patch Area.**
     - **1)** Remove material to a minimum depth of 3 inches (80 mm). Where this depth is adequate, make the prepared surface relatively even. The maximum depth is 75% of the pavement thickness, but no more than 9 inches (230 mm).
     - **2)** Remove material so that the edges of all patch areas are vertical to a depth of 1 1/2 inches (40 mm). Minor rounding of the bottom edge is permissible. Cut and remove exposed reinforcing steel. Clean the patch area.
     - **3)** Where removal to the depth described above leaves unsound concrete within the limits of the patch area, the Engineer may designate a part of the patch area as a full depth patch. Remove the concrete for the full depth, but removal to a depth greater than 12 inches (300 mm) will not be required. Consolidate the subgrade or subbase material with a mechanical tamper or other compaction equipment as directed by the Engineer.

b. Placing HMA Patch Material.

1) After removal of the old pavement, lightly tack the edges and bottom of the patch area. Deposit and compact the HMA patch mixture in layers as follows:

a) Deposit the upper 5 inches (130 mm) in at least two layers, with the top layer not exceeding 2 inches (50 mm) in thickness, when compacted. Lifts should be at least 3 times the mixture size.

b) Thoroughly compact each layer, while hot, using appropriate compaction equipment. Succeeding layers may be placed as soon as the preceding layer has been properly compacted.

c) Smooth the final layer with a steel tired finish roller meeting requirements of Article 2001.05, B or F. A roller meeting requirement of Article 2001.05, F, may be a small roller suitable for this type of operation.

d) Ensure the final compacted surface is level with, or not more than approximately 1/4 inch (6 mm) above, the surrounding pavement.

2) Open the patch to traffic after the mixture has cooled to provide stability; however, on two lane roadways, do not leave barricades in place overnight. If the patch becomes distorted beyond the smoothness requirements for any reason, smooth the surface within 1 working day by blading, scraping, filling, or by other approved means.

3) Prior to final acceptance, a finish patch shall be level with, or not more than 1/8 inch (3 mm) above, the adjacent pavement, and have a smooth riding surface.

c. Sealing Joints and Cracks.

1) Seal all edges of HMA patches to a width of 3 inches (80 mm) centered on the edge. Use CRS-2 bitumen applied with a "V" shaped squeegee tool. Blot excess bitumen material with sand.

2) When joint and crack sealing work is part of the contract, saw joints and cracks that cross areas of HMA finish patches to a width of 1/8 inch to 1/4 inch (3 mm to 6 mm). Saw to the depth of the patch with a maximum depth of 3 inches (80 mm). Perform this work within 3 working days after placement.

3. Portland Cement Concrete Patches.

Construct partial depth PCC finish patches as follows:

a. Preparation of Patch Area.

1) If a joint or crack is within a patch area, construct the edge of that patch to be at least 6 inches (150 mm) beyond the joint or crack.

2) Each patch will have a generally rectangular area. Remove the PCC concrete in that area to a minimum depth of 3 inches (80 mm). Many areas will require removal of unsound PCC concrete to a greater depth to reach sound concrete. The maximum depth is 75% of the pavement thickness but not more than 9 inches (230 mm).

3) Milling will be allowed, but the depth within the designated patch area is to be at least 3 inches (80 mm). Remove

concrete from feathered runouts to a depth of 3 inches (80 mm) if within the designated patch area, or to a depth of 2 inches (50 mm) if outside the designated patch area. Saw these edges vertically. Ensure the prepared area has reasonably straight and vertical edges, not to exceed 1 inch (25 mm) in saw cut depth. Sawing will be required around the remainder of the patch perimeter, unless the Contractor demonstrates that an edge can be produced that is true and vertical, without sawing.

4) When removal to the maximum depth leaves unsound concrete within the patch area, the Engineer may designate a part of the patch area as a full depth patch. Remove the concrete for the full depth of the existing pavement, but no more than 12 inches (300 mm). Consolidate the subgrade or subbase material using a mechanical tamper or other compaction equipment as directed by the Engineer.

5) When it is necessary to go below reinforcing steel to reach sound concrete, cut the reinforcing steel flush with the perimeter edges of the patch and remove.

6) Clean the patch area by sandblasting, followed by cleaning with compressed air. The completed surfaces are to appear surface dry to visual examination.

7) Recreate a joint or crack in the patch area with a joint board of the proper size and shape. Extend the board to the bottom of the area to be patched, so as to separate completely all patching material on both sides. Use a board of a width approximately equal to the joint or crack. For wide openings, several thicknesses may be used.

b. Placing PCC Patch Material.

1) Scrub a cement-sand-water grout of creamy consistency onto the patch surfaces, including the edges. Place the patch material before the grout dries.

2) Mix Class A patching material with water and coarse aggregate, if required. Place the properly mixed material in the patch area, consolidated and worked into place in a manner that will provide good bonding. Level it with the adjacent pavement to provide a smooth riding surface. Texture patches longer than 1 foot (0.3 m) in the manner of the adjacent pavement surface.

3) Perform this work according to the patching manufacturer's recommendations and limitations, subject to approval of the Engineer. Furnish these recommendations to the Engineer. After 1 hour, remove the joint board in a manner that does not damage the patch. The area may then be returned to public traffic.

4) Mix Class B and Class C patching material and place in the patch area. Consolidate it by vibration in a manner that will provide good bonding. Level the patch to provide a smooth riding surface. Texture patches longer than 1 foot (0.3 m) in the manner of the adjacent pavement surface.

c. Protecting and Curing.

1) Class A patching material.

Cure according to the manufacturer's recommendations. Use a minimum curing time according to Materials I.M. 491.20, Appendix A.

2) **Class B patching material.**
   a) Cure as specified in Article 2529.03, H.
   b) Cure these patches for the minimum time specified in Article 2529.02 for the mixture used.
3) **Class C patching material.**
   a) Cure according to Article 2529.03, H. Patches may be covered immediately with white pigmented curing compound. In this case, the specified cure may be delayed as much as 2 hours.
   b) Cure patches with Class M concrete a minimum of 36 hours or as directed by the Engineer.
   c) After the required curing period, the insulation blanket and the joint forming board may be removed in a manner that does not damage the patch, or removal may be delayed until the sealing is to be done provided no damage results from the delay.

d. **Surface Finish.**
Prior to final acceptance, level finish partial depth patches with the adjacent pavement. Ensure they have a smooth riding surface.

e. **Joint and Crack Sealing.**
Where joints and cracks cross areas of partial depth PCC patches, saw, seal, and clean the patch according to Article 2301.03, P. Complete sealing within 5 working days after the patch is placed. When joint and crack sealing is included in the contract, perform sealing as part of that work.

C. Limitations of Operations.

1. Unless the road is closed, maintain traffic during construction operations. Conduct all operations with minimum inconvenience to traffic. On two-lane roads, limit operations to one traffic lane at a time, except for minor encroachment in the adjacent lane for sawing and installing forms when traffic is maintained. For multiple lane roadways, the work area may include one lane in each direction.

2. An adjacent lane shall be opened to traffic prior to the old pavement being removed from a patch area.

3. When approved by the Engineer, patch areas may extend up to 2 feet (0.6 m) into an adjacent lane as allowed in the traffic control plan. In this case, a flagger will be required at that location until the patch is placed. Use Class A patching material in these patches.

4. Adjust the work schedule so all work for each patch, including removal of barricades and equipment (except the cure period for PCC Class C concrete), will be completed on the same day it is started between the hours of 30 minutes after sunrise to 30 minutes before sunset. If unforeseen conditions result in excavated areas being left overnight, assign a sufficient number of flaggers to warn and direct traffic until the

patches are placed. Extra payment will not be made for the necessary flaggers.

5. Place PCC patching material only when the ambient air and pavement temperatures are 45°F (7°C) or above.

6. The Engineer may limit advance sawing.

7. If an emergency makes a DW joint necessary, temporarily fill the excavated area following the joint with a suitable hot or cold paving mixture or stable granular material, as directed by the Engineer. The Engineer may direct that the lane remain closed to traffic overnight. Provide traffic control.

8. When PCC patches without calcium chloride are constructed, place two drums meeting the requirements of Article 2528.03, C, in front of each patch location where there is a possibility of turning into or returning to the closed lane. Additional drums need not be placed for patches spaced closer than 150 feet (45 m).

9. Apply Articles 1107.08, 1107.09, and 1108.03.

D. Area Restoration.

When the patch is completed, remove forms if they have been used. Fill all excavated space along the outside pavement edge with material similar to that in the existing shoulder, satisfactory to the Engineer. Thoroughly compact the material before the section is opened to traffic.

2530.04 METHOD OF MEASUREMENT.

The Engineer will determine the quantities involved in satisfactory construction of partial depth finish patches for the areas specified as follows:

A. Partial Depth PCC Finish Patches.

1. The Engineer will calculate the area of each patch in square feet (square meters) from surface measurements. The area of each patch less than 1 square foot (0.1 m^2) will be counted as 1 square foot (0.1 m^2) for payment purposes. If the patch area is increased by the Contractor to accommodate milling equipment, only the area designated by the Engineer will be measured for payment.

2. The Engineer will also calculate the area of patches in square feet (square meters) which have been directed to be constructed full depth.

B. Partial Depth HMA Finish Patches.

1. The Engineer will measure the area for each patch and the weight (mass) of HMA placed in partial depth patches according to Article 2303.04. Regular patches and irregular patches will be calculated and totaled separately. If the patch area is increased to accommodate milling equipment, only the quantities for the area designated by the Engineer will be measured for payment.

2. Asphalt binder and tack coat will not be measured separately for payment.

3. The Engineer will also calculate the area and weight (mass) of patch material placed in HMA patches which have been directed to be constructed full depth. The Engineer will deduct quantities not used.

2530.05 BASIS OF PAYMENT.

Payment for construction of the various types of partial depth finish patches, satisfactorily constructed, at the areas specified, will be the contract unit price as follows:

A. Partial Depth PCC Finish Patches.

1. Per square foot (square meter).

2. Payment is full compensation for removal of all pavement, preparing the patch area, furnishing and placing all material, construction of joints, sawing, finishing, curing, and restoration of the area.
3. When parts of PCC partial depth finish patches are constructed to full depth at the direction of the Engineer, payment will be for the areas of those parts at 2.0 times the contract price per square foot (square meter) for partial depth PCC patches.

B. Partial Depth HMA Finish Patches.

1. Payment will be for both the patch area and the quantity of HMA placed in the patch.
   a. **Regular Partial Depth HMA Finish Patches, by Area.**
      Per square yard (square meter).
   b. **Irregular Partial Depth HMA Finish Patches, by Area.**
      Per square yard (square meter).
   c. **Hot Mix Asphalt Mixture.**
      Per ton (megagram). Includes mixture designated for full depth patches.

2. When parts of PCC partial depth finish patches are constructed to full depth at the direction of the Engineer, payment will be for the areas of those parts at 2.0 times the contract price per square foot (square meter) for partial depth PCC patches.

3. Payments are full compensation for:
   - Removal of the old pavement,
   - Preparing the patch area,
   - furnishing and placing the HMA patching material, including asphalt binder in the mixture and necessary tack coat bitumen,
   - Sawing and sealing,
   - Sealing the patch edges, and
   - Restoration of the area.

4. When joint and crack sealing is included in the contract, it will be paid for as a part of that work.

Section 2531. Pavement Surface Repair (Milling)

2531.01 DESCRIPTION.

A. Mill the surface of HMA or PCC pavement to improve:
- The surface profile and cross section for use as a traffic surface, and
- The surface texture.

B. For the purpose of this work, milling is a general term meaning removal of a pavement surface by milling with cold planing equipment.

C. The type of coarse aggregate existing in the concrete will be identified.

D. Unless designated in the contract documents, do not extend milling across bridges.

2531.02 MATERIALS.
None

2531.03 CONSTRUCTION.

A. Equipment.

1. Meet the following requirements for milling equipment:
- **a.** Capable of removing the pavement surface to the necessary depth. Use cold planing equipment.
- **b.** Capable of milling the surface of one traffic lane in no more than two passes.
- **c.** Milling drum with a minimum of 60 cutting teeth per foot (195 cutting teeth per meter) of width with a transverse spacing of approximately 1/4 inch (5 mm).
- **d.** Cutting teeth with a cutting head face which is pointed to an angle of not more than 75 degrees.
- **e.** Milling drum that produces a uniformly cut surface free of ridges or valleys.

2. Use milling equipment that is automatically controlled on one side, and has cross slope control or is automatically controlled on both sides.

3. Replace broken teeth immediately.

4. Use a rotary broom as described in Article 2001.14 to clean the milled surface.

5. Use water as necessary to avoid a traffic hazard and a dust nuisance.

B. Pavement Surface Repair.

1. Mill the entire surface of the pavement in a longitudinal direction. Mill substantially the entire surface area of the pavement until:
- The pavement surface on both sides of the transverse joints and all cracks are in the same plane and have the same surface texture, and
- The pavement meets the smoothness requirement.

2. In each lane, ensure at least 95% of the area in each 100 foot (30 m) section has a newly textured surface. Except at or near joints and cracks, limit milling to no more than 1/2 inch (15 mm) in depth. At joints and cracks, limit milling to no more than 3/4 inch (20 mm) in depth.

3. Meet the following requirements for milling:
- **a.** Progress in the direction against normal traffic in the lane being milled unless specified otherwise by the Engineer.
- **b.** Ensure all construction traffic entering or leaving the work area moves in the direction of traffic of the open lane.
- **c.** Begin and end at lines normal to the pavement center line within any one milled area and at the project limits. This will not be required at the end of each shift.
- **d.** Control the depth of adjacent cuts to produce a smooth, uniform cross section, free from irregularities between adjacent passes of the milling equipment.
- **e.** Ensure there are no transverse troughs due to lowering the drum below the cutting plane (caused by continued down pressure when forward motion of the machine has stopped).
- **f.** Limit milling in each traffic lane to no more than two passes, but additional passes in the cutting path may be necessary to secure a smooth profile.
- **g.** Ensure each single pass does not extend to both sides of the center line or a lane line between traffic lanes. However, ensure the first pass at the center line or lane line overlaps the joint line approximately 2 inches (50 mm) to minimize spalling.
- **h.** Ensure the joint match, if any, between two passes in a traffic lane is within 1 foot (0.3 m) of the center of the lane, to avoid joints directly in the wheel path, and is straight or parallel to the center line or lane line.
- **i.** Ensure each pass is designed to maintain the existing crown and a taper from center line to pavement edge.
- **j.** Ensure the transverse slope of the milled pavement is uniform to a degree that there is no depression or misalignment greater than 1/4 inch in 12 feet (6 mm in 3.6 m) when tested by stringline or straightedge placed perpendicular to the center line. Ensure the joint match between two adjacent passes matches within 1/8 inch (3 mm).
- **k.** In order to match the outside edge of the pavement, mill adjacent paved areas (for example, shoulders, curb and gutter, turn lanes, tapers, paved crossovers, and so forth) to minimize vertical projections.

l. Ensure the finished surface has a uniform, coarse texture. Obtain the Engineer's approval.

m. Control the forward speed of the milling machine to prevent the formation of visible corrugations on the pavement surface.

C. Smoothness.

1. The Engineer will partly profile the pavement on the initial trace using the procedure described in Article 2316.02, B. The average profile index for each area may be shown in the contract documents. The bidder is also advised that all profilograph information is available for inspection at the Office of Contracts by a request to the Contracts Engineer.

2. After the contract is awarded, the profilograph information will be available from the Engineer. This information represents a summary of conditions found to exist at the time the survey was made. The availability of this information will not constitute a guarantee that a profile other than that indicated will not be encountered at the time of milling.

3. Provide a control profilograph trace as described in Article 2316.02, B prior to performing any grinding work. This control trace will be used to identify the required smoothness for the project. Each segment of the finished ground surface is to:

- Have a final profile index of 35% of the control profilograph trace or 10 inches per mile (160 mm/km), whichever is greater, and
- Not include any bumps exceeding 0.5 inches in 25 feet (13 mm in 8 m).

4. When the Engineer approves, the following areas will be excluded from profilograph testing:

- Depressed pavement areas due to subsidence or other localized causes, and
- Areas where the maximum cut at mid panel or a fault restricts further milling.

5. End profilograph testing 15 feet (5 m) prior to excluded areas and resume 15 feet (5 m) following excluded areas.

6. Test and evaluate the milled surface according to Section 2316, with the following modifications:

a. Run the test and evaluate the profilograph using the same procedure as for the control trace.

b. Each segment for which continuous milling is designated will be evaluated individually, and it shall meet the smoothness and bump requirements specified above, regardless of its length.

c. In excluded areas, smoothness requirements will be modified or may be waived by the Engineer.

d. Certify smoothness of the finished surface according to Article 2316.02, C.

e. The Engineer may test for smoothness and bumps near the center line and at other spot locations where compliance is questioned. Additional milling may be required.

f. Do not use the original and final profilograph trace to determine milling depth.

D. Limitations.

1. Perform lane closures necessary to accomplish this work as shown in the contract documents, or as directed the Engineer. Open the entire roadbed to traffic at the end of the working period. Uncompleted sections may be opened to traffic without completion of milling across an entire lane.

2. Overnight lane closures will not be permitted. Work will not be permitted on Sundays or holidays described in Article 1108.03. Apply Articles 1107.08 and 1107.09.

3. Continuously remove all slurry or residue resulting from the milling operations. Do not deposit on the slab or paved shoulder. Pavement and paved shoulders shall be left in a clean condition. Residue from milling operations should not be permitted to flow across lanes occupied by public traffic or to flow into gutters or other drainage facilities. This residue may be placed on the shoulder or foreslope, or removed according to Article 1104.08.

4. When the following work is included in the contract, sequence the operations in the following order:

a. Undersealing,
b. Longitudinal subdrains,
c. Patching,
d. Milling,
e. Installation of load transfer, and
f. Crack and joint sealing.

E. Pavement Markings.
Place pavement markings according to Section 2527; however, pavement marking of edge lines on Interstate pavement may be delayed up to 24 hours after the lane is opened to traffic. Pavement marking will not be allowed on Sundays or holidays, unless the Engineer approves otherwise.

2531.04 METHOD OF MEASUREMENT.

A. The Engineer will calculate the area in square yards (square meters) of pavement milled, for each type of coarse aggregate from the length of each area and the nominal pavement width.

B. Adjacent paved areas milled to minimize vertical projections will not be measured for payment.

2531.05 BASIS OF PAYMENT.

A. Payment for Pavement Surface Repair (Milling Limestone) or Pavement Surface Repair (Milling Gravel) will be the contract unit price per square yard (square meter).

B. Payment is full compensation for furnishing all equipment, materials, and labor to mill the pavement and test for smoothness according to the contract documents, including removal of slurry and residue from the project.

Section 2532. Pavement Surface Repair (Diamond Grinding)

2532.01 DESCRIPTION.

A. Use a diamond grinder to grind an existing PCC pavement surface, used as traffic surface, for profile improvement. Perform grinding and texturing at the locations shown in the contract documents. Refer to Article 2532.03, B, 3 for grinding bridge decks.

B. The existing surface and the coarse aggregate will be described in the contract documents.

C. This work may involve using a diamond grinder to grind a newly constructed deck surface for temporary surface texture. Perform grinding prior to opening the deck segment to traffic.

2532.02 MATERIALS.

None

2532.03 CONSTRUCTION.

A. Equipment.

1. Perform grinding and texturing using diamond blades mounted on a self propelled machine that has been designed for grinding and texturing concrete surfaces. Ensure the equipment will not cause strain or damage to the underlying pavement.

2. Do not use grinding and texturing equipment that causes excessive ravels, aggregate fractures, spalls, or disturbance of the transverse and/or longitudinal joints.

3. Use grinding equipment with a minimum effective head width of 36 inches (300 mm).

B. Pavement Surface Repair.

1. General.

a. Grind and texture the concrete surface in a longitudinal direction.

b. Ensure the surface, after grinding, is of uniform texture.

c. When using more than one grinding machine in the same travel lane, use similar blade segment thicknesses, blade spacings, and blade diameters on all machines so the texture of the ground surface is reasonably uniform across the lane.

d. To be in compliance, the land area and the texture depth shall be within the specified ranges. It may be necessary to adjust the blade spacing during a project to stay within specified ranges.

e. For multiple passes, carefully control the equipment to minimize the overlap. Ensure overlaps do not exceed 1 inch (25 mm).

f. Ensure that, after grinding, the transverse slope of the concrete surface is uniform to a degree that there are no depressions or misalignment of slope greater than 1/4 inch in 12 feet (6 mm in 3.6 m) when tested by stringline or straightedge placed perpendicular to the center line.

g. In order to match the outside edge of the pavement, grind adjacent paved areas (for example shoulders, curb and gutter, turn lanes, tapers, paved crossovers, and so forth) to minimize vertical projections.

h. The Contractor is responsible for quality control of the texture. The Engineer will conduct random Quality Assurance inspections.

2. PCC Pavement.

a. Grind and texture substantially the entire surface area of the pavement until:

- The pavement surface on both sides of the transverse joints and all cracks are in the same plane, and
- The pavement surface meets the smoothness required.

b. In each lane, ensure at least 95% of the area in each 100 foot (30 m) section has a newly textured surface.

c. Meet the following requirements for grinding:

1) Ensure all construction traffic entering or leaving the work area moves in the direction of traffic of the open lane.

2) Begin and end at lines normal to the pavement center line within any one ground area and at the project limits. This will not be required at the end of each shift.

3) Maintain good transverse drainage at all times.

4) Assemble the grinding head to produce the tolerances in Table 2532.03-1 on pavements with the indicated coarse aggregates.

Table 2532.03-1: Grinding Head Tolerances

(ENGLISH)	Limestone	Gravel
Blade segment thickness Land area between grooves[(a)]	0.130 inch maximum 0.100 inch to 0.125 inch	0.130 inch maximum 0.080 inch to 0.110 inch
Texture depth[(b)]	Target of 1/16 inch with average between 1/32 inch to 3/32 inch	
(METRIC)	**Limestone**	**Gravel**
Blade segment thickness Land area between grooves[(a)]	3.30 mm maximum 2.5 mm to 3.4 mm	3.30 mm maximum 2 mm to 2.75 mm
Texture depth[(b)]	Target of 2 mm with average between 1 mm to 2.5 mm	

(a)	Based on an average of a minimum of ten measurements across the ground width for one pass.
(b)	Based on an average of a minimum of six measurements across the ground width for one pass.

5) A test area 500 feet (150 m) long and the width of the grinding head will be allowed for each new or restacked head, provided a surface texture in reasonable conformance with the specification is being produced.

3. Bridge Deck.

a. Grind and longitudinally groove the entire surface of the bridge deck according to Article 2412.03, D, a.

b. Assemble the grinding head to produce the tolerances in Table 2532.03-2 on bridge decks.

Table 2532.03-2: Grinding Head Tolerances

(ENGLISH)	Limestone
Blade segment thickness Land area between grooves[(a)]	0.130 inch maximum 0.100 inch to 0.125 inch
Texture depth[(b)]	Target of 1/8 inch ± 1/32 inch
(METRIC)	**Limestone**
Blade segment thickness Land area between grooves[(a)]	3.30 mm maximum 2.5 mm to 3.4 mm
Texture depth[(b)]	Target of 3 mm ± 1 mm

(a) Based on an average of a minimum of ten measurements across the ground width for one pass.

(b) Based on an average of a minimum of six measurements across the ground width for one pass.

C. Smoothness.

1. PCC Pavement.

a. The Engineer will partly profile the pavement on the initial trace using the procedure described in Article 2316.02, B. The average profile index for each area will be shown in the contract documents. The bidder is also advised that all profilograph information is available for review at the Office of Contracts by contacting the Contracts Engineer. After the contract is awarded, the profilograph information will be available from the Engineer. This information represents a summary of conditions found to exist at the time the survey was made. The availability of this information will not constitute a guarantee that a profile other than that indicated will not be encountered at the time of milling.

b. Provide a control profilograph trace as described in Article 2316.02, B prior to performing grinding work. This control trace will be used

to identify the required smoothness for the project. Each segment of the finished ground surface is to:

- Have a final profile index of 10 inches per mile (160 mm/km)or less, and
- Not include any bumps exceeding 0.5 inches in 25 feet (13 mm in 8 m).

c. Identify depressed pavement areas and localized areas with excess faulting greater than 1 inch (25 mm). Review these areas with the Engineer to determine the limits for exclusion from the profile index calculation.

d. After grinding, test and evaluate the surface according to Section 2316. Incentives for pavement smoothness will not apply.

2. Bridge Deck.

Ensure the smoothness requirements of Section 2428 are met prior to performing the texturing. After texturing, test the bridge deck again according to Article 2428.02, C. Ensure the resulting profile index does not exceed the corrected profile index prior to the texturing.

D. Limitations.

1. General.

a. When nighttime work is required, include lighting at each work area. Ensure lighting does not glare into oncoming motorists.

b. Continuously remove all slurry or residue resulting from the grinding operations. Do not deposit on the slab or shoulder. Leave pavement and paved shoulders in a clean condition. Ensure residue from grinding operations does not flow across lanes occupied by public traffic or into gutters or other drainage facilities. This residue may be spread on the foreslope or removed according to Article 1104.08.

2. PCC Pavements.

a. Uncompleted sections may be opened to traffic without completion of grinding across an entire lane.

b. During nighttime grinding operations, progress in the direction with normal traffic flow.

c. When the following work is included in the contract, sequence the operations in the following order:

1) Undersealing,
2) Longitudinal subdrains,
3) Patching,
4) Installation of retrofit load transfer,
5) Diamond grinding, and then
6) Crack and joint sealing.

3. Bridge Decks.

Prior to opening to traffic, complete the work under this specification and meet the smoothness requirements.

2532.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. PCC Pavement.

1. Square feet (square meters) of Pavement Surface Repair, of the type specified, shown in the contract documents.

2. Adjacent paved areas ground to minimize vertical projections will not be measured for payment.

B. Bridge Deck.
Square yards (square meters) of Pavement Surface Repair, of the type specified, shown in the contract documents.

2532.05 BASIS OF PAYMENT.
Payment will be as follows:

A. Contract unit price per square yard (square meter) for Pavement Surface Repair (Grinding Limestone) or Pavement Surface Repair (Grinding Gravel).

B. Payment is full compensation for furnishing all equipment, materials, and labor to:
- Grind the concrete surface,
- Test for smoothness according to the contract documents, and
- Remove slurry and residue from this operation.

Section 2533. Mobilization

2533.01 DESCRIPTION.

A. Preparatory work and operations for all items under the contract, including, but not limited to those necessary for:
- The movement of personnel, equipment, supplies, and incidentals to the project site,
- The establishment of all offices, buildings, and other facilities necessary for work on the projects, and
- All other work or operations which shall be performed or costs incurred prior to beginning work on the various items on the project site.

B. Mobilization may include bonding, permit, and demobilization costs.

C. Nothing herein is to be construed to limit or preclude partial payments otherwise provided for by the contract.

D. A contract item for Mobilization will not be included for maintenance aggregate, materials, granular surfacing, or for any other minor projects.

E. When the proposal includes a lump sum item for Mobilization, the bidder shall indicate the bid price in dollars, and this is the contract price for this item. When the proposal does not include a lump sum item for Mobilization, all costs incurred by the Contractor for Mobilization are incidental to other work.

2533.02 MATERIALS.
None

2533.03 CONSTRUCTION.
None.

2533.04 METHOD OF MEASUREMENT.
None.

2533.05 BASIS OF PAYMENT.
Payment for Mobilization will be as follows:

A. Partial Payments.

Partial payments may be made as follows:

1. For projects exceeding $500,000, a partial payment of mobilization will be made after receipt of a signed contract. This partial payment will be either 10% of the contract price for this item or 1% of the original project sum, whichever is less.

2. When 5% of the original project sum is earned, either 25% of the contract price for this item or 2.5% of the original project sum, whichever is less, will be paid.

3. When 10% of the original project sum is earned, either 50% of the contract price for this item or 5% of the original project sum, whichever is less, will be paid.

4. When 25% of the original project sum is earned, either 100% of the contract price for this item or 10% of the original project sum, whichever is less, will be paid.

B. Full Payment.
Upon completion of all work on the project required by the contract, full payment will be made for this contract item, including any amount not paid as a partial payment.

Section 2534. Delivery of Samples

2534.01 DESCRIPTION.
This item covers the delivery of project samples for testing purposes. It applies to Interstate and Primary projects for which certified plant inspection is required or authorized. These provisions do not apply to Non-Primary projects for which certified plant inspection is required or authorized, unless indicated in the contract documents.

2534.02 MATERIALS.
None.

2534.03 SAMPLE DELIVERY AND RECIEVING.

A. Sample Delivery.

1. Deliver to the Engineer samples for the purposes of acceptance, monitoring, and verification testing. Include aggregates and asphalt mixtures. Samples of other materials may be required.

2. Properly identify the samples. Deliver to the District Materials Laboratory for the District having jurisdiction over the contract, unless the Engineer directs otherwise. Deliver the samples promptly, as determined by the Engineer.

B. Sample Receiving.

1. Samples received by the District Materials Engineer will be promptly tested. Materials for projects with accelerated work schedules will be given special consideration.

2. Not all samples are to be tested. The selection of samples to be tested will be made by the District Materials Engineer, based on Construction Office and Materials Office instructions. Samples initially identified for testing will normally be tested at least by the end of the working day following delivery. These test results will be available to the Contractor as soon as testing is completed.

2534.04 METHOD OF MEASUREMENT.
None.

2534.05 BASIS OF PAYMENT.
Preparing, identifying, and delivering samples will be considered incidental to the cost for samples of the appropriate item.

Section 2535. Bin Type Crib Walls

2535.01 DESCRIPTION.

A. Bin type crib walls will be used to retain earth embankments when lateral clearance will not allow normal earth slopes. These walls may be constructed of precast concrete units in the form of alternate courses of stretchers and headers or may be constructed of formed galvanized sheets so that when assembled, they will form a succession of vertical, rectangular cells which will be filled with suitable backfill material.

B. Both precast concrete units and formed galvanized sheets are required to conform to the contract documents.

2535.02 MATERIALS.
For materials used in construction of the cell walls, meet the following requirements for the respective types:

A. Concrete Crib Units.
Precast concrete complying with the applicable requirements of Section 2407.

B. Formed Galvanized Sheets.

1. Sheets.
Comply with requirements of Section 4141 for the type of base metal and galvanizing. Ensure the sheets are of the gage specified in the contract documents. Sheets may be galvanized before punching and forming.

2. Nuts and Bolts.
Use bolts and nuts galvanized according to ASTM A 153, Class C. Use unfinished regular bolts meeting requirements of ASTM A 307, Grade A, full diameter body.

- Threads: ANSI B1.1, Unified Coarse Thread Series.
- Bolt heads and nuts: either standard square, hexagonal, or heavy hexagonal style; meet the requirements of ASTM A 307 or ASTM A 563.

2535.03 CONSTRUCTION.

A. Excavation.

1. Excavate the site to provide a firm foundation at the desired elevation. If the wall face is to be battered, excavate the foundation to be sloped to the heel to provide the required batter of the wall face. Otherwise, excavate the foundation to be level. Compact the soil beneath the entire bin area by rolling or tamping to provide a firm foundation.

2. Unless designated otherwise, when construction of bin type crib wall is included in the contract for grading a section of road, all excavation in connection with this construction is classified according to Article 2102.03, B, the same as other excavation in the contract. When not included in contracts for grading, all excavation in connection with this construction is Class 23 Excavation according to Article 2402.03, J.

B. Construction of Crib Walls.

1. When the total height of wall does not exceed 6 feet (1.8 m), the foundation may be level and wall face vertical. When the height of wall exceeds 6 feet (1.8 m), batter the wall face as indicated in the contract documents, but no less than 2 inches in 12 inches (50 mm in 300 mm). Adjust the foundation to provide the required batter in the wall face. Ensure courses of stretchers or plates in the wall face are level.

2. When specified in the contract documents, cover the subgrade for the wall with special backfill material meeting requirements of Section 4132. When drainage is provided beneath the wall foundation, cover the drain and foundation with porous backfill material meeting requirements of Section 4131.

3. **Concrete Units.**
   a. Furnish concrete crib wall units in two patterns: one to be used as stretchers, and the other to be used as headers in building the wall. Ensure these units:
      - Meet the requirements for dimensions and reinforcement shown in the contract documents,
      - Are free from cracks, spalls, or surface depressions on any face,
      - Have rectangular cross section, and
      - Are beveled as shown in the contract documents.
   b. Place a double row of stretchers along the line of the toe of the wall. Place one or more rows of stretchers along the heel of the wall, as indicated in the contract documents, according to the height of the wall. Ensure the end stretchers are of a length that full bearing is provided for the end headers. Place headers at right angles to the wall face at 6 foot (1.8 m) intervals. Leave a space of 1/4 inch (6 mm) between the stretcher and the projecting lug of the header to allow for slight movement of the wall.
   c. Use the stretchers for the wall face that are indicated in the contract documents. Open type stretchers will provide approximately a 5 inch (125 mm) vertical opening between courses of stretchers. Closed type stretchers will provide approximately 1 inch (25 mm) vertical space between courses of stretchers.
   d. Ensure stretcher courses in the wall face are level. If shimming is necessary, do so using layers of heavy asphalt roofing paper at bearings. Where the wall is stepped up or down, hold end headers in place using extra headers placed parallel to and between the rows of stretchers.

4. **Formed Galvanized Sheets.**
   a. Ensure sheets are fabricated so they may be assembled and bolted to form cells of the shape and dimensions shown in the contract documents. Assemble the sheets as shown in the contract documents. Sheets may be placed individually and bolted in place, or the transverse walls and posts may be assembled as a unit and sheets of the front and rear walls placed individually.
   b. After the plates of each course are in place, draw tight all bolts in that course.
   c. Tighten all bolts in each course at least twice to assure that all bolts are properly tightened.

C. **Placing Backfill.**

1. After each 3 foot (1 m) lift of crib wall cell is completed, promptly place backfill material consisting of suitable earth or granular material, as specified. Ensure the backfill material completely fills the cell, as well as the space between the cell and any face of natural earth behind the wall. Place backfill material in layers no greater than 6 inches (150 mm), thoroughly compacted by tamping. Granular material may be compacted by vibration.

2. Use a method of compaction that neither distorts the wall nor displaces the units.

2535.04 METHOD OF MEASUREMENT.

Measurement for the items associated with Bin Type Crib Walls will be as follows:

A. Excavation.

1. Part of a contract for grading a section of road: as provided in Section 2102.

2. Not a part of a contract for grading a section of road: Class 23 excavation will be computed as provided in Section 2402. In addition, the quantity of excavation will include only material actually removed above the elevation of the subgrade designated in the contract documents and bounded by:
   - Vertical planes 1 foot (0.3 m) beyond the horizontal projection of the headers at the ends, and
   - The stretchers at the rear and by the natural ground surface at the top and front.

B. Backfill Material.

1. Granular backfill material furnished: cubic yards (cubic meters) or in tons (megagrams) as indicated in the contract documents and as provided in Article 2402.04, E.

2. Earth backfill material: not measured.

C. Bin Type Crib Wall.
The Engineer will compute in square yards (square meters) the face area of each design of bin type crib wall from measurements of the length of wall and the height from the extreme top and bottom of stretcher units or sheets.

2535.05 BASIS OF PAYMENT.

A. Payment for the various items associated with Bin Type Crib Walls will be the contract unit price as follows:

1. **Excavation.**
   Per cubic yard (cubic meter) for the type of excavation.

2. **Backfill Material.**
   Per cubic yard (cubic meter) or per ton (megagram).

3. **Bin Type Crib Wall.**
   Per square yard (square meter) for each design constructed.

B. Payments are full compensation for:
- Furnishing all materials, tools, and labor necessary to construct the crib walls complete for the respective type,

- For placing and compacting of earth or granular backfill material, and
- For all other operations necessary to the work and not covered by other items.

Section 2536. Asbestos Removal

2536.01 DESCRIPTION.

Removal, transport, and disposal of asbestos from buildings and structures scheduled for demolition or renovation. Perform the work according to 40 CFR Part 61, Subpart M. The work will be detailed in the contract documents.

2536.02 LICENSING, IDENTIFICATION OF WORK, AND RIGHTS OF POSSESSION OR OCCUPANCY.

A. Bidding.

Bids will be received for this project from bidders who hold a valid permit for this type of work issued by the Iowa Workforce Development, Labor Services Division.

B. Identification of Work.

1. The Contracting Authority will have inspected the buildings and structures for the presence of asbestos. Suspect materials will have been sampled and tested. The results will be included in the contract documents.

2. Access to the buildings and structures by prospective bidders will be allowed. Arrangements for access will be made by the Office of Contracts, on request.

3. The Contracting Authority assumes no responsibility for the condition of the existing buildings and structures.

4. Inspect the sites identified in the contract documents from which asbestos is to be removed prior to submittal of a bid.

5. Furnish, install, and maintain protective barricades and fences for public safety during the contract period.

C. Rights of Possession or Occupancy.

The Contracting Authority has complete authority as to the possession of properties by any occupant. The Contractor, the Contractor's authorized subcontractors, their agents, or other individuals do not have any right of authority to grant occupancy or to charge or collect any rents on any properties in this contract within the limits of this project.

2536.03 ASBESTOS REMOVAL AND DISPOSAL.

A. Reporting.

1. Give a minimum of 14 calendar days advance notification of the work to the Iowa DNR and the Iowa Labor Services Division according to 40 CFR Part 61, Subpart M and other applicable regulations concerning asbestos removal work. In addition, obtain all necessary authorizations for the work. Provide copies of all notification and authorization information to the Engineer prior to starting work.

2. Specific reporting, authorization, and notification requirements may be specified in the contract documents.

B. Removal.

1. Remove, transport, and dispose of all asbestos specified in the contract documents. Perform this work in compliance with current applicable local laws, rules, regulations, and ordinances and requirements of the U.S. EPA, the Iowa DNR, and the Iowa Workforce Development. The Contractor is expected to be fully knowledgeable of these requirements.

2. Provide workers licensed and trained in asbestos abatement according to 875 Iowa Administrative Code, Chapter 155. Ensure these workers are on-site during the asbestos removal work. Ensure evidence that the required training has been accomplished by these persons is available for inspection during normal business hours.

3. Limit this work to asbestos removal. Salvage will not be permitted. Removal of pipes, ducts, or other items as units will be permitted only if future demolition is intended and the removal of these items is necessary for asbestos removal.

4. Some of the asbestos may not be friable. It may be possible to remove and dispose of this material in a manner to maintain its non-friable condition.

5. Monitor and test for air borne asbestos particles during working hours according to the current EPA and Iowa Labor Services Division regulations. Conduct the operations to keep air borne particles within the established regulation limits. Provide the Engineer with copies of correspondence, test results, recommendations, and other information the Engineer needs to document compliance with these requirements.

6. When asbestos removal is completed, all work will be inspected for the presence of asbestos debris. Continue removal and cleaning until air monitoring clearance testing indicates a level of air borne fibers is equal to or less than the requirements in the current EPA and Iowa Labor Services Division regulations. Notify the Engineer when this sampling is started. Provide documentation to the Engineer that the level of air borne fibers, after the work is completed, is equal to or less than the requirements in the current EPA and Iowa Labor Services Division regulations.

7. Provide the Engineer with test results for all air monitoring tests within 24 hours after the sampling has been completed.

8. Comply with current EPA, State, and Federal regulations. At all times, take necessary precautions and provide necessary equipment to all persons employed on the project.

C. Disposal.

1. Dispose of removed asbestos promptly. Transport and dispose of waste containing asbestos according to current U.S. EPA and Iowa DNR regulations.
2. Identify or mark hauling vehicles used to transport asbestos waste, during loading and unloading, as required by the applicable regulations for transporting asbestos waste.

3. Provide a Waste Shipment Record (WSR) to the waste site owner or operator at the time the waste is delivered to the waste disposal site. Provide a copy of the WSR to the Engineer as well.

D. Safety Rules.
The Contractor is solely responsible for enforcement of the safety rules for employees and any person the Contractor authorizes for entry into the work area. The Engineer will have a right of entry to the work area, and they will comply with the Contractor's safety rules.

2536.04 METHOD OF MEASUREMENT.

Lump sum.

2536.05 BASIS OF PAYMENT.

A. Payment for Removal of Asbestos identified in the contract documents will be the lump sum contract price.

B. Payment is full compensation for:
- Removal of asbestos, transporting asbestos, and disposal of asbestos at an approved disposal site, and
- The cost of all labor, monitoring, materials, equipment, permits, disposal fees, and preparation of and filing reports, notifications, and records.

C. Adjustment of contract price for Removal of Asbestos which is identified in the contract documents will not be allowed should any buildings from which asbestos is to be removed be altered or damaged by others during the period of time between inspection by bidders and asbestos removal.

D. Partial payments may be paid as the work progresses, as authorized by the Engineer.

E. Should asbestos be discovered, in addition to that identified in the contract documents, removal of the additional asbestos will be paid for as extra work according to Article 1109.03, B.

Section 2537. Underground Tank System Removal and Petroleum Contaminated Soil Remediation

2537.01 SCOPE OF WORK.

Perform all work according to 567 IAC, Chapters 120 and 135, applicable OSHA regulations, and this specification.

A. Removal of Underground Tanks.
Complete the following:

1. Remove, collect, and dispose of contents of the tank system.

2. Vent, remove, transport, and destroy all components of the tank system.

3. Obtain and test soil and groundwater samples necessary to complete Iowa DNR's Tank Closure Report.

4. Furnish, install, maintain, and subsequently remove safety fence enclosure around excavated areas.

5. Remove non-contaminated soil and rubble.

6. Furnish, place, and compact suitable backfill soil to finish the excavation to grade.

7. Prepare and provide Tank Closure Reports to the Engineer.

B. Remediation of Petroleum Contaminated Soil.

1. Complete the following:
- **a.** Remove contamination by excavating a specified volume of soil.
- **b.** Transport, spread, and turn contaminated soil at remediation areas designated or approved by the Engineer, or transport and dispose of contaminated soil at an approved solid waste landfill.
- **c.** Obtain and test soil and groundwater samples necessary to complete Iowa DNR's requirements for removal of contaminated soil by excavation.
- **d.** Furnish, place, and compact suitable backfill soil to finish the excavation to grade.
- **e.** Prepare and provide an Over-Excavation of Contaminated Soil report to the Engineer.

2. In situations where suitable remediation sites are not available within the ROW, the contract documents will require delivery of petroleum contaminated soil to a solid waste landfill facility approved by the Engineer.

2537.02 DEFINITIONS.

For the purpose of this specification the following definitions will apply:

A. Contamination.
Contamination or contaminated means the presence of petroleum hydrocarbon constituents at concentration levels at or above those listed in Iowa DNR's Tier 1 Look-Up Table in 567 IAC, Chapter 135. Soils with constituent concentrations below these levels will be classified "non-contaminated."

B. Destroy.
Destroy means rendering a tank system unusable for any purpose other than scrap metal, or landfill material in the case of plastics or fiberglass. Cut up or crush, or both, all components of a system prior to being recycled as scrap or disposed of in a landfill.

C. Land Application.
Land application means the act or process of placing, leveling to a uniform thickness and application rate, incorporation, and remediation of petroleum contaminated soil to a level of constituent concentration less than those listed in the Tier 1 Look-Up Table in 567 IAC, Chapter 135. Land application and land farming are terms which are often used interchangeably.

D. Incorporation.
Incorporation means the process of mixing the contaminated soil after placement to provide a loose and divided soil texture, and leveling at the remediation site. Mixing operations such as disking or harrowing to approximately 2 inches (50 mm) greater than the depth of material placed are considered acceptable.

E. Remediation of Contaminated Soil.
Remediation of contaminated soil means the process of removing contaminated soil by excavation, surface applying the contaminated soil in a relatively thin layer, and allowing natural processes to reduce contamination levels below regulated action levels. Once contaminated soil has been land applied, it shall remain in place until the levels of contamination are below those listed in the Tier 1 Look-Up Table in 567 IAC, Chapter 135.

F. Tank System.
Tank System means underground storage tanks and all associated piping, auxiliary equipment, containment systems and leak detection equipment. A tank system includes, but is not limited to:

- Fill and vent piping,
- Product delivery piping,
- Product pumps,
- Product dispensers,
- Leak detection piping, and
- Leak detection wells.

2537.03 TANK REMOVAL AND SOIL REMEDIATION.

A. Notification.
Based on the Contractor's work schedule, the Engineer will complete necessary Iowa DNR regulatory notifications for tank removals and additional excavation for petroleum contaminated soil.

1. Removal of Underground Tanks.
Provide written notification to the Engineer 45 calendar days prior to removing underground tanks. The Engineer will provide the 30 calendar day Iowa DNR written pre-tank-removal notification.

2. Remediation of Petroleum Contaminated Soil.
- **a.** Provide and submit the Iowa DNR's "Land Application Notification" form to the Iowa DNR with a copy sent to the Engineer at least 30 calendar days prior to beginning excavation activities.
- **b.** The Engineer will waive this notification if:
  - **1)** Petroleum contaminated soil will be taken to an approved solid waste landfill.
  - **2)** The remediation notification was separately identified and included with the 45 calendar day notification for removal of underground tanks.
  - **3)** The excavated material will be stockpiled, pending further remediation activities. In this case, submission of the Iowa DNR notification will be required at least 30 calendar days prior to removing the soil from the stockpile for land application.

B. Location.

1. Removal of Underground Tanks.
The location of all known underground tanks will be identified in the contract documents. Should an underground tank system that is not identified in the contract documents be encountered:
- **a.** Stop all activities in close proximity of the discovery,
- **b.** Promptly notify the Engineer of the discovery, and
- **c.** Do not resume work in the immediate area until authorized by the Engineer.

2. Remediation of Petroleum Contaminated Soil.
- **a.** The location o fexcavation and Engineer-designated remediation area, or approved solid waste landfill will be designated in the contract documents. The Contractor may propose an alternate remediation area, subject to the requirements of 567 IAC, Chapter 120 and the Engineer's approval.
- **b.** If a remediation area is located within a designated borrow or staged construction area, coordinate with the other project contractors and be prepared to stage land application operations so the remediation area remains available for construction project requirements.
- **c.** The contract documents may contain other specific containment requirements.

C. Underground Tank Removal.

1. Removal of Tank Contents.
Prior to tank removal:
a. Remove all liquid, sludge, and/or sand from the tank system. Collect, and dispose of according to Federal, State, and local regulations.
b. Vent tanks and purge to reduce vapors below explosive levels.

2. Removal of Underground Tanks.
Remove and destroy the tank, all associated piping, and auxiliary equipment.

D. Excavation, Placing Backfill Material, and Safety Fence.

1. Removal of Underground Tanks.
a. Excavation required for underground tank removal includes:
- The excavation necessary to remove the tank including all original backfill material that was placed when the tank was installed, and
- The excavation necessary to remove piping associated with the underground tank system.

b. Immediately notify the Engineer if excavated material contains suspected contamination pursuant to 567 IAC 135.6. Remediate, in the manner described in this specification, excavated material that has petroleum contamination. All other sand fill, rubble, and materials associated with tank removal become the property of the Contractor. Remove these materials from the project according to Article 1104.08.

2. Remediation of Petroleum Contaminated Soil.
a. Approximate limits of excavation (horizontal and vertical) will be identified in the contract documents. Actual excavation limits will be determined in the field and based on the extent of contaminant migration. Continue excavation until:
- Organic Vapor Monitoring (OVM) readings and laboratory tests indicate remaining soil is at, or below, Iowa DNR's Tier 1 Look-Up Table levels published in 567 IAC, Chapter 135, or
- Directed by the Engineer to stop.

b. In situations where petroleum contaminated soil is below a layer of non-contaminated soil, remove and stockpile the non-contaminated soil before or during excavation of the contaminated area. Non-contaminated soil may be used for backfill material provided Type A compaction, according to Section 2107, can be achieved. If non-contaminated excavated soil does not meet the requirements of Article 2102.03, F or cannot achieve adequate compaction, it becomes the property of the Contractor. Remove it from the project according to Article 1104.08.

3. Placing Backfill in Excavations.
a. Furnish backfill material consisting of earth fill. Use material meeting the requirements of Article 2102.03, F.

b. Obtain the Engineer's authorization prior to placing backfill. Complete the backfill placement and compaction operation:
- According to the requirements of Section 2107 for Type A compaction, and
- Within ten working days after authorization is given.

c. Grade the site, shape to drain, and leave in a condition complying with Article 1104.08.

4. Safety Fence.
Furnish, place, and maintain safety fence meeting the requirements of Article 4188.03 around the site of work. Remove after completing backfill placement operations. Fencing material remains the property of the Contractor.

E. Sampling and Testing for Petroleum Contamination.
Ensure all sampling and environmental site work is supervised by a Groundwater Professional certified by the Iowa DNR in accordance with 567 IAC, Chapter 134. The Groundwater Professional shall obtain, prepare, and submit samples for laboratory analysis. Ensure this work is performed in a manner consistent with standard practices for sampling and testing of petroleum contamination and 567 IAC, Chapter 135. Ensure analysis of samples is performed by a laboratory certified by Iowa DNR pursuant to 567 IAC, Chapter 83.

1. Removal of Underground Tanks, Sampling and Testing.

a. After a tank has been removed, have the Groundwater Professional obtain soil and groundwater samples and submit them for laboratory analysis as required by 567 IAC, Chapter 135.

b. Submit all laboratory analysis reports and a copy of the Chain-of-Custody form to the Engineer as soon as available from the testing laboratory.

c. Dispose of all soil and water generated during the sampling, testing, and installation of ground water monitoring wells. Dispose of this material according to applicable Federal, State, and local regulations.

d. Sample and test as follows:

1) Soil Samples.

a) The locations for sampling in the areas where the tanks and the associated piping have been removed are as defined in the Iowa DNR guidance document for "Underground Storage Tank Closure Procedures for Tank and Piping Removal".

b) The presence of standing water in an excavation may cause bottom soil samples to be invalid. In this situation, take required bottom soil samples from the excavated sidewall immediately above the surface water and in the assumed down gradient direction when possible. Ensure the Tank Closure Report contains an explanation and justification for all alternate sampling locations.

2) Ground Water Sample.

a) Sampling locations are as outlined in 567 IAC, Chapter 135. Ensure groundwater sampling wells are:

(1) Installed and closed by a Certified Water Well contractor registered in the State of Iowa pursuant to 567 IAC, Chapter 82.

(2) Cased wells constructed according to 567 IAC 110.11.

b) Ensure water samples are obtained from cased, fully developed, purged, and stabilized wells. After use, close all sampling locations according to applicable Iowa DNR regulations. Provide a completed Iowa DNR "Abandoned Water Well Plugging Record," DNR Form 542-1226, to Iowa DNR for each well closed. Submit a copy of these forms to the Engineer at the conclusion of the project.

c) Obtain the Engineer's approval prior to closing a well.

2. Remediation of Petroleum Contaminated Soil, Sampling and Testing.

a. During excavation of contaminated soil, have the Groundwater Professional test a representative sample of soil from each truck load for VOCs, using appropriate confined head-space air sampling procedures and portable Organic Vapor Monitoring (OVM) equipment. Ensure OVM equipment is calibrated using a benzene standard and readings are approximately correlated to known Total Petroleum Hydrocarbon (TPH) concentrations in a soil matrix. Continue excavation until:

- In the judgment of the Groundwater Professional, remaining soil contamination is below Iowa DNR's Tier 1 Look-Up Table levels, or
- Excavation is stopped by the Engineer.

b. Upon completion of excavation, ensure the Groundwater Professional obtains soil samples for laboratory analysis from the excavated side walls and bottom according to 567 IAC, Chapter 135 unless directed otherwise by the Engineer. Have the Groundwater Professional develop a final site sampling plan and submit it to the Engineer for approval prior to final sampling. Ensure this plan, at a minimum, identifies the total number of samples to be collected and the distribution of sampling locations.

F. Documentation and Reports.

1. Removal of Underground Tanks.

a. Submit a completed Tank Closure Report to the Engineer within 30 calendar days of completing tank removal. Ensure this report complies with the requirements of 567 IAC, Chapter 135. In the report include the location of all tanks, piping, sampling locations, and excavation limits referenced to station and offset distance from mainline or side road survey center line on the tank closure site map. The use of a Professional Land Surveyor licensed in the State of Iowa is not required for the development of a tank closure site map.

b. Complete and return to the Engineer a written "Certificate of Destruction" for all tanks which have been removed. These forms are available from the Engineer.

2. **Remediation of Petroleum Contaminated Soil.**
Document all field activities. Make all field documentation available to the Engineer upon request. Prepare and submit an Over-Excavation Soil Report at the end of the project. In this report include, at a minimum:
   a. **Daily Diary.**
   A narrative record of daily site events relative to excavation, sampling, transporting, and spreading of soil as outlined in this specification.
   b. **Field OVM Testing.**
   A field log tabulating all OVM field testing, dates and approximate times for individual tests, the results of each OVM test, and site map designating approximate site location of removed soil being tested.
   c. **Laboratory Results and Site Map.**
   A copy of all laboratory analytical results, a scaled site map locating sampling locations, and a copy of all chain-of-custody forms. Ensure site maps are referenced to station and offset distance from mainline or side road survey center line. The use of a Professional Land Surveyor licensed in the State of Iowa is not required for the development of a sampling and soil excavation site map.
   d. **Abandoned Water Well Plugging Record.**
   Include in the report a copy of DNR Form 542-1226 for each ground water sampling well constructed and closed.

2537.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. **Removal of Underground Tanks.**
By count for the number of underground tanks removed.

1. **Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Removal of Underground Tanks).**
By count for the number of soil and water samples taken and tested by a laboratory as described in this specification.

2. **Water Sampling Well.**
By count for the number of water sampling wells constructed and closed. Payment for water sampling wells constructed, but which are required by the Engineer to remain available for later sampling, will be according to Article 1109.03, B.

B. **Remediation of Petroleum Contaminated Soil.**
Cubic yards (cubic meters) of excavated petroleum contaminated soil determined by cross-sectioning the excavated area before and after excavation. Quantities will be computed from cross section measurements by the average end area method.

1. **Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Remediation of Petroleum Contaminated Soil).**
By count for the number of samples taken and tested by a laboratory as described in this specification.

2. **Embankment-in-place.**
Cubic yards (cubic meters) determined according to the provisions of Article 2102.04. Non-contaminated soil stockpiled during the excavation, and which is used for backfill material, will not be measured for payment.

2537.05 BASIS OF PAYMENT.

Payment for the items below will be at the contract unit price as follows:

A. Underground Tanks

1. **Removal of Underground Tanks.**
   - **a.** Each. Payment is full compensation for:
     - Removal of the tank and associated piping,
     - All labor, equipment, material, health and safety requirements, excavation, and backfill material and placement necessary for required removal,
     - Transporting and destruction of the tank system,
     - Removal, containment, transportation, and disposal of the tank system's contents,
     - Removal of non-contaminated excavated materials from the project,
     - Furnishing, placing, and removing safety fence,
     - Furnishing, placing, and compacting backfill material,
     - Final grading and seeding of the excavated area,
     - Providing the services of a Groundwater Professional, and
     - Preparing and submitting Certificate of Destruction forms.
   - **b.** If remediation of contaminated soil is required by the contract documents, the cost of remediation is included in the cost of Remediation of Petroleum Contaminated Soil.

2. **Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Removal of Underground Tanks).**
   - **a.** Each for soil or water samples taken and tested by a laboratory as described in this specification.
   - **b.** Payment is full compensation for:
     - All labor, equipment, sample preparation, transportation, and testing to comply with applicable Iowa DNR regulations,
     - Disposal of all contaminated soil from sampling events, and
     - Preparation and submittal to the Engineer of Iowa DNR's Tank Closure Reports.

3. **Water Sampling Well.**
   - **a.** Each for water sampling wells constructed and closed.
   - **b.** Payment is full compensation for:
     - All labor, equipment, and materials to install each cased well,
     - Purging prior to taking samples,
     - Closing the well
     - Disposal of all contaminated soil and water generated as a result of well installation,
     - Purging and sampling events, and

- The preparation and submittal to the Engineer of Iowa DNR's Abandoned Water Well Plugging Records.

4. Remediation of Petroleum Contaminated Excavation.
Payment for remediation of contaminated excavation soil not identified in the contract documents, but associated with Removal of Underground Tanks, will be according to Article 1109.03, B.

B. Petroleum Contaminated Soil.

1. Remediation of Petroleum Contaminated Soil.

a. Per cubic yard (cubic meter).

b. Payment is full compensation for:

- All labor, equipment, and materials required to excavate, transport, spread, incorporate, and turn petroleum contaminated soil in compliance with Federal, State, and local regulations,
- Contractor's employee health and safety requirements,
- Furnishing, placing, and removing safety fence,
- Final grading and seeding of the excavated area, and
- Providing the services of a Groundwater Professional.

c. Payment includes:

- Landfill costs if so designated in the contract documents. Stockpiling, covering the stockpile, and work associated with ultimate placement in a borrowed or staged construction area is incidental to this item.
- Turning the petroleum contaminated soil once a month for the first three months during landfarm season as defined in 567 IAC, Chapter 120. Payment for additional turning directed by the Engineer will be according to Article 1109.03, B. Field sampling and testing using OVM equipment is incidental to this item.

2. Sampling and Testing for Petroleum Contamination (Water and Soil Samples for Remediation of Petroleum Contaminated Soil).

a. Each for soil or water samples taken and tested by a laboratory as described in this specification.

b. Payment is full compensation for:

- All labor, equipment, materials, sample preparation, transportation, and testing to comply with Iowa DNR requirements for petroleum contaminated soil,
- The preparation and submittal to the Engineer of site documentation including a Site Sampling Plan, if required, and
- An Over-Excavation Report.

3. Embankment-in-place.

a. Per cubic yard (cubic meter).

b. Payment is full compensation for furnishing, transporting, placing, compacting, and final grading of the backfill material.

c. Placement and compaction of non-contaminated backfill soil stockpiled as a result of the excavation is incidental to this item.

Section 2538. Salvage, Removal, and Disposal of Obstructions

2538.01 DESCRIPTION.

Salvage, remove, and dispose of buildings and other obstructions from the project site as designated in the contract documents.

2538.02 NOTIFICATION AND RIGHTS OF POSSESSION OR OCCUPANCY.

A. Notification.

1. Notify the Engineer, in writing, of the intended starting and completion dates for demolition no less than 25 calendar days prior to the start of demolition.

2. If unable to begin work on the intended start date, notify the Engineer, by telephone with a written follow-up, of the new intended start date. To meet the requirements of 40 CFR 61.145(b), provide notification of the inability to commence work on the intended start date as soon as possible before, but no later than 1 working day prior to, the original intended start date. Failure to commence work on the specified start date, and failure to notify of a change in start date 1 working day prior to the original start date, will result in the need for a new 25 calendar day notification to the Engineer.

3. The Contracting Authority will provide notification of the work to the Iowa DNR.

B. Rights of Possession or Occupancy.

1. The Contracting Authority retains the exclusive right to grant occupancy and collect rent on any property included in this contract.

2. Do not view the interior of occupied houses.

2538.03 SALVAGE, REMOVAL, AND DISPOSAL.

A. General.

1. Unless designated otherwise in the contract documents, the Contractor may elect to:
- Demolish the buildings on site and remove the building materials, or
- Move the building structure intact from the site.

2. Demolition by burning and the burning of demolition debris and material is prohibited.

3. Perform Clearing and Grubbing according to Section 2101.

B. Regulated Materials.

1. The Contracting Authority will have inspected the building for the presence of asbestos, mercury, and PCB-containing materials. These materials will be removed by others.

2. Mercury-containing materials include:
- Fluorescent, high pressure sodium, mercury vapor, metal halide light bulbs, and
- Thermostats containing a liquid filled capsule.

3. PCB-containing materials include capacitors, ballasts, and transformers where the component is contained within a metal jacket and does not have a specific, legible, label stating no PCB's are present.

4. Should the Contractor encounter unforeseen regulated materials, immediately suspend all activities that may disturb the suspect regulated material and notify the Engineer.

C. Underground Tanks.

1. If the presence of underground tanks is known, they will be indicated in the contract documents. Unless specified otherwise in the contract documents, perform all work involved in removing and disposing of underground tanks, the associated plumbing, and the contents, as well as placing backfill in the excavation, according to Section 2537.

2. Should the Contractor encounter an underground tank not indicated in the contract documents, avoid disturbing the tank, its associated plumbing, and its contents. Promptly notify the Engineer.

D. Removal Requirements.

1. Rodent Extermination.
When required by local government ordinances, exterminate rodents before commencing demolition.

2. Utilities.

a. Water and Sewer Disconnections.

1) Tap off all water service lines at the main according to the requirements of the local jurisdiction.

2) Seal storm and sanitary sewers leading to the buildings to be removed. Unless otherwise required by the City or County, use a burlap plug capped with concrete. If desirable to use drains during the removal work, take preventive measures to prevent dirt, plaster, and other material from entering and clogging sewers.

3) Water and sewer disconnections may be performed prior to the intended start date referenced in Article 2538.02, A, with no working days charged.

b. Other Disconnections.

1) Disconnection of other utilities will typically be arranged by the Contracting Authority prior to salvage and removal work. Verify

the disconnection of all utilities and notify Iowa One-Call at 800.292.8989 prior to the commencement of work.

2) If a utility has not been disconnected at the time the work is to commence, make arrangements for the disconnections. This work will be paid for according to Article 1109.03, B.

3. Permits.
Some local jurisdictions require a permit for the performance of demolition work or the moving of intact structures, or both, according to Article 1107.03.

4. Dust Control.
Minimize the spread of fugitive dust during demolition of masonry by thoroughly wetting the material.

5. Safety Fence.
Furnish and place a safety fence meeting the requirements of Article 4188.03 around the site of work. Leave the safety fence in place until the demolished materials are removed from the site and backfill is placed in all holes or excavated areas. The fencing material remains the property of the Contractor.

6. Removal of Buildings and Materials.

a. Unless directed otherwise in the contract documents, remove all structures, trash, rubbish, basement walls, floors, foundations, sidewalks, steps and driveways from the specified parcel. All materials remain the property of the Contractor, unless designated otherwise in the contract documents.

b. Remove and dispose of all materials according to Federal, State, and local regulations. Cover all demolition materials being removed from the site, or transport in a manner that prevents visible emissions. Transport all demolition materials that are not being recycled or salvaged directly to a landfill approved by the Iowa DNR (or the equivalent environmental department in a surrounding State) to accept construction and demolition wastes.

c. Complete the removal of intact structures from the right-of-way within the contract period.

d. Remove and dispose of appliances and other items that may contain refrigerants according to 40 CFR, Part 82. Appliances and other items that may contain refrigerants include, but are not limited to, refrigerators, freezers, dehumidifiers, and portable or central air conditioners. Venting refrigerants into the atmosphere when removing or disposing of these appliances is prohibited. Ensure a technician certified through a U.S. EPA approved course evacuates refrigerants from these appliances. Ensure equipment used to evacuate refrigerants is certified by the ARI or UL.

e. Remove building cornerstones and other historical markers without damaging. Deliver to the Engineer.

f. Obtain the Engineer’s approval prior to commencing backfill placement.

7. Septic Tanks and Cisterns.

Remove septic tanks and cisterns, when included in the contract documents, as described below:

a. Septic Tanks.

1) Remove liquids and sludge from all septic tanks prior to their removal. Ensure pumping, transporting, and disposing of septic tank sewage is performed by a Commercial Septic Tank Cleaner licensed for such work by the State of Iowa. Ensure sewage is disposed of according to 567 Iowa Administrative Code, Chapter 68.

2) Remove septic tanks and place backfill in the excavation according to Article 2538.03, F, 9. Removed septic tanks become property of the Contractor. Transport off the project.

3) Plug all lateral lines (inflow and outflow) at the side of the excavation or tank.

b. Cisterns.

Remove all cisterns and place backfill in the excavation according to Article 2538.03, F, 9. Cisterns will be considered demolition debris. Remove from the site.

8. Wells.

a. Seal the well with methods and materials according to IAC 567, Chapter 39, Requirements for Properly Plugging Abandoned Wells. Ensure wells are sealed by a certified well subcontractor.

b. Remove all obstructions before beginning to fill and seal the abandoned well. Use one or more of the following materials to fill the well:

- Sand,
- Pea gravel,
- Class A, B, or C granular surfacing material,
- Agriculture lime.

c. Ensure all fill materials are free of foreign matter and any toxic residue. Introduce the material at the bottom of the well, or at the starting location. Fill and place progressively upward to the bottom of the seal material location.

d. Use one or more of the following materials to seal the well:

- Neat cement (14 lbs. (1.7 kg) cement per gallon (liter) of water),
- Graded bentonite, bentonite pellets, or bentonite grout,
- Sand cement grout (1 sack of cement/equal volume masonry sand/not more than 6 gallons (23 L) water),
- PCC.

e. Place sealing materials using a grout pipe, tremie pipe, cement bucket, or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Bentonite pellets or graded bentonite may be added as sealing materials by pouring in place and agitating to avoid bridging.

f. For a deep well, place neat cement from 10 feet (3 m) below the bottom of the casing to 10 feet (3 m) above the bottom of the casing or to the static water level, whichever is higher.

g. For wells complete in multiple aquifers, re-use this same procedure throughout subsequent aquifers.

h. Cut off the upper portion of the well casing at least 4 feet (1.2 m) below ground or construction level. Plug the upper 6 feet (2 m) of the remaining casing with neat cement.

9. Placing Backfill Material.

a. For placing backfill material, furnish earth fill material meeting the requirements of Article 2102.03, F. Place backfill material and compact according to the requirements of Section 2107 for Type A compaction. Complete within 10 working days after completion of the removal of structures.

b. Grade and shape the site to drain and ensure the condition of the completed site complies with Article 1104.08.

10. Erosion Control.

Seed and fertilize, as specified in the contract documents, all areas disturbed by the Contractor's operations. The Engineer may require additional erosion control measures. Additional erosion control measures will be paid for according to Article 1109.03, B.

2538.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Salvage, Removal, and Disposal of Obstructions identified in the contract documents: lump sum item; no measurement.

B. Sealing Wells: by count for each well filled and sealed.

2538.05 BASIS OF PAYMENT.

Payment will be as follows:

A. Salvage, Removal, and Disposal of Obstructions on Parcel No. _; and Salvage, Removal, and Disposal of Obstructions:

1. Lump sum.

2. Payment is full compensation for:

- Removal and disposal of buildings, building materials, contents of buildings, appliances, trash, rubbish, basement walls, foundations, sidewalks, steps and driveways,
- Water and sewer disconnection,
- Obtaining permits,
- Removal and handling of refrigerants,
- Furnishing and compacting backfill material,
- Finish grading of disturbed areas,
- Furnishing and placing seed and fertilizer,
- Placing and removing safety fencing, and
- Removal of septic tanks and cisterns.

3. Other items of work will be paid for in accordance with Article 1109.03, B.

B. Sealing Wells:

1. Contract unit price per unit.

2. Payment is full compensation for materials, equipment, excavation, filling, and sealing according to the contract documents.

Section 2539. Concrete Pavement Undersealing by Pressure Grouting

2539.01 DESCRIPTION.

A. Underseal and support the concrete pavement to specified grade tolerances by drilling and injecting cement/fly ash grout as shown in the contract documents.

B. The contract may also include patches, longitudinal subdrains, pavement surface repair, and crack and joint sealing.

2539.02 MATERIALS.

A. Mix Design.
The mix design for the pressure grout for undersealing is as follows:

1. One part by volume of Type I Portland cement, and three parts by volume of Class C fly ash. Use fly ash from a source approved for this use according to Materials I.M. 491.17.

2. Add water to achieve required fluidity, according to Paragraph B of this article.

3. Obtain the Engineer's approval for additives.

4. The mix design approval will include a suggested set time, intended for ideal temperature conditions.

B. Fluidity.
Measure fluidity of the grout slurry using the Corps of Engineers flow cone method according to their specification CRF-C611-80. Time of efflux shall range from 10 seconds to 16 seconds. A more fluid mix having a flow cone time of efflux of 9 seconds to 15 seconds may be used during the initial injection at each hole. These measurements will be made by the Engineer, normally at least once every 4 working hours.

C. Material Proposal.
Submit to the Engineer the proposal for materials and additives to be used for the mix design.

2539.03 CONSTRUCTION.

A. Contractor Qualification.

1. Competency in concrete pavement undersealing is required.

2. Before the work is started, submit to the Engineer evidence of competence and previous experience with this type of work. Include in the evidence:
   - An equipment list,
   - Personnel and their experience, and
   - A detailed undersealing procedure which will be followed.
3. Submit this evidence to the Contracts Engineer prior to the letting. Specific approval will be required before this work is started.

B. Equipment.

Furnish all equipment necessary for the adequate performance of the work of this contract. As a minimum, these are as follows:

1. **Grout Plant.**
   - **a.** Mixing may be with a colloidal mixer or other type of mixer as approved by the Engineer. Ensure the mixer has the capability of thoroughly mixing the various components of the grout.
   - **b.** Ensure the following:
     - The plant includes a positive action or rotor injection pump, capable of forcing grout through a hole drilled in the pavement so that grout will fill voids and cavities beneath the pavement slab.
     - The pump is capable of supplying a pressure up to 200 psi (1380 kPa) at the end of the discharge pipe so as to be able to lift the slab without damaging the pavement.
     - The pressure is monitored by an accurate pressure gage in the grout line.
     - The supply tank is equipped with paddles or other means of agitation to maintain a homogeneous mixture.
   - **c.** Measure the dry materials by weight (mass), if in bulk, or use materials packaged in uniform volume sacks. Batch the water through a meter or scale.

2. **Water Tanker.**
   Supply water from a water truck with adequate capacity and pressure for delivery to the grout plant.

3. **Drilling Equipment.**
   - **a.** Furnish compressed air or hydraulically operated rock drills, or other devices, which have the capability of drilling grout injection holes through the pavement and subbase material, if any.
   - **b.** Ensure the equipment is in good condition and is operated in a manner that the holes are vertical and not "out-of-round."

4. Transport.
Furnish the material transport as well as the handling equipment.

5. Miscellaneous Equipment.
Furnish the following:
- All necessary hoses, valves, and valve manifolds to control pressure and volume,
- Pressure gage protectors,
- Expanding packers for the grout injection,
- Wood plugs,
- Hole washing tools,
- Drill steel and bits, and
- All miscellaneous tools, equipment, and supplies that may be required to complete the work.

C. Undersealing by Pressure Grouting.
Underseal the pavement by pressure grouting as shown in the contract documents. The Engineer will designate specific locations for pavement undersealing.

1. Drilling Holes.

a. Drill 1 1/4 inch to 1 1/2 inch (30 mm to 40 mm) diameter holes through the concrete pavement at the locations designated by the Engineer and in a pattern designated in the contract documents or approved by the Engineer. If a pattern is not designated, a three hole pattern will normally be used at each joint or crack in each lane:
- One hole is to be placed in the approach panel, 1.5 feet (0.5 m) from the joint or crack, and 4 feet to 8 feet (1.2 m to 2.4 m) from the center line.
- Two holes are to be placed in the leave panel, 3 feet (1 m) from the joint or crack, and 3 feet (1 m) from the panel edges.

b. For holes nearest the edges of the slab, the joints, or a major crack, a maximum tolerance of 3 inches (75 mm) from the precisely marked location is considered to be reasonable. For other holes, a maximum tolerance of 6 inches (150 mm) is considered to be reasonable. Comply with the following:

1) Do not drill holes directly over joints or cracks.

2) Rotate the drills to avoid cracking the pavement and to provide satisfactory holes of the proper diameter for effective operations in pressure grouting.

3) When drilling holes, hold the drills perpendicular as possible to the pavement surface.

4) Plug irregular or unsatisfactory holes which cannot be satisfactorily used in pressure grouting by filling with the hole patching mixture. Drill new holes.

5) Ensure the downward weight (mass) does not exceed 200 pounds (100 kg) during drilling.

c. Ensure concrete spalling resulting from drilling does not exceed 20% of the pavement thickness. When such spalling occurs, the Engineer may require a lower down feed pressure to be used.

d. Ensure the holes do not extend more than 4 inches (100 mm) below the base of the pavement or stabilized subbase, if any.

2. Washing Holes.
Holes may be washed to create a small cavity, allowing initial spread of grout.

3. Undersealing.

a. When undersealing, pump grout under the pavement panel until movement in the slab is detectable. For the purpose of detection, use:

- A beam having a base length of at least 4 feet (1.2 m), and
- At least two accurate gages (capable of detecting movement of 0.010 inch (0.25 mm)) placed so that relative movement can be checked between both adjacent panels and the shoulder.

b. Comply with the following:

1) Limit panel movement to 0.10 inch (2.5 mm) or less.
2) Limit the initial pressure to 20 psi (150 kPa) or less.
3) After pumping has been started, limit the pumping pressure to 7 psi (50 kPa) or less.

c. If the Engineer determines that continued grout injection at a specific location is no longer feasible due to major voids, the Engineer may direct the Contractor to cease grout injection at that particular location.

4. Water Displacement.
Allow water that is displaced from the void structure by the grout to flow out freely. Excessive loss of the grout through cracks, joints, or in the shoulder area will not be tolerated.

5. Inspection Holes.

a. The Engineer may require inspection holes to be drilled in the shoulder area at the pavement edge. The purpose shall assure that the grout is not infiltrating existing underdrains during the pumping operation.

b. Drilling of inspection holes will be limited to areas where there are existing subdrains.

6. Radial Cracks.
Cracks extending radially from the grout injection holes will be presumed to have been caused by improper injection techniques by the Contractor.

7. Hole Patching.

a. Upon completion of the undersealing, plug all drill holes by tamping the hole full of very dry concrete (1 part cement, 2 parts sand).

b. Finish the plug flush with the pavement surface.

c. Fill inspection holes with material similar to that in the shoulder area.

D. Limitations of Operations.

1. Do not perform pavement undersealing when the temperature at the bottom of the pavement slab is below 40°F (4°C).

2. Do not allow grout to be held in the mixer or injection pump sump for more than 45 minutes after mixing. Do not use grout held for a longer time than this. Grout held in the mixer for more than 45 minutes will be deducted from the pay quantity.

3. Traffic will be permitted on the undersealed pavement slab when the grout has obtained a set satisfactory to the Engineer. Use the minimum set time included in the mix design approval intended for ideal temperature conditions. It is anticipated that the set time will be extended to approximately 6 hours at 40°F (4°C) and 4 hours at 50°F (10°C). The minimum set time will vary with individual material combinations.

4. Conduct the work on only 50% of the pavement width at a time.

5. Allow traffic to use the pavement during construction operations. Conduct all operations to provide a minimum of inconvenience to traffic.

6. Adjust the work schedule so that all traffic lanes can be opened to public traffic during nonworking hours.

7. Limit drilled holes to the amount that can be grouted during the following working day, unless the Engineer approves otherwise.

8. If unforeseen conditions should result in uncompleted sections being left overnight and requiring protection, provide a sufficient number of traffic control devices and flaggers to warn and direct traffic from the time construction operations have stopped until they have resumed again. No extra payment will be made for the necessary traffic control devices and flaggers.

9. Apply Articles 1107.08, 1107.09, and 1108.03. When there is a contract item for Traffic Control, furnish, erect, and maintain all signs, barricades, and other traffic control devices required by the contract documents.

10. Remove debris resulting from the operations from the traffic lanes and shoulders as the work progresses and before the traffic lane is opened to public traffic.

11. Shoulder adjustments will be made by the Contracting Authority, as the Engineer deems appropriate. Except when additional shoulder work is required by the contract, the Engineer will provide and maintain signing for vertical drop-offs at the pavement edges that remain after the Contractor has completed the pressure grouting operation. Provide signing, barricades, and other traffic control required by the contract documents for the shoulder while work at the specific location remains uncompleted.

12. When other work is included in the project, sequence the operations so that undersealing, longitudinal subdrains, patching, diamond grinding, and crack and joint sealing are done in an area in that order. All of these operations required by the contract documents should be completed in an area in the same construction season, or not started until the following construction season.

E. Acceptance.
Before final acceptance, clean up all unused material. Ensure the surrounding areas are left in a neat and orderly condition as provided in Article 1104.08.

2539.04 METHOD OF MEASUREMENT.

A. Measurement for Pavement Undersealing by Pressure Grouting will be as follows:

1. Holes (for Pressure Grouting).
By count for Holes drilled through the pavement at locations designated by the Engineer. Irregular or unsatisfactory holes which cannot be satisfactorily used in pressure grouting will not be counted.

2. Portland Cement (for Pressure Grouting).
Calculated from the bulk weight (mass) in tons (megagrams) or number of sacks of cement furnished and used in the work. This will include the quantity used in pressure grouting and in filling drilled holes. Cement that is not used will be deducted.

B. When grouting is discontinued at any specific location, as directed by the Engineer, the holes drilled and the Portland cement used will be included in the measured quantities.

C. Inspection holes will be counted separately.

D. Water and fly ash will not be measured for payment.

2539.05 BASIS OF PAYMENT.

A. Payment for Pavement Undersealing by Pressure Grouting will be the contract unit price as follows:

1. Holes (for Pressure Grouting).
Each.

2. Portland Cement (for Pressure Grouting).
Per ton (megagram) for cement used in the work.

B. When the contract documents include an item for Traffic Control, payment will be the lump sum contract price according to Section 2528.

C. When the undersealing operation results in radial cracking, payment will be reduced by $0.50 ($1.60) for each linear foot (meter) of crack measured by the Engineer, to the nearest foot (0.1 m).

D. Payment for the number of inspection holes drilled will be 50% of the contract unit price for a hole for pressure grouting.

E. Payments are full compensation for:
- Furnishing all materials, including fly ash and water and hole sealing mixture,
- Proportioning and mixing,
- Drilling holes,
- Pumping and repumping,
- Filling the holes, and
- Furnishing all equipment, tools, labor, and incidentals necessary to complete the work in accordance with the contract documents.

Section 2540. Longitudinal Joint Repair

2540.01 DESCRIPTION.

A. For longitudinal joint repair:
- Mill the existing unstable asphalt material down to the PCC base over longitudinal widening joints and the center line joint, as shown in the contract documents or as directed by the Engineer. The width to be milled will be designated in the contract documents.
- Clean and seal or fill the existing longitudinal opening in the concrete base.
- Fill the milled trench with the specified mixture.

B. The Engineer may also designate other joints and cracks for this repair.

2540.02 MATERIALS.

A. Use the following materials for filling the longitudinal joint in the PCC base:

1. For a 0 to 3/4 inch (0 mm to 20 mm) opening, fill the existing joint with either PG 58-xx or CRS-2 emulsion.

2. For an opening greater than 3/4 inch (20 mm), fill the existing joint with a 3/8 inch to 1/2 inch (9.5 mm to 12.5 mm) commercial HMA mixture with PG 58-xx or other suitable hot or cold bituminous mixture approved by the Engineer.

B. For completing the joint repair (filling the milled trench above the PCC base), use a 300,000 ESAL HMA or similar mixture approved by the Engineer.

2540.03 CONSTRUCTION.

A. Equipment.

1. Use milling equipment capable of removing deteriorated material 6 inches (150 mm) in width and up to 7 inches (175 mm) in depth in a single pass operation. Use equipment capable of delivering high pressure compressed air to the joint from a nozzle on a flexible hose to:
   - Remove other deteriorated material, and
   - Clean the existing joint in the PCC base.

2. The intent is to use maintenance type equipment for filling joints with bituminous material and for producing and placing asphalt mixtures for joint and trench filling. The Engineer may waive those requirements that make it impractical to use this type of equipment.

3. To compact the lower lifts, use any one of the following:
   - Mechanical tampers meeting the requirements of Article 2001.04,
   - Trench rollers,
   - Vibratory compactors, or
   - Weighted vehicles operated in the trench.

B. Joint Repair.

1. Use milling equipment to remove the deteriorated material above the longitudinal joint. Remove all deteriorated material to the PCC base surface, including any mesh. Spread this material on the adjacent shoulder, or remove according to Article 1104.08.

2. Remove all loose and adjacent deteriorated material from the existing joint in the PCC base to a depth of at least 4 inches (100 m) using high pressure compressed air. Air blast the joint twice. Should the air blast remove deteriorated material in a manner that undermines any of the asphalt surfacing, use hand tools to produce a nearly vertical face of sound material.

3. It is anticipated that the blasting operation will, on occasion, remove or indicate the need for removal of material outside of the trenched area. When these additional areas are in excess of 2 square feet in 10 linear feet (0.2 m^2 in 3 m), they will be considered as part of the surface patching operation. The material used to repair these areas will be measured and paid for as surface patching.

4. Fill joints in the PCC Base with the material specified in Article 2540.02. Spade and rod into place the material used to fill joints over 3/4 inches (20 mm) in width. Compact the material with suitable hand tools to the satisfaction of the Engineer. Take care not to overfill the joint.
5. Lightly tack the vertical faces and the base of trench prior to filling the trench with HMA. Ensure these surfaces are clean and dry enough to make this tacking operation effective.

6. Place the material for filling the trench in uniform lifts of no more than 3 inches (80 mm) in depth. Compact the material with a minimum of three passes with compaction equipment. Cores may be required to ensure that compaction is adequate. Ensure the finish elevation of the trench material is level with, or no more than 1/4 inch (6 mm) above, the surrounding pavement surface.

C. Limitations.
Apply Article 2212.03, C.

2540.04 METHOD OF MEASUREMENT.
Measurement for Longitudinal Joint Repair will be to the nearest 0.1 foot (0.1 m) on the basis of 6 inch (150 mm) width of repair.

2540.05 BASIS OF PAYMENT.

A. Payment will be paid the contract unit price per linear foot (meter) of Longitudinal Joint Repair completed.

B. Payment is full compensation for:
- All labor, materials, equipment necessary for milling to the existing PCC base,
- Removal of all deteriorated material from the joint and trench,
- Cleaning and filling the joint with the specified material, and
- Filling the trench with HMA.

Section 2541. Crack and Joint Cleaning and Sealing (HMA Surfaces)

2541.01 DESCRIPTION.

A. Rout and clean (prepare) cracks in HMA surface and seal the prepared cracks with a joint sealer.

B. Crack and joint cleaning and sealing is intended to address transverse (thermal) cracking, longitudinal cracking, joint reflective cracking, low severity fatigue cracking, and low severity block cracking. Crack and joint cleaning and sealing is not intended to clean or seal moderate or high severity block cracking, moderate or high severity fatigue cracking, edge cracking, alligator cracking, or mat slippage cracking. Definitions for these pavement distress types can be found in the 'Distress Identification Manual for the Long-Term Pavement Performance Program' (Publication No. FHWA-RD-03-031, dated June 2003, web address: http://www.tfhrc.gov/pavement/ltpp/reports/03031/03031.pdf).

2541.02 MATERIALS.

A. Use a poured joint sealer material meeting the requirements of Article 4136.02. A hot pour sealer will be required.

B. In conjunction with this sealer, use backer rod meeting the requirements of Article 4136.02. Use backer rod of a size that compression is required for installation in the crack so it maintains its position during the filling operation. More than one size may be necessary to complete the work.

2541.03 CONSTRUCTION.

A. Equipment.

1. Routing or Sawing Equipment.
Use power driven routing or sawing equipment capable of cutting the cracks to the required dimensions. Do not use equipment designed to "plow" the cracks to dimension.

2. Air Compressors.
Use air compressors that provide moisture and oil free air and are of sufficient size to blow sand and other foreign material from the crack and the pavement surface.

3. Equipment Used for Heating and Placing the Material.
Use oil jacketed, double boiler type equipment capable of heating the material to 400°F (205°C) and pumping the material into the prepared cracks.

B. Crack and Joint Cleaning and Sealing.

1. Cleaning Cracks and Joints.

a. Cracks and Joints with Average Opening of 3/8 Inch (10 Mm) or Less.
Rout or saw to provide a minimum sealant reservoir of 3/8 inch (10 mm) in width by a nominal 1/2 inch (13 mm) in depth.

b. Cracks and Joints with Existing Width Greater Than 3/8 Inch (10mm).
Use backer rod or clean dry sand. Clean cracks and joints of all foreign material to a depth necessary to accommodate the sealer material and the backer rod, or sand, to be used. Ensure backer rod is dry when placed.

2. Sealer Material.
Heat, handle, and apply according to the manufacturer's recommendations.

3. Filling Cracks.

a. Ensure cracks are clean and dry prior to sealing.
b. Slightly overfill the entire crack reservoir with sealant.
c. Tightly squeegee with a narrow V-shaped squeegee immediately after placement of the sealant while still hot.
d. Operate the squeegee within approximately 1 foot (0.3 m) of the wand tip used to place the sealant.
e. Sealant on the roadway surface in excess of 1/2 inch (13 mm) on each side of the crack edge will not be acceptable.

4. **Prior to Opening to Traffic.**
Remove asphalt cement concrete and foreign material resulting from crack preparation from the roadway by brooming, compressed air, or other methods satisfactory to the Engineer.

C. Limitations.

1. Do not perform crack sealing after September 30.

2. Perform crack cleaning and sealing only when the ambient air and pavement surface temperatures are above 40°F (4°C). When near this minimum, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the crack surfaces.

3. Conduct the work on only one lane of the pavement width at a time. When work encroaches on an adjacent lane, a flagger will be required at that location.

4. Apply Articles 1107.08, 1107.09, and 1108.03.

5. Lanes may be opened to traffic only after the sealer has set sufficiently so it will not pick up under traffic. Blotting material may be applied to the sealer, but only after the sealer surface has set so as to avoid penetration of the blotting material into the sealer.

6. Before the pavement is opened to traffic, ensure debris and saw slurry or dust from dry sawing or routing operations is removed from the pavement surface.

7. Clean all dry sawed or routed joints or cracks using a stream of air sufficient to remove all dirt, dust, and deleterious material that can adhere to the joint face before the pavement is opened to traffic. Complete this work within 3 hours after the joint or crack has been dry sawed or routed.

8. Clean all wet sawed joints with high pressure water immediately after sawing to remove residue produced by the sawing operation.

9. Seal cracks within 3 working days after preparation.

2541.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Crack and Joint Cleaning and Sealing (HMA Surfaces).

1. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 kilometer), of main line pavement and shoulders on which cracks and joints were cleaned and sealed. Calculations will be based on the center line distance of main line, two-lane pavement, corrected for main line pavement of more than two lanes, including climbing lanes.

2. Shoulders 4 feet (1.2 meters) wide or less will not be measured separately.

3. At intersections, rest areas, and interchanges designated for cleaning and sealing, the additional areas of widened pavement, ramps, storage lanes, turning lanes, paved medians, and parking in rest areas will not be separately measured for payment.

4. Between limits for which cleaning and sealing is intended for either pavement or shoulders, no deductions will be made for bridges, intersections, or other interruptions where cracks or joints are not to be cleaned and sealed.

B. Sealer Material (HMA Surfaces).
Pounds (kilograms) of sealer material used in cracks and joints.

2541.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Crack and Joint Cleaning and Sealing (HMA Surfaces).

1. Per mile (kilometer) for pavement or shoulders on which the cracks and joints were cleaned and sealed.

2. Shoulders 4 feet (1.2 meters) or less in width are incidental to the price bid for Crack and Joint Cleaning and Sealing (HMA Surfaces).

3. Payment is full compensation for all labor, equipment, and materials (except for sealer, but including backer rod or sand) for cleaning and sealing cracks and joints.

B. Sealer Material (HMA Surfaces).

1. Per pound (kilogram). Price is predetermined.

2. Payment is full compensation for furnishing the sealer material only.

Section 2542. Crack and Joint Cleaning and Sealing (Portland Cement Concrete Pavement)

2542.01 DESCRIPTION.

A. Rout or saw and clean random cracks and existing transverse and longitudinal joints in PCC pavement. Seal the prepared cracks and joints with an approved sealing material.

B. Crack and joint cleaning and sealing is intended to address longitudinal cracking, transverse cracking, and corner breaks. Crack and joint cleaning and sealing is not intended to clean or seal durability (“D”) cracking or map cracking. Definitions for these pavement distress types can be found in the ‘Distress Identification Manual for the Long-Term Pavement Performance

Program' (Publication No. FHWA-RD-03-031, dated June 2003, web address: http://www.tfhrc.gov/pavement/ltpp/reports/03031/03031.pdf).

2542.02 MATERIALS.

A. Use hot poured joint sealer and backer rod that meet the requirements of Article 4136.02.

B. Installation of preformed elastomeric joint seals meeting the requirements of Article 4136.02 may be required in the contract documents. Substitution of elastomeric joint seal material for poured joint sealer material will not be allowed unless specified otherwise in the contract documents.

2542.03 CONSTRUCTION.

A. Equipment.

1. Routing or Sawing Equipment.

a. Use power driven routing or sawing equipment, where required, capable of cutting the cracks to the required dimensions without excessive spalling of the adjacent surface.

b. Use power driven sawing equipment (wet or dry), where required, capable of sawing the sealant reservoir to the dimensions shown in the contract documents.

2. Water and Abrasive Blasting Cleaning Equipment.

a. To remove existing joint sealer, debris, and loose material from the crack or joint, use water cleaning equipment capable of delivering water with a pressure of 2,000 psi (13.8 MPa) from a nozzle.

b. Use abrasive blast equipment capable of removing the existing sealant, saw slurry, silt, or other foreign material from the vertical face of the crack or joint to the specified depth. Ensure the equipment leaves a clean, dry, newly exposed concrete surface.

3. Air Compressors.

Use air compressors that provide moisture and oil free air and are of sufficient size to blow sand and other foreign material from the crack or joint prior to placing the sealant material.

4. Equipment for Heating and Placing Sealant Material.

Use an oil jacketed, double boiler type, heating kettle or other thermostatically controlled equipment of a type approved by the Engineer, capable of heating the material to 400°F (205°C) and pumping the material into the prepared crack or joint.

5. Auxiliary Equipment.

Provide auxiliary equipment, such as brooms, scrapers, etc., as necessary to perform the work.

B. Construction.

1. A partial depth finish patch may be required when joints or cracks have edge spalls or other distress greater than 3 inches (75 mm) in width. If not otherwise included as part of the contract work, these areas will be designated by the Engineer as extra work. Construct partial depth finish patches according to Section 2530. Seal joints or cracks less than or equal to 3 inches (75 mm) in width without patching.

2. Clean cracks and joints of existing joint sealer, vegetation, dirt, and all other foreign material to the depth of the bottom of the backer rod. Sand blast the edges throughout the proposed depth of the joint sealer, leaving a clean, dry, newly exposed concrete surface on the vertical edges. This will require two passes of the sand blasting operation for each joint and crack: one pass for each joint or crack edge. Set the angle of approach of the sand blast nozzle to each vertical face of the reservoir to be approximately 30 degrees. The sand blast nozzle shall have a guide which inserts in the joint and assures positive location and directional control of the nozzle.

3. Perform sand blasting just prior to the application of the joint sealer. When cleaned joints or cracks are contaminated before being sealed, reclean them by sand blast before sealing. Rain will be considered contamination.

4. Place a backer rod at the bottom of the joint or crack as a bond breaker. Install it dry. If the width of opening exceeds the maximum size available, approved alternates of bond breakers at the bottom of the crack or joint may be used.

5. Widen cracks and joints in partial depth HMA finish patches to 1/2 inch (13 mm), if widening is necessary. Extend the cleaning and sealing operation across the joint or crack.

6. Prior to placing backer rod and joint sealer:
- Ensure cracks and joints are dry.
- Use compressed air to blow cracks and joints clean.

7. Fill joints and cracks to the level shown in the contract documents.

8. Heat, handle, and apply the sealer material according to the manufacturer's recommendations.

9. Rout or saw cracks and joints with an average opening of 3/8 inch (10 mm) or less to provide a minimum sealant reservoir of 3/8 inch (10 mm) in width by a nominal 1/2 inch (13 mm) in depth. For cracks and joints with an existing width greater than 3/8 inch (10mm), place backer rod to a depth that will provide at least 5/8 inch (16 mm) clearance above the backer rod for the sealer. Clean cracks and joints of all foreign material to a depth necessary to accommodate the sealer material and the backer rod to be used. Ensure backer rod is dry when placed.

C. Traffic Control.

1. When there is a separate item for traffic control, furnish all signs and traffic control devices, such as flaggers, barricades, traffic cones, warning lights, and pilot car signs (when required) according to Section 2528. Erect, maintain, and remove all traffic control devices.

2. Conduct the work on only one lane of the pavement width at a time. When work encroaches on an adjacent lane, a flagger will be required at that location.

3. Apply Articles 1107.08, 1107.09, and 1108.03.

D. Limitations.

1. When other work is included in the contract, sequence operations in the following order:

- **a.** Undersealing,
- **b.** Longitudinal subdrains,
- **c.** Patching,
- **d.** Installation of retrofit load transfer,
- **e.** Grinding or milling, and then
- **f.** Crack and joint sealing.

2. Perform joint and crack sealing only when the ambient air and pavement surface temperatures are above 40°F (4°C). When near this minimum temperature, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the joint surfaces.

3. Lanes may be opened to traffic only after the sealer has set sufficiently so it will not pick up under traffic. Blotting material may be applied to the sealer, but only after the sealer surface has set so as to avoid penetration of the blotting material into the sealer.

4. Remove old sealant, other debris, and saw slurry from the pavement surface before the pavement is opened to traffic.

5. Before the pavement is opened to traffic, clean the dry sawed or routed joints or cracks with a stream of air sufficient to remove all dirt, dust, and deleterious material that can adhere to the joint face. Complete this work within 3 hours after the joint or crack has been dry sawed or routed.

6. Clean wet sawed joints using high pressure water immediately after sawing to remove residue produced by the sawing operation.

7. Seal joints and cracks within 5 working days after completion of any sawing or routing or removing old joint sealant material or debris from the crack or joint.

8. Do not perform crack and joint sealing after September 30. When joint sealer cannot be placed in an otherwise completed joint or crack prior to

this date due to temperature or other conditions, temporarily seal these joints or cracks with a joint sealer over the winter shutdown period. Remove this seal and reclean and reseal the joint or crack according to this specification during the next construction season (at no additional cost to the Contracting Authority).

9. Do not overfill with sealant. Immediately remove sealant placed on the pavement surface.

2542.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Crack and Joint Cleaning and Sealing (PCC Pavement).

1. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 km), of main line pavement and shoulders on which cracks and joints were cleaned and sealed. Calculations will be based on the center line distance of main line, two-lane pavement, corrected for main line pavement of more than two lanes, including climbing lanes.

2. Shoulders 4 feet (1.2 meters) or less in width will not be measured separately for payment.

3. At intersections, rest areas, and interchanges designated for cleaning and sealing, the additional areas of widened pavement, ramps, storage lanes, turning lanes, paved medians, and parking in rest areas will not be separately measured for payment.

4. Between limits for which cleaning and sealing is intended for either pavement or shoulders, no deductions will be made for bridges, intersections, or other interruptions where cracks or joints are not to be cleaned and sealed.

B. Sealer Material (PCC Pavement).
Pounds (kilograms) of sealer material used in cracks and joints.

2542.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Crack and Joint Cleaning and Sealing (PCC Pavement).

1. Per mile (kilometer) for pavement or shoulders on which the cracks and joints were cleaned and sealed.

2. Shoulders 4 feet (1.2 meters) or less in width are incidental to the price bid for Crack and Joint Cleaning and Sealing (PCC Pavement).

3. Payment is full compensation for all labor, equipment, and materials (except for sealer, but including backer rod) for cleaning and sealing cracks and joints.

B. Sealer Material (PCC Pavement).

1. Per pound (kilogram). Price is predetermined.

2. Payment is full compensation for furnishing the sealer material only.

C. Partial Depth Finish Patches.
If not included otherwise as part of the contract work, payment for partial depth finish patches designated by the Engineer will be as extra work according to Article 1109.03, B.

Section 2543. Transverse Joint Repair for HMA Pavements

2543.01 DESCRIPTION.

Mill unstable material from transverse joints of existing HMA pavements as directed by the Engineer, clean the milled trench, fill the milled trench with the specified mixture, and seal the edges of the repair when required.

2543.02 MATERIALS.

A. Unless stated elsewhere in the contract documents, use HMA meting or exceeding Section 2303 requirements for a 300,000 ESAL surface mixture.

B. The mixture size may be 3/4 inch, 1/2 inch, or 3/8 inch (19 mm, 12.5 mm, or 9.5 mm).

C. Use tack coat bitumen meeting the provisions of Article 2303.02, E.

2543.03 CONSTRUCTION.

A. Equipment.

1. Furnish milling equipment capable of removing deteriorated material a minimum of 12 inches (0.3 m) in width in one pass and to the depth specified in the contract documents.

2. Furnish tools or hand tools approved by the Engineer to remove other deteriorated material and clean the joint in the existing pavement.

3. Furnish one of the following to compact the lower lifts:
- Mechanical tampers meeting the requirements of Article 2001.04,
- Trench rollers,
- Vibratory compactors, or
- Weighted vehicle wheels operated in the trench.

B. Transverse Joint Repair.

1. Mill a transverse area not less than 12 inches (0.3 m) wide or more than 24 inches (0.6 m) wide for the entire pavement width at joint repair areas. Additional width may be specified by the contract documents or

by the Engineer. The maximum depth of the milled area will also be specified in the contract documents.

2. Remove all loose material and clean the joint using methods approved by the Engineer. The use of hand tools may be required to provide a nearly vertical face of sound material. All removed material becomes the property of the Contractor, unless specified otherwise in the contract documents.

3. Prior to filling the milled area with HMA, lightly tack the vertical faces and the base of the area. Ensure these surfaces are clean and dry to make the tacking operation effective.

4. Place HMA in uniform lifts not to exceed 3 inches (75 mm) in depth.

5. Compact each lift with a minimum of three passes using the compaction equipment specified.

6. Ensure the finish elevation of the compacted material in the milled area is level with, or not more than 1/4 inch (5 mm) above, the surrounding pavement surface.

7. If the transverse joint repair is to be used for the roadway wearing surface, seal the edges of transverse joint repair with a coat of CRS-2 Bitumen. Apply the bitumen material with a V-shaped squeegee tool at a width of 3 inches (75 mm) centered on the joint edge. Blot excess bitumen material with sand.

C. Limitations of Operations.

1. Conduct the work on one lane at a time unless the road is closed to traffic. Conduct all operations to provide a minimum of inconvenience to traffic.

2. Complete all the milling, cleaning, filling and compacting, and sealing of each transverse joint repair in 1 day if the road is not closed to traffic.

3. If unforeseen conditions should result in milled trench sections being left overnight, assign a sufficient number of flaggers to warn and direct traffic from the time construction operations have stopped until they have resumed again. No extra payment will be made for the necessary flaggers.

4. Apply Articles 1107.08, 1107.09, and 1108.03.

2543.04 METHOD OF MEASUREMENT.

A. Measurement for Transverse Joint Repair will be the number of tons (megagrams) placed.

B. Unused quantities will be deducted based on actual scaled weight (mass) or estimates.

2543.05 BASIS OF PAYMENT.

A. Payment for Transverse Joint Repair will be the contract unit price per ton (megagram) for the specified material used.

B. Payment is full compensation for:
- Removal of all deteriorated material from the joint,
- Cleaning,
- Tack coat,
- Asphalt binder,
- HMA production, placement, and compaction in the trench, and
- Sealing the transverse joint repair edges, when required.

Section 2544. Cleaning and Filling Cracks for HMA Surfaces

2544.01 DESCRIPTION.

A. Clean and fill cracks in an existing pavement or paved shoulder. Fill large cracks and spalled areas with HMA. Fill smaller cracks with filler material.

B. This type of work is intended primarily for existing pavements that are not to be resurfaced. If additional work is to be required, it will be defined elsewhere in the contract documents.

2544.02 MATERIALS.

A. General.

1. Use an HMA mixture meeting the requirements of Section 2203 for a 3/4 inch, 1/2 inch or 3/8 inch (19 mm, 12.5 mm or 9.5 mm) mixture size, or a similar mixture from a commercial source subject to approval of the Engineer. A high performance bituminous cold premix mixture may be used with the Engineer’s approval. The Engineer's approval of the use of a premix will be based on the availability of the specified hot mixture when this work is being done and the length of haul.

2. For tack-coat material, use SS-1, SS-1H, CSS-1, CSS-1H, and MC-70 meeting requirements of Section 4138 or 4140. Do not mix CSS and SS grades. Prior to October 1, use emulsion as the tack-coat bitumen. For Fall work after that date, a cutback asphalt may be used.

3. For filler material, use emulsified asphalt meeting the following requirements for CRS-2P or CRS-2 and of the quality to also be used for seal coat construction.

4. For blotting material, use a sand meeting requirements of Section 4124 or 4125, or a similar sand approved by the Engineer.

B. Polymer-Modified Cationic Rapid Set Asphalt Emulsion, CRS-2P.
Use a rapid set emulsion that has elastic properties.

C. Cationic Rapid Set Asphalt Emulsion, CRS-2.
Use a material having the properties of rapid set emulsion.

D. Requirements.
Use CRS-2P and CRS-2 emulsions complying with Section 4140.

2544.03 CONSTRUCTION.

A. Equipment.
Includes the following:

1. Water cleaning equipment capable of delivering water with a pressure of 2,000 psi (13.8 MPa) from a nozzle to the crack being cleaned.

2. Compressed air capable of providing moisture free and oil free air to blow sand and other foreign material from a crack.

3. Air chisel or hand tools to remove loose and spalled material adjacent to cracks.

4. Heating kettle or pressure distributor for applying filler material through a hand-operated wand or nozzle.

B. Cleaning and Filling.

1. **General.**
   a. Clean with either a high-pressure air or with water equipment, except do not use water blasting equipment when the temperature is below 32°F (0°C). In all cases, ensure vegetation is removed from the cracks. Cleaning methods other than those specified in this specification may be necessary to remove vegetation. Obtain the Engineer's approval for other cleaning methods.
   b. When specifically required by the plans, place a soil sterilant, such as Spike or an approved equal, in the crack prior to placing the filler material.
   c. For filling cracks, use a hand-operated wand or pouring pot, either of which is capable of placing the filler material into the crack and filling to the adjacent surface. Use a nozzle or spout small enough to place the filler material into the crack without soiling the adjacent surface.
   d. Immediately after placement of the filler, use a narrow, 2 inch (50 mm) or less, V-shaped, rubber-edged squeegee to tightly squeegee all cracks filled with emulsion. Take proper measures (for example a sand dam or an application of blotter material, in conjunction with the squeegee operation) to hold the filler in place, preventing run-out at pavement or shoulder edges and low areas.

2. **Cracks Wider than 1 Inch (25 mm).**
   a. Clean the cracks of loose and spalled material, old crack filler when deemed necessary by the Engineer, sand, and other foreign debris using high-pressure water. Continue cleaning until essentially all

debris and loose materials have been removed to a depth of 3 inches (75 mm) within the crack opening.

b. Blow the cleaned cracks free of water.

c. Lightly tack the crack surfaces with tack-coat material as a hand operation.

d. Fill the cracks with the hot mix specified. Rod and tamp into place and level with the adjacent surface. Ensure the mixture is warm and pliable when placed. Place this mixture prior to filling cracks with emulsion. Place a thin application of emulsion over the hot mix and tightly squeegee.

3. Cracks 1/4 Inch to 1 Inch (5 mm to 25 mm) in Width.

a. Clean with air pressure or high-pressure water sufficient to remove old crack filler, sand, and other foreign debris when the Engineer requires. Clean to a depth of at least 1 inch (25 mm). Clean down to sound material, but a depth greater than 3 inches (75 mm) will not be required.

b. Fill cracks with emulsion filler material. Use a hand-operated wand capable of placing the filler material into the crack and filling it to the adjacent surface. Use a nozzle attached to the wand small enough to place filler material into the crack without soiling the adjacent surface.

4. Cracks Less than 1/4 Inch (5 mm) in Width.

Clean sufficiently to remove sand and other foreign debris, and, when deemed necessary by the Engineer, old crack filler. Fill cracks with emulsion filler material.

5. Map-cracked Areas.

Cover with emulsion filler material using a suitable hand-operated squeegee. Apply as a thin, smooth application. Promptly blot the filler material with a light application of blotter material.

C. Limitations.

1. On projects where a fog seal or other surface treatment is to be done in conjunction with this work, complete the crack filling first. Except when this work is in preparation for a seal coat or slurry seal, do not perform crack filling on pavements from May 15 to September 30. Crack filling on paved shoulders will be allowed during this time.

2. When filling cracks with emulsion, allow sufficient time for the emulsion to flow to the bottom of the crack and to fill it completely full. In filling, a second pass may be necessary before leaving the work zone.

3. One additional filling, or refilling, will be necessary where the filler has settled into the crack opening. The Engineer will identify these areas.

4. The cleaned cracks need not be filled the same day they are cleaned. However, at the time of filling, ensure cracks are free of standing water as determined by visual examination. Recleaning may be necessary if

the openings become contaminated before being filled. The work may be done as a single, coordinated operation.

5. Conduct the work on only one lane of the pavement at a time, and according to the traffic control plan and Article 1107.09. Use of a pilot car may be required.

6. Allow traffic to use the pavement during this construction. Conduct all operations so as to provide a minimum of inconvenience to traffic.

7. Apply Articles 1107.08, 1107.09, and 1108.03.

2544.04 METHOD OF MEASUREMENT.

Measurement for maintenance cleaning and filling cracks, satisfactorily completed, will be as follows:

A. Cleaning and Filling Cracks.

1. Cleaning and Filling Cracks (Pavement Maintenance).

a. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 km), of main line pavement on which cracks were cleaned and filled. Calculations will be based on the center line distance of main line, two-lane pavement, corrected for main line pavement of more than two lanes, including climbing lanes.

b. At intersections, rest areas, and interchanges designated for cleaning and filling, the additional areas of widened pavement, ramps, storage lanes, turning lanes, paved medians, and parking in rest areas will not be separately measured for pavement.

c. Between limits for which cleaning and filling is intended for either pavement or shoulders, no deductions will be made for bridges, intersections, or other interruptions where cracks are not to be cleaned and filled.

2. Cleaning and Filling Cracks (Shoulder Maintenance).

a. Miles (kilometers), calculated to the nearest 0.1 mile (0.1 km), of paved shoulders on which cracks were cleaned and filled. Calculations will be based on the center line distance of the adjacent main line pavement, a single measurement for shoulders on both sides of the pavement.

b. At intersections, rest areas, and interchanges designated to be cleaned and filled, the additional areas of paved shoulders on ramps, gores, and turning lanes will not be measured separately for payment.

B. Hot Mix Asphalt for Crack Filling.

Weight (mass) of hot mixture used for filling cracks larger than 1 inch (25 mm). Mixture not used in the work will be deducted, based on actual scaled weights (mass) or estimates.

C. Filler Material (Maintenance).

1. Computed according to Article 2307.04, B. The total quantity will include the material placed in cracks and used to cover map-cracked areas.

2. Blotting material and tack-coat material will not be measured separately for payment.

2544.05 BASIS OF PAYMENT.

A. Payment for cleaning and filling cracks will be the contract unit price as follows:

1. **Cleaning and Filling Cracks (Pavement Maintenance) or Cleaning and Filling Cracks (Shoulder Maintenance).**
   Per mile (kilometer) for pavement or shoulders on which the cracks were cleaned and filled.

2. **Hot Mix Asphalt for Crack Filling.**
   Per ton (megagram) for HMA used in filling cracks over 1 inch (25 mm).

3. **Filler Material (Maintenance).**
   Per gallon (liter).

B. Payments are full compensation for:
- Cleaning the cracks,
- Furnishing and placing the HMA,
- Filler material,
- All blotting material and tack-coat material that is necessary, and
- Furnishing all equipment and labor.

Section 2545. Overlay of Type B Guide Signs

2545.01 DESCRIPTION.

A. Overlaying of existing Type B signs. The signs to be overlaid will be identified in the contract documents.

B. This work is intended to be done by applying retroreflective sheeting, as specified in Article 4186.03, to sheets of thin aluminum and applying to existing sign panels with pop-rivets.

2545.02 MATERIALS.

A. Use retroreflective sheeting meeting the requirements of Article 4186.03.

B. Ensure the thin aluminum sheets have a thickness of 0.063 inches ± 0.004 inches (1.6 mm ± 0.1 mm) and meet the requirements of ASTM B 209/B 209M, Alloy 6061-T6 with no specified limit for yield strength of bend test.

C. Apply the retroreflective sheeting, as specified in Article 4186.03, to the thin aluminum sheets according to the sheeting manufacturer's recommendations.

2545.03 PREPARING PANELS, APPLYING ALUMINUM OVERLAY STRIPS, AND APPLYING LEGENDS.

A. Preparation of Panels.

1. Leave the sign panel to be overlaid in place on sign supports while the work is in progress. If proposing an alternate method requiring removal of the panel, submit the procedure to the Engineer for approval prior to beginning work.

2. Remove all existing legends, symbols, shields, and borders from the sign panel without damage to the aluminum extrusions. Removed items become the property of the Contractor. Remove rivets protruding from the surface of the sign panel. Additional preparation work may be shown in the contract documents.

B. Application of Aluminum Overlay Strips.

1. Apply the thin overlay aluminum strips with retroreflective sheeting in uniform width vertical strips no less than 1.5 feet (0.5 m) wide, except the last strip may be of lesser width. Form vertical joints by butting aluminum strips together as close as possible without overlapping.

2. Edge molding on the panel is to remain in place. Indent the overlay strips 3/4 inch (20 mm) from the left and right edge of the sign face to allow the edge molding to grip the extrusions.

3. With the sign 4 feet (1.2 m) or less in height, place the overlay strip horizontal in one piece.

4. Attach the overlay sheets with rivets. Use aluminum pull through, hollow blind rivets with a diameter of 1/8 inch (3 mm) and a brazier head with an appropriate grip range. The maximum spacing between rivets is to be 12 inches (0.3 m) both vertical and horizontal. The maximum spacing that the rivets may be indented is 3 inches (75 mm) from edge of the overlay strips.

5. Control color matching of pieces of overlay by maximum use of overlay from a single lot number on each sign. When overlay from different lots is to be used on a sign, match the colors. In matching, place the overlay pieces side by side and inspect visually in existing light from a 10 foot (3 m) distance perpendicular to the faces of the pieces. If a difference in color is perceptible at that distance, the pieces are not to be used on the same sign.

C. Application of Legend.

For legends to be placed on refurbished sign panels, use retroreflective sheeting applied to an aluminum base according to Type B sign layouts on the plans. Use detachable type legends. Use new material meeting the

requirements of Article 4186.05. Attach legends to the sign panel as specified in Article 4186.06, D.

D. Limitations.
The sequence of overlay work and the time requirements for each sign are subject to the limitations shown on the plans.

2545.04 METHOD OF MEASUREMENT.
Measurement for Overlay Type B Guide Signs will be in square feet from measurements to the nearest 0.1 feet (square meters from measurements to the nearest 0.1 m) computed for the area of the vertical, front face of the signs, as specified in the contract documents, according to Article 2524.04.

2545.05 BASIS OF PAYMENT.

A. Payment for Overlay Type B Guide Signs will be the contract unit price per square foot (square meter) of sign area overlaid.

B. Payment is full compensation for:
- Sign panel preparation,
- Furnishing and applying overlay sheeting material to existing sign panels, and
- Furnishing and applying all legend, border, and symbols according to the contract documents.

Section 2546. Gabions and Revet Mattresses

2546.01 DESCRIPTION.
Gabions are intended for high strength installations in both horizontal and vertical structures. Revet mattresses are intended for lower strength, horizontal or nearly horizontal structures.

2546.02 MATERIALS AND FABRICATION.
Ensure gabions and mattresses are constructed using materials meeting the following requirements. Ensure they are fabricated as required for gabions, unless mattresses are specifically designated in the contract documents. At the Contractor's option, for lid fastening at edges and diaphragms, either the "Lacing Wire" or the "Steel Ring Fastener System" may be used.

A. Baskets.

1. General.
a. Baskets are to be fabricated by twisting or welding a mesh from galvanized steel wire.
b. For gabions, the mesh opening is not to exceed 4 1/2 inches (115 mm), and its area is not to exceed 10 square inches (6450 mm^2).
c. For mattresses, the maximum linear dimension of mesh opening is not to exceed 3 1/4 inches (80 mm).
d. Twisted wire mesh for gabion gaskets and revet mattresses is to be formed in a uniform hexagonal pattern with double twists so bound as to prevent unraveling.

e. Welded wire mesh for gabion baskets is to have each connection welded to obtain a minimum average shear strength of 585 pounds (2600 N), with a minimum shear strength of 450 pounds (2000 N).

f. For revet mattresses, the minimum average shear strength of welded connections is to be 292 pounds (1300 N), with a minimum shear strength of 225 pounds (1000 N).

2. Wire.

Ensure wire complies with the following:

a. Tensile strength of 60,000 psi to 75,000 psi (413.7 MPa to 517.1 MPa) for twisted wire mesh gabion baskets.

b. Tensile strength of 60,000 psi to 70,00 psi (413.7 MPa to 482.7 MPa) for twisted wire mesh revet mattresses.

c. Minimum tensile strength of 80,000 psi (550.0 MPa) for welded wire baskets and mattresses.

d. Galvanized according to ASTM A 764, Class III, Type B Coating, except all wire coated with 0.80 ounce (244 g) of zinc per foot (square meter).

e. Mesh, edge, and selvage wire are the same material.

f. Minimum sizes shown in Table 2546.02-1:

Table 2546.02-1: Minimum Wire Sizes

	Gabions	Mattresses
Mesh Edges and selvage Lacing and connecting	11 gage (3.06 mm) 9 gage (3.76 mm) 13 1/2 gage (2.18 mm)	13 1/2 gage (2.18 mm) 11 gage (3.06 mm) 13 1/2 gage (2.18 mm)

3. Steel Ring Fastener System.

Ensure one of the following is used:

- Galvanized 11 gage (3.05 mm) wire with a tensile strength meeting the requirements of ASTM A 764, Class I Tensile, and with a Class III, Type B Coating of a minimum of 0.80 ounce (244 g) of zinc per square foot (square meter).
- Stainless steel 11 gage (3.05 mm) wire (use only with PVC coated gabion baskets and mattresses) with a tensile strength meeting the requirements of ASTM A 313, Type 302, Class I.

4. Basket Fabrication.

a. Ensure baskets are fabricated as shown in the contract documents. Standard sizes are shown in Table 2546.02-2:

Table 2546.02-2: Gabion Basket Fabrication

GABIONS				
Dimensions, ft. (m)[(a)]			Number of Cells or Compartments	Capacity yd^3 (m^3)
Length	Width	Height		
6 (1.8)	3 (0.9)	3 (0.9)	2	2.0 (1.5)
9 (2.7)	3 (0.9)	3 (0.9)	3	3.0 (2.3)
12 (3.6)	3 (0.9)	3 (0.9)	4	4.0 (3.1)
6 (1.8)	3 (0.9)	1.5 (0.5)	2	1.0 (0.8)
9 (2.7)	3 (0.9)	1.5 (0.5)	3	1.5 (1.1)
12 (3.6)	3 (0.9)	1.5 (0.5)	4	2.0 (1.5)
6 (1.8)	3 (0.9)	1 (0.3)	2	0.66 (0.5)
9 (2.7)	3 (0.9)	1 (0.3)	3	1.0 (0.8)
12 (3.6)	3 (0.9)	1 (0.3)	4	1.33 (1.0)
MATTRESSES				
Dimensions, ft. (m)[(a)]			Number of Cells or Compartments	Capacity yd^3 (m^3)
Length	Width	Height		
9 (2.7)	6 (1.8)	0.50 (0.17)	3	6 (5.2)
12 (3.6)	6 (1.8)	0.50 (0.17)	4	8 (6.69)
9 (2.7)	6 (1.8)	0.75 (0.23)	3	6 (5.2)
12 (3.6)	6 (1.8)	0.75 (0.23)	4	8 (6.69)
9 (2.7)	6 (1.8)	1.0 (0.3)	3	6 (5.2)
12 (3.6)	6 (1.8)	1.0 (0.3)	4	8 (6.69)

[(a)] Dimensions are subject to a tolerance of ±5%.

b. Ensure baskets are fabricated into panels in such a manner that the base, sides, and ends can be assembled into a single, rectangular unit of the specified size. Ensure all perimeter edges of the baskets are selvaged with the specified wire so that the selvaged connections have the same strengths as the body of the mesh.

c. Baskets will normally be furnished in bundles of flat panels of appropriate sizes. On site assembly is intended.

d. Ensure the gabion units are furnished with the necessary diaphragms secured in proper position on the base in a manner so that no additional tying at this juncture will be necessary.

e. Ensure the mattress units are subdivided into compartments by the insertion of diaphragms made of the same mesh as the rest of the mattress. Ensure the diaphragms are factory secured in proper position at the base with a continuous spiral wire, in such a manner that no additional tying at this junction will be necessary.

5. Elongation.

Ensure the wire mesh permits elongation equivalent to a minimum of 10% of the length of the section under test without reducing the gage or tensile strength of the individual wire.

6. Elasticity.

a. Ensure the mesh withstands, without rupture of any wire or opening of any mesh fastening, the following load test:

1) The ends of an uncut section of mesh 6 feet (1.8 m) long, not less than 3 feet (1 m) wide and including all selvage binding, are securely clamped for 3 feet (1 m) along the width of the sample. When the width of the sample under test exceeds 3 feet (1 m), the clamps will be placed in the middle portion of the width, and the excess width will be allowed to fall free on each side of the clamped section.

2) The sample is then subjected to sufficient tension to cause 10% elongation of the sample section between the clamps.

3) After elongation and while clamped as described above (and otherwise unsupported), the section is subjected to a load applied to an area of 1 square foot (0.1 m^2), located approximately in the center of the sample section between the clamps, and in a direction perpendicular to the direction of the tension force. For gabions, use a load equaling or exceeding 6000 pounds (26.7 kN). For mattresses, use a load equaling or exceeding 4000 pounds (17.8 kN).

b. Ensure the ram head used in the test is circular with its edges beveled or rounded to prevent cutting of the wires.

7. Certification.

a. As a condition of source approval, the manufacturer may be required to furnish test results which show compliance with elongation and elasticity requirements.

b. Ensure each shipment of wire structures to a job site is accompanied by a certification which states that the material meets the requirements of this specification. A shipment consists of all materials arriving at the job site at substantially the same time.

c. Ensure all certifications are signed by an authorized representative of the company.

B. Anchor Stakes.

Use anchor stakes made from 2 inch (50 mm) nominal diameter, galvanized standard weight pipe meeting the requirements of ASTM A 53. The length will be shown in the contract documents.

C. Engineering Fabric.

Use engineering fabric meeting the requirements of Article 4196.01, B, 3.

D. Gabion Stone.

Meet the requirements of Article 4130.06.

E. Grout.

Apply Article 2507.02, B.

2546.03 CONSTRUCTION.

A. Perform the work as required by the contract documents. Excavate or smooth the area, or both, as necessary for proper placement of the gabions

or mattresses, as shown in the contract documents. The contract documents may also require compaction of the prepared surface, or placement of selected or special backfill material in preparing the surface.

B. When specified, furnish and transport concrete grout and place within the voids to the full width of the gabion basket.

C. When designated in the contract documents, place engineering fabric under and behind the baskets. Place the fabric in vertical strips, or transverse to the flow line, lapped at least 3 inches (75 mm) with the downstream strip to the outside of the structure.

D. At the construction site, assemble the baskets into rectangular baskets of the specified sizes. Assemble them to be single unit construction. Weave the base, lid, and sides into a single unit. Connect the ends to the base section in a manner so that strength and flexibility at the point of connection is at least equal to that of the mesh.

E. Carefully place the baskets into their proper positions for slope and alignment as shown in the contract documents. When the slope is not shown, slope the faces of gabions at 1 (horizontal) to 6 (vertical).

F. When anchor stakes are designated for mattresses, drive them into position as shown in the contract documents. The top of the anchor stake should be at the elevation of the tops of adjacent baskets. Securely tie the anchor stakes to adjacent baskets at the top and the base of the baskets.

G. Connect adjacent baskets in a manner so that the connection is strong enough that a failure will occur in the mesh, rather than the lacing. Adjoining gabions and mattresses are to be connected at vertical corner edges and diaphragms. Stacked gabions are to be also connected at the horizontal edges, front and back. Lace all connections with loops at approximate 4 inch (100 mm) intervals, and as recommended by the manufacturer. To achieve proper alignment during filling, use a come-along or other means to tension gabions 3 feet (0.9 m) high placed in a line.

H. Carefully fill each basket with the revetment stone specified. Machine placement will be permitted. However, considerable handwork is necessary and will be required to assure orientation for maximum density without bulges, a compact and dense exposed face, and maximum aggregate contact with the lid and other baskets placed or to be placed in the structure.

I. For gabions 3 feet (0.9 m) high, fill in three lifts, 1 foot (300 mm) at a time, orienting the stones with each lift as necessary.

J. When a 3 foot (0.9 m) high cell is to be exposed in the finished structure, securely install two connecting wires between each lift, connecting each cell face to be exposed with the opposite face or diaphragm. Locate the wires with equal horizontal spacing. Install the wires by looping each end around two mesh openings, then wrapping the wire tightly around itself with at least four full wraps. Lock the end of the wire in place by lacing it under the previous lap. (For each 3 foot (0.9 m) high cell with one face to be exposed,

four connecting wires are required. For the same cell as an end unit, there are two exposed faces and eight connecting wires are required.)

K. Connecting wires are not required for mattresses.

L. Fasten the lids in place at edges and diaphragms as specified above.

M. If steel ring fasteners are used, limit spacing to nominal 5 inches (±1.0 inch) (125 mm (± 25 mm)).

N. Special features or details may also be required. Construct these as shown in the contract documents.

O. When specified, do not place grout until the Engineer has inspected and approved the gabion. Sufficient jarring of rocks may be done to aid penetration of the grout to ensure all voids are filled and the grout fully penetrates the basket. Place grout according to Article 2507.03, E.

P. When the structure is completed, finish the earthwork as shown in the contract documents.

2546.04 METHOD OF MEASUREMENT.

A. Gabions or Mattresses.

1. Gabions or Mattresses: Calculated volume satisfactorily placed. When placement is according to the contract documents, plan quantities will be used.

2. Anchor Stakes (if required for mattresses): by count.

3. Associated earthwork: Article 2402.04 or 2102.04 applies.

B. Concrete Grout for Gabions.
Article 2507.04 applies.

2546.05 BASIS OF PAYMENT.

Payment will be for the contract unit price as follows:

A. Gabions or Mattresses.

1. Gabions or Mattresses:
- **a.** Per cubic yard (cubic meter).
- **b.** Payment is full compensation for:
  - Furnishing and placing engineering fabric as shown in the contract documents,
  - Furnishing, assembling, and placing the baskets, and
  - Furnishing and placing the revetment stone in the baskets.

2. Anchor Stakes: each.

3. Associated earthwork: Article 2402.05 or 2102.05 applies. For small quantities, the contract documents may designate this work as incidental. If so, it will not be paid for separately.

4. Special features or details: as shown in the contract documents. They may be made incidental, with no separate payment.

B. Concrete Grout for Gabions.
Article 2507.05 applies.

Section 2547. Temporary Stream Access

2547.01 DESCRIPTION.
This work consists of the construction, use, maintenance and removal of temporary structures used to provide construction access across along or into waters of the United States. Temporary structures are any features not a part of the completed project that are constructed or installed to provide access to the project site including stream crossings, causeways, pads and temporary bridges or barges.

2547.02 MATERIALS.
Furnish fill materials. Do not obtain from the stream unless specifically allowed elsewhere in the contract documents.

2547.03 CONSTRUCTION.

A. The type of structure used, if any, is at the Contractor's discretion provided it complies with Article 1105.14. Unless indicated otherwise in the contract documents, the Contracting Authority will obtain approval for temporary stream crossings, constructed according to Standard Road Plan RL-16 or as shown in the contract documents, in the Section 404 permit. Obtain a Section 404 permit for temporary stream crossings not to be constructed according to RL-16 or the contract documents.

B. Ensure temporary structures do not restrict expected high flows or disrupt the movement of aquatic life native to the stream or water body. Expected high flows are those flows which the Contractor expects to experience during the period of time that the crossing is in place. Temporary structures are not to extend over 100 feet (30 m) into any swamp, bog, marsh, or similar area that is adjacent to the stream or water body.

C. Ensure pre-construction downstream flow conditions are maintained.

D. Maintain temporary structures to prevent unnecessary erosion and other non-point sources of pollution.

E. Completely remove temporary structures within 30 calendar days of no longer being needed. Revetment that has been removed may be incorporated elsewhere in the project, provided it meets the specification for the intended final use. Remove all other fill material to an upland area. Reshape and stabilize all disturbed areas.

2547.04 METHOD OF MEASUREMENT.
None.

2547.05 BASIS OF PAYMENT.
Temporary Stream Accesses is incidental to Mobilization.

Section 2548. Milled Shoulder Rumble Strips - HMA or PCC Surface

2548.01 GENERAL.
Provide equipment, furnish all necessary labor and materials, and perform all operations necessary for milling shoulder rumble strips in HMA or PCC surfaced shoulders. Mill shoulder rumble strips to the dimensions and spacing shown in the contract documents. Apply diluted asphalt emulsion to the milled shoulder rumble strips on HMA surfaced shoulders by means of a bituminous distributor.

2548.02 MATERIALS.

A. Milling.
Equip milling equipment with a cutting head having cutting tips arranged in a pattern as to provide a smooth cut, approximately 1/16 inches (2 mm) between peaks and valleys.

B. Asphalt Emulsion Fog Seal.

1. Use asphalt emulsion Grade CSS-1h, meeting requirements of Section 4140.

2. Dilute the asphalt emulsion with water prior to application to the milled shoulder rumble strip. The dilution rate is one part of asphalt emulsion to one part of water.

2548.03 CONSTRUCTION.
Notify the Engineer if degraded shoulders are encountered that will not accommodate milled rumble strips. Skip those sections.

A. Test Strip.
Demonstrate to the Engineer on an initial 500 foot (150 m) test section that the equipment and method will provide the desired milled shoulder rumble strip and surface inside each depression without damaging the adjacent pavement. If the desired results are not being provided, as determined by the Engineer, provide different equipment or methods, or make necessary adjustments to provide the desired results. If the initial 500 foot (150 m) section results are unsatisfactory, repair or replace the section as determined by the Engineer, at no additional cost to the Contracting Authority.

B. Milling.

1. Mill shoulder rumble strips in a straight line, offset from the painted edge line as shown in the contract documents. Do not deviate from that offset more than ± 2 inches (50 mm). The offset may be decreased to 6 inches

(150 mm) on shoulders with a top width less than 30 inches (750 mm). Ensure the depth of the rumble strips is as shown in the contract documents. The Engineer will randomly check the alignment and depth.

2. Remove waste material (millings) resulting from the operation on a daily basis. The waste material may be used as fillet material adjacent to the paved shoulder or it may become property of the Contractor and disposed of off the project. Disposal of material may be at an approved landfill or approved stockpile, or by other methods that will allow the material to be recycled. Remove waste material prior to opening adjacent lane to traffic.

C. Asphalt Emulsion Fog Seal.

1. Ensure the equipment meets the requirements of Section 2001.

2. Ensure the application width covers the entire milled shoulder rumble strip.

3. Place the diluted asphalt emulsion fog seal according to Article 2308.03, D, at a rate of 0.13 gallon per square yard (0.6 L/m^2).

4. Do not place asphalt emulsion on a damp or wet surface.

5. Apply asphalt emulsion during weather conditions under which satisfactory application can be obtained. Do not apply asphalt emulsion when the air temperature is below 50°F (10°C). Do not place asphalt emulsion after October 15 without the Engineer's permission.

D. Limitations.
Do not disturb desirable grass areas and desirable trees outside the construction limits. Do not park or service vehicles and equipment or use these areas for storage of materials. Obtain the Engineer's approval for storage, parking, and service areas.

2548.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Milled Shoulder Rumble Strips.
Stations (meters) shown in the contract documents, measured along each edge of mainline pavement abutting a paved shoulder. Unless stated otherwise in the contract documents, no deduction will be made for gapped areas. The quantity will be adjusted for the length of degraded shoulders skipped, as defined in Article 2548.03 of this specification. The quantity will be adjusted for test sections that were deemed unsatisfactory.

B. Asphalt Emulsion for Fog Seal.
Gallons (liters) as provided in Article 2307.04, B.

2548.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Milled Shoulder Rumble Strips.
Per station (meter) for the type specified.

B. Asphalt Emulsion for Fog Seal.

1. Per gallon (liter) for undiluted Asphalt Emulsion for Fog Seal that is mixed and used on the project. Diluted asphalt emulsion that is delivered to the project site, but not applied to the roadway surface will not be considered for payment.

2. Payment is full compensation for cleaning the shoulder surface, furnishing and applying diluted asphalt emulsion, mixing water, and protecting the adjacent pavement and edge lines.

Section 2549. Pipe and Manhole Rehabilitation

2549.01 DESCRIPTION.

This section was developed in conjunction with Sections 4050 and 6020 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Pipe Lining:

1. Resin impregnated, cured-in-place.

2. Deformed/reformed polyethylene.

3. Folded/formed polyvinyl chloride.

4. Sliplining.

B. Pipe spot repairs.

C. Rehabilitate existing manholes to waterproof and to prevent inflow and infiltration, to prevent corrosion, or to reestablish the structural integrity of the manhole. Includes construction of structural liners, protective liners, and chimney seals.

2549.02 MATERIALS.

A. Pipe Rehabilitation.

1. Apply Article 4147.01.

2. The Engineer may allow substitutions. Provide as a minimum the following information for evaluation:

a. Product Information.

1) Product name.
2) Year product first available in the United States.
3) Total footage or number of line segments installed in the United States.

4) Results of all available product testing, including but not limited to leakage, physical properties, pipe stiffness, chemical resistance, strain-corrosion, external loading, flow characteristics, infiltration/inflow reductions, structural capacity, and external hydrostatic loading capacity.
5) Samples of before and after product.
6) Design method.
7) Typical lining thickness for pipe sizes included in the project.

b. Manufacturer Information.
1) Manufacturer name.
2) Years of experience manufacturing the product.
3) Country of manufacture of all product components.
4) Quality control procedures for product manufacture, including inspection requirements, testing procedures, and allowable tolerance levels.
5) Related ASTM standards, or other nationally recognized standards for product manufacturing.

c. Installer Information.
1) Installer name.
2) Completed project list for last five years including for each project and year completed, client name/address/contact person/phone number, footages installed by pipe diameter, and number of lateral reinstatements.
3) Detailed installation procedures, including estimated times for each task, lateral reinstatement methods, number of required excavations, and other items unique to each product.
4) Video of installation process, if available.
5) Evidence of properly trained personnel.
6) Related ASTM standards or any nationally recognized standards for product installation.
7) Available equipment list.
8) Detailed procedures for repairing the product in the event of future damage or failure and for tapping future service connections, including required specialized equipment or training.
9) Videos of two rehabilitated sewer sections showing before and after conditions.
10) Additional information may be required. The submittal of prequalification information in no way implies that the product, manufacturer, or installer will be deemed to be qualified. The Contracting Authority, in its sole discretion, will determine whether a product, manufacturer, or installer does or does not qualify as an approved equal.

B. Manhole Rehabilitation.
Apply Article 4147.02

2549.03 CONSTRUCTION.

A. Pipe Rehabilitation.

1. **Public Relations Program.**
   Establish a Public Information and Notification Program for contacting each home or business connected to the affected sanitary sewer, informing them of the work to be done and when the sewer will be off line. The following specific steps are part of the Public Information and Notification Program:
   - **a.** Provide written notice to be delivered to each affected home or business describing work, schedule, how the work affects them, and a local telephone number of the Contractor they can call to discuss the project or their problems.
   - **b.** Personally contact each home or business on the day lateral verifications using closed circuit video inspection are to be performed. The homeowner or business will be asked to run water down their drain to verify each lateral. If the homeowner is unavailable, attempt other arrangements (cleanouts) to drain water through the lateral to verify each connection.
   - **c.** Provide written notice and personally contact the home or business the day prior to beginning inversion of the section of sewer to which they are connected.
   - **d.** Personally contact all homes or businesses that can not be reconnected within the time stated in the written notice.
   - **e.** Furnish and service portable toilets for use by the home or business occupants if so required by any affected served business or homeowner.

2. **Special Requirements.**
   - **a.** Prior to start of work, notify all affected parties 24 hours in advance as to the length of time their service will be blocked.
   - **b.** Notify the Engineer's Water Works Department to use meter and pay for water, if required.
   - **c.** Unless specified otherwise, the Contracting Authority will provide water for installation of cured-in-place pipe from a nearby hydrant through a separate valve mounted on the hydrant.

3. **Examination.**
   - **a. Cleaning.**
     - **1)** Clean and remove soil, grit, debris, and obstructions prior to video inspection or insertion of lining pipe, or both.
     - **2)** Do not flush debris to downstream sections.
     - **3)** Deposit removed material at an approved site.
   - **b. Video Inspection.**
     - **1)** Furnish the Engineer with a recording of sewers: 1) before the lining process and while the flow is being bypassed; and 2) after lining process and service reconnections have been completed.
     - **2)** Provide an on screen numerical display of camera location, indexed from the starting manhole, in feet (meters).
   - **c. Service and Obstruction Location.**
     - **1)** Coordinate and cooperate with the Engineer for service and obstruction location.
     - **2)** Locate the active sewer services by one of following:

a) Use video inspection to observe service locations, breaks, obstructions, and structural failures.
b) Insert a sounding device through the service, noting its location on the ground surface.
c) Dye testing.

4. Bypassing Sewage.
a. Submit a bypassing plan to the Engineer for review.
b. Plug the line at a point upstream of pipe to be rehabilitated if bypassing is required.
c. Pump flow to a downstream point or adjacent system as directed by the Engineer.
1) Provide pump and bypass lines of adequate capacity to handle all flows.
2) Provide adequate reserve pumps on site for emergency use and for storm flows.

5. Obstructions.
a. Remove all obstructions.
b. If an obstruction is encountered that cannot be removed by equipment operating within the pipe, excavate and remove the obstruction upon approval of the Engineer.
c. Place backfill material, compact, and restore the surface according to the contract documents.

6. Temporary Sewer Service.
If full normal sewer service is not re-established within the times stated, provide temporary facilities or hotel accommodations for affected residents and businesses.

7. Sliplining.
a. Excavation.
1) For sliplining insertions, excavate at or near one structure and work from the existing manhole at the other end of the section to be pulled.
2) Insertion Pit:
a) For sliplining with segmented pipe (one pipe section at a time), construct the insertion pit as required to accommodate the length of individual pipe sections.
b) For sliplining with pipe that is to be welded together above ground and pulled into sewer, dig a pit length 12 times the inside pipe diameter and slope the pit end back to the ground surface at 2.5 (horizontal) to 1.0 (vertical).
b. Test Head.
1) Pull the pulling head with one short section of slipling pipe through the sewer before inserting the liner to test for taps or obstructions protruding too far into the sewer.
2) Attach cables to both ends of the test head to allow for removal if an obstruction is encountered.

c. Installation.
Push segmented pipe into the host pipe according to the manufacturer's recommendations, or pull in a continuously welded pipe according to ASTM F 585.

d. Service Reconnection.
1) Allow the sliplining pipe to recover according to the manufacturer's recommendations.
2) Do not leave the sanitary service unconnected for more than 24 hours.
3) Complete reconnections involving excavation of service lines according to the local plumbing codes.
4) Reconnect excavated service connections according to the local plumbing code, except that the annular space between the host pipe and the sliplining pipe is to be filled with grout.

e. Grouting.
1) Before trimming the ends of the pipe and sealing, allow for the pipe to recover its original length according to the manufacturer's recommendations. Recovery time is at least equal to the time required to pull the pipe into place.
2) Fill the space between the sliplining pipe and the host pipe with CLSM complying with Article 2552.02, E, 3, or other material approved by the Engineer. Pump filler in from the lower end of the sliplining pipe.

8. Resin Impregnated Cured-In-Place Pipe Lining.
a. Install according to the manufacturer's recommendations for this lining process and ASTM F 1216 unless noted otherwise.
b. Use a resin impregnated tube, hydraulically inverted in place with an approved lubricant, and cured in place according to ASTM F 1216, Section 7.
c. Make the tube continuous between manholes. The tube may span several manhole reaches as allowed by the equipment, properties of the CIPP, and the size and condition of the sewer.
d. Ensure the tube is free of uncured spots, lifts (spots cured away from the sewer), and delaminations. Remove and replace deficient sections.
e. Service Reconnections:
1) Do not leave sanitary service unconnected for more than 24 hours.
2) Complete reconnections involving excavation of service lines according to the local plumbing code.

9. Deformed/Reformed High Density Polyethylene Pipe or Folded/Formed Polyvinyl Chloride Pipe Lining Installation.
Install according to the manufacturer's recommendations for particular lining material and process, unless specified otherwise.
a. Lining Installation.
1) Designate location where insertion is to begin, subject to the Engineer's approval.
2) Transport lining to the site in one continuous length on spools compatible with manufacturer's designated process.

3) Heat lining material at the job site as necessary for insertion. Pull lining into the sewer with appropriate pulling heads, cables, and heat distribution equipment.
4) Ensure lining is continuous between manholes as allowed by the tensile properties of lining and the size and condition of the sewer.
5) Connect fully inserted lining to the heat source distribution equipment.
6) Round and expand by uniformly distributed heat, steam, and pressure and by mechanical devices.
7) After lining has been expanded to a tight fit, cool gradually under pressure until the process is complete.
8) Provide a continuous pipe lining, without joints, over the entire length of pipe.
9) Ensure the lining is free of all material defects, pits, pinholes, cracks, crazing, folds, or unrounded sections.
10) Repair all defects at no additional cost to the Contracting Authority.

b. Service Reconnections.

1) Do not leave sanitary service unconnected for more than 24 hours.
2) Complete reconnections involving excavation of service lines according to the local plumbing code.

10. Spot Repairs by Pipe Replacement.

a. Excavate trench according to Section 2552.
b. Remove existing pipe to the extent required and disconnect affected sewer services.
c. Install replacement pipe of the same nominal size as the existing pipe.
   1) Use the same materials as specified in the contract documents that comply with Section 2504.
   2) Place bedding material according to Section 2552.
d. Install pipe repair coupling.
   1) Cut pipes to length require allowing no more than a 1/2 inch (13 mm) gap between butted pipe ends at coupling location. Cut pipes perpendicular to centerline.
   2) Clean the outside surface of the existing and replacement pipes as required to provide a positive seal with the pipe repair coupling.
   3) Wrap coupling around pipes, centered on butt joint, and tighten bolts according to manufacturer's recommendations.
e. Reconnect sewer services.
f. Place backfill material in trench according to Section 2552.

11. Cleanup and Closeout.

a. Verify that the services are reconnected and fully operable, with at least 90% of original capacity.
b. Submit initial and final video tapes, CDs, or DVDs to the Engineer.
c. Remove all equipment and debris.

B. Manhole Rehabilitation.

1. Submittals.
- **a.** Concrete mix design, if required by the Engineer.
- **b.** Catalog cuts of all mortar mixes, sealants, and liners.

2. Rubber Chimney Seal.
Apply Article 2435.03, A.

3. Urethane Chimney Seal.
- **a.** Prepare the surface according to the manufacturer's recommendations, including sandblasting, pressure washing, sealing leaks or gaps, and drying the surface.
- **b.** Apply primer, prepare product, and brush-apply the seal to a minimum thickness of 175 mils (4.5 mm), covering 2 inches (50 mm) above the bottom of the frame and the entire adjustment ring area to 3 inches (75 mm) below the bottom adjustment ring.

4. In-Situ Manhole Replacement, Cast-in-place Concrete.
- **a. Preparation.**
  Prepare according to the forming system manufacturer's recommendations, including the following:
  - **1)** Clean the existing surface to remove loose material and debris.
  - **2)** Remove existing steps that might interfere with the erection of the forms.
  - **3)** Control infiltration that may affect placement of concrete.
- **b. Installation.**
  Install and test according to the forming system manufacturer's recommendations, including the following:
  - **1)** Place pipe extensions through the structure to maintain flow during installation.
  - **2)** Erect forms inside the manhole. Secure the assembled internal forms to prevent shifting and to provide sufficient stiffness and strength to prevent collapse.
  - **3)** Install a plastic liner when specified.
  - **4)** Seal the forms at the bottom of the manhole to ensure the concrete does not enter the sewer.
  - **5)** Carefully place concrete between the forms and the existing manhole walls. Place concrete from the bottom up to prevent segregation of concrete.
  - **6)** Consolidate concrete as required to fill all pockets, seams, and cracks within the existing manhole wall.
  - **7)** Remove the forms when the concrete has cured sufficiently.
  - **8)** Weld and test joints if a plastic liner is installed.
  - **9)** Apply a sealing strip around the circumference of the invert top where it meets the vertical wall and around all pipe penetrations to form a waterstop.
  - **10)** Overlay the invert top with concrete or high-strength mortar. Vary thickness from 3 inches (75 mm) at the wall to 1/2 inch (13 mm) at the edge of the channel.
  - **11)** Apply an epoxy lining to the invert top. Apply clean sand to the epoxy to create a non-slip surface.

12) Seal the plastic liner to the manhole casting and existing pipe stubs as recommended by the manufacturer.
13) Install a new casting.

5. Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal.

a. Surface Preparation.
Prepare according to the manufacturer's recommendations, including the following:
1) Wash the interior with a high pressure washer.
2) Plug active leaks with the appropriate sealing material.

b. Mortar Application.
Apply according to the manufacturer's recommendations, including the following:
1) Apply with a rotating centrifugal casting applicator, beginning at the bottom of the manhole.
2) Retrieve the applicator head at the manufacturer's recommended speed to achieve the desired thickness.
3) Apply to the full required thickness utilizing multiple passes as necessary. Minimize the time between passes so subsequent passes are cast against fresh mortar.
4) Verify thickness with a wet gage at several locations to ensure proper depth.
5) Hand-apply high-strength mortar to the invert surface. Vary thickness from 3 inches (75 mm) at the wall to 1/2 inch (13 mm) at the edge of the channel.

c. Epoxy Seal Application.
Seal according to the manufacturer's recommendations, including the following:
1) Apply with a rotating centrifugal casting applicator or airless sprayer onto the fresh mortar liner.
2) If the epoxy seal is applied more than 24 hours after application of the mortar liner, or if the mortar liner is contaminated, clean the liner and then apply the epoxy.

d. Finishing.
Install a new casting.

2549.04 METHOD OF MEASUREMENT.

A. Pipe Lining.
Measurement for each type and size of pipe lining will be in linear feet (meters) along the centerline of the pipe lining from center of manhole to center of manhole.

B. Building Sanitary Sewer Service Reconnection.
Each active existing building sanitary sewer service reconnected to the pipe lining, including the services reconnected by excavating and reconnecting services or by trenchless reconnection methods, will be counted.

C. Spot Repairs by Pipe Replacement.
Both of the following methods will be specified for measurement of spot repairs by pipe replacement:

1. **Spot Repairs by Count.**
   Each spot repair location will be counted.

2. **Spot Repairs by Linear Foot (Meter).**
   Measurement will be in linear feet (meters) along the centerline of the replacement pipe.

D. **Rubber Chimney Seal.**
Each rubber chimney seal installed on an existing manhole will be counted.

E. **Urethane Chimney Seal.**
Each urethane chimney seal installed on an existing manhole will be counted.

F. **In-Situ Manhole Replacement, Cast-in-place Concrete.**
Measurement of the vertical dimension of in-situ manhole replacement will be in feet (meters) from the lowest flowline to the top of the rim.

G. **In-Situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner.**
Measurement of the vertical dimension of in-situ manhole replacement with plastic liner will be in feet (meters) from the lowest flowline to the top of the rim.

H. **Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal.**
Measurement for depth of the vertical dimension of manhole lining will be in feet (meters) from the bottom of the lining to the top of the lining for each liner thickness specified.

2549.05 BASIS OF PAYMENT.

A. **Pipe Lining.**

1. Payment will be made at the contract unit price per linear foot (meter) for each type and size of pipe lining.

2. Payment is full compensation for pipe lining removal of internal obstructions, pipe cleaning, inspection, and all costs associated with the public information and notification program.

B. **Building Sanitary Sewer Service Reconnection.**

1. Payment will be made at the contract unit price for each reconnection.

2. Payment is full compensation for building sanitary sewer service reconnection.

C. **Spot Repairs by Pipe Replacement.**
Both of the following methods will be specified for payment of spot repairs by pipe replacement:

1. **Spot Repairs by Count.**
   a. Payment will be made at the contract unit price for each spot repair.
   b. Payment is full compensation for uncovering and removing existing pipe, placing backfill material for replacement pipe, and restoring the surface.

2. **Spot Repairs by Linear Foot (Meter).**
   a. Payment will be made at the contract unit price per linear foot (meter) of spot repair.
   b. Payment is full compensation for furnishing and installing replacement pipe and connections.

D. Rubber Chimney Seal.

1. Payment will be made at the contract unit price for each chimney seal.

2. Payment is full compensation for all necessary compression or expansion bands and extension sleeves as necessary to complete chimney seal.

E. Urethane Chimney Seal.
Payment will be at the contract unit price for each urethane chimney seal.

F. In-Situ Manhole Replacement, Cast-in-place Concrete.

1. Payment will be at the contract unit price per vertical foot (meter).

2. Payment is full compensation for handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, and testing the manhole upon completion.

G. In-Situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner.

1. Payment will be at the contract unit price per vertical foot (meter).

2. Payment is full compensation for handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, sealing at the frame and cover, sealing pipe penetrations as recommended by the manufacturer, and testing the manhole upon completion.

H. Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal.

1. Payment will be at the contract unit price per vertical foot (meter) for each liner thickness properly installed.

2. Payment is full compensation for the handling of sewer flows during lining operations as required to properly complete the installation, and replacement of the existing casting with a new casting.

Section 2550. Night Work Lighting

2550.01 DESCRIPTION.

Furnish, install, operate, maintain, move, and remove night time lighting to illuminate construction work areas for night work when construction activities (vehicles, equipment, or workers) are within 15 feet (4.6 m) of an open lane of traffic. Night work is defined as work performed between 30 minutes before sunset and 30 minutes after sunrise.

2550.02 LIGHTING PLAN.

A. Submit a lighting plan to the Engineer for review no later than the Preconstruction Conference. On the lighting plan show:
- The areas to be illuminated,
- Type and layout of the lighting systems, and
- Calculations of the averaged maintained lighting intensity.

B. Provide night work lighting in areas where construction equipment or workers are active within 15 feet (4.6 m)of an open lane of traffic. Illuminate the work area and extend the lighting a minimum of 25 feet (7.6 m) in advance and beyond the work area. Meet the following requirements for lighting:
- Minimum intensity of 5 foot candles (54 lux) over the entire area described above.
- Sources positioned to not interfere with or impede traffic in any direction and not cause glare for motorists or spillover onto adjacent properties.

C. Illumination may be accomplished by using a combination of portable lights, floodlights, equipment lights, roadway lights (temporary or existing), or other lighting methods that will provide the required minimum lighting intensity.

D. The Engineer may require modifications to the lighting setup in order to fit field conditions.

2550.03 LIGHT METER.

Provide the Engineer one light meter (to be returned to the Contractor at the completion of night work) capable of measuring light intensity in foot candles (lux). Provide the Engineer instructions for operating the light meter

2550.04 TRAFFIC CONTROL.

A. Ensure all vehicles, except ready mix trucks, hauling material to or from the work area during night work as described in Article 2550.01 display a minimum 16 inch by 48 inch (400 mm by 1200 mm) sign with the legend “DO NOT FOLLOW - INTO WORK AREA” as shown in Standard Road Plan. Comply with the following requirements for the sign:

- Orange with black lettering using Type VII (Iowa) sheeting.
- Kept clean in order to maintain its visibility.

B. Ensure all vehicles and equipment (except for hand operated equipment) operating or parked within 15 feet (4.6 m) of an open lane of traffic and all vehicles and equipment entering or exiting the work area display amber high intensity rotating, flashing, or oscillating lights.

C. Place and remove all traffic control devices during daytime hours, when possible, unless specified otherwise in the contract documents.

D. Continually review all traffic control devices, including monitoring of lights, to ensure proper installation and working order.

2550.05 METHOD OF MEASUREMENT AND BASIS OF PAYMENT.
All costs associated with furnishing, installing, operating, maintaining, moving, and removing night work lighting and other traffic control requirements required by this Developmental Specification, are incidental to the lump sum bid price for Mobilization.

Section 2551. Crash Cushions

2551.01 GENERAL.

A. Furnish and install crash cushions accepted as crashworthy devices by the FHWA and meeting the requirements of NCHRP Report 350, Test Level 3 criteria. Approved products are listed in Materials I.M. 455, Appendix A. All products listed in Materials I.M. 455, Appendix A, are acceptable for use as temporary crash cushions.

B. When a permanent, redirective, or severe-use crash cushion is required by the contract documents, install one of the crash cushions specifically designated for such use in Materials I.M. 455, Appendix A.

C. In case of a discrepancy between these specifications and the manufacturer's recommendations, these specifications govern.

2551.02 MATERIALS.

A. Meet the manufacturer's requirements.

B. Ensure crash cushions are in good repair when installed.

C. For permanent crash cushions and spare parts kits, use equipment and materials of new stock, unless the contract documents provide for the relocation or the use of fixtures furnished by others.

D. Refer to Materials I.M. 455, Appendix A, for parts to be included in spare parts kits. Spare parts kits are to be supplied by the crash cushion manufacturer and contain materials designated for repairing the specific brand and model of crash cushion furnished.

2551.03 CONSTRUCTION.

A. General.

1. Install crash cushions according to the manufacturer's recommendations. Prior to installation, provide the Engineer with:
   - Three copies of the manufacturer's most current product manuals covering installation and maintenance of the unit.
   - Required certification statements.
   - Additional hardware, tools, or documentation supplied by the manufacturer.

2. The manufacturer may require the use of additional connection hardware, construction of a backup structure, or construction of a paved footing for a specific installation. When required, construct and attach these items to the obstacle, the crash cushion, or both, in a manner specified by the manufacturer.

3. Complete grading work, if required, prior to installation of crash cushions.

4. When a roadway is closed to public traffic for construction, install all crash cushions prior to opening the road to traffic.

5. Do not allow attachments to new concrete or to anchor bolts set in epoxy resin to be stressed until the new concrete or epoxy resin has attained an age of 3 calendar days. This time requirement may be lengthened by the Engineer during cool weather.

B. Temporary Crash Cushions.

1. Unless shown otherwise in the contract documents, apply a retroreflective panel as described for permanent crash cushions.

2. When damaged, repair or replace the crash cushion. Initiate service to a damaged crash cushion within one hour of notification. Do not allow the object being shielded to be exposed to traffic for more than 12 hours.

3. When a temporary crash cushion is no longer required, remove it. The crash cushion becomes the property of the Contractor. Remove anchor bolts, if used, and fill the bolt holes with one of the non-shrink grouts listed in Materials I.M. 491.13, Appendix B.

4. When a crash cushion is required after the final stage of a project, leave it in place. The crash cushion becomes the property of the Contracting Authority.

C. Permanent Crash Cushions.

1. Mark the approach end of the crash cushion with a rectangular panel consisting of materials approved by the manufacturer and install according to the manufacturer's recommendations. Cover the panel with

alternating black and retroreflective yellow stripes that meet the following:

- Minimum of 3 inches (75 mm) in width,
- Slope down at an angle of 45 degrees toward the side on which traffic is to pass the crash cushion.
- Form chevrons that point upwards if traffic can pass to either side of the crash cushion.
- Retroreflectivity requirements for Type III or Type IV reflective sheeting (yellow stripes only).

2. Crash cushions with a flat face, the panel is to cover the entire face of the crash cushion.

3. Crash cushions with a rounded face, the panel is to cover the entire height and width of that portion of the face between the sides of the crash cushion. However, the panel need not cover that portion of the face within 12 inches (300 mm) of the ground or higher than 42 inches (1050 mm).

4. Permanent crash cushions become the property of the Contracting Authority.

2551.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Temporary Crash Cushions.
By count.

B. Permanent Crash Cushions.
By count.

C. Crash Cushion Spare Parts Kits.
By count for crash cushion spare parts kits delivered to the local maintenance office.

D. Backup structures, paved footings, and additional connection hardware.
Not measured separately for payment.

2551.05 BASIS OF PAYMENT.

Payment will be contract unit price as follows:

A. Temporary Crash Cushions.

1. Installed: each.

2. Repaired or replaced due to damage by public traffic: extra work according to Article 1109.03, B.

B. Permanent Crash Cushions.
Each.

C. Crash Cushion Spare Parts Kit.
Each.

D. Backup structures, paved footings, and additional connection hardware.
Incidental to crash cushions.

Section 2552. Trench Excavation and Backfill

2552.01 DESCRIPTION.

This section was developed in conjunction with Section 3010 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Excavate trench for pipe installation.

B. Stabilize trench and install pipe bedding materials.

C. Place backfill material in trench.

2552.02 MATERIALS.

A. Materials Excavated from a Trench.

1. Standard Trench Excavation.
All materials encountered during trench excavation, except rock and over-excavation.

a. Suitable Backfill Material.
Class II, Class III, Class IVA, or Class IVB as defined in Article 2552.02, B.

b. Unsuitable Backfill Material.
Includes, but is not limited to:

1) Soils not classified as suitable backfill material, as defined in Article 2552.02, B.
2) Individual stones or concrete chunks larger than 6 inches (150 mm) and averaging more than one per cubic foot (0.03 cubic meters) of soil.
3) Frozen materials.
4) Stumps, logs, branches, and brush.
5) Trash, metal, or construction waste.
6) Soil in clumps or clods larger than 6 inches (150 mm) and without sufficient fine materials to fill voids during placement.
7) Environmentally contaminated soils.
8) Materials removed as rock excavation or over-excavation.

c. Topsoil.
Class V material. Apply Article 2552.02, C.

2. **Rock Excavation.**
Boulders or sedimentary deposits that cannot be removed from the trench without continuous use of pneumatic tools or blasting.

3. **Over-Excavation.**
Excavation of unsuitable or unstable material in trenches below the pipe zone.

B. Bedding and Backfill Material.

1. **Class I Material.**
   a. Crushed stone complying with the following gradation:

Sieve	Percent Passing
1 1/2 inch (37.5 mm)	100
1 inch (25 mm)	95 to 100
1/2 inch (12.5 mm)	25 to 60
No. 4 (4.75 mm)	0 to 10
No. 8 (2.36 mm)	0 to 5

   b. The Engineer may allow the use of gravel or authorize a change in gradation subject to materials available locally at the time of construction
   c. The Engineer may authorize the use of crushed PCC for pipe sizes up to 12 inches (300 mm).
   d. Use aggregates having a percentage of wear, Grading A or B, not exceeding 50%, determined according to AASHTO T 96.

2. **Class II Material.**
Manufactured and non-manufactured open graded (clean) or dense graded (clean) processed aggregate, clean sand, or coarse grained natural soils (clean) with little or no fines. Comply with Table 2552.02-1 in the Appendix.

3. **Class III Material.**
   a. Natural coarse-grained soils with fines. Comply with Table 2552.02-2 in the Appendix.
   b. Do not use where water conditions in trench may cause instability.

4. **Class IVA Material.**
   a. Natural fine grained inorganic soils. Comply with Table 2552.02-3 in the Appendix.
   b. The Engineer will determine if material is not suitable for use as backfill material under deep fills, surface applied wheel loads, heavy vibratory compactors, tampers, or other conditions.
   c. Do not use where water conditions in trench may cause instability.
   d. Material is suitable for use in dry trench conditions only.

5. **Class IVB Material.**
   a. Natural fine grained inorganic (high elastic silts and plastic clays - fat clay) with a liquid limit greater than 50%. Comply with Table 2552.02-4, in the Appendix.
   b. When approved by the Engineer, material may be used as final trench backfill in a dry trench.
   c. Do not use in the pipe embedment zone.

C. **Class V Material (Topsoil).**
   1. Organic soils. Comply with Table 2552.02-5, in the Appendix.
   2. Use only as topsoil outside of the pavement, unless specified otherwise or allowed by the Engineer.
   3. Do not use in the pipe embedment zone.

D. **Stabilization (Foundation) Materials.**

   1. Clean 2 1/2 inch (63.5 mm) crushed stone with the following gradation:

Sieve	Percent Passing
2 1/2 inch (63 mm)	100
2 inch (50 mm)	90 to 100
1 1/2 inch (37.5 mm)	35 to 70
1 inch (25 mm)	0 to 20
1/2 inch (12.5 mm)	0 to 5

   2. The Engineer may authorize a change in gradation subject to materials available locally at time of construction.

   3. Crushed concrete may be used, if approved by the Engineer, if it is within ± 5% of the gradation for each size of material.

E. **Special Pipe Embedment and Encasement Material.**

   1. **Concrete Cradle, Arch, or Encasement.**
      Minimum 3000 psi (21 MPa) compressive strength.

   2. **Flowable Mortar.**
      Apply Section 2506.

   3. **Controlled Low Strength Material (CLSM).**
      a. Approximate quantities per cubic yard (cubic meter):
         1) Cement 50 pounds (30 kg)
         2) Fly ash 250 pounds (150 kg)
         3) Fine aggregate 2910 pounds (1729 kg)
         4) Water 60 gallons (296 L)
      b. A compressive strength of at least 50 psi (345 kPa) at 28 calendar days can be expected.

2552.03 CONSTRUCTION.

A. Trench Excavation.

1. Notify the Engineer prior to the start of excavation activities.

2. Remove topsoil to a minimum depth of 12 inches (300 mm) and stockpile.

3. Excavate trench to required elevations and dimensions.
   - **a.** Protect existing facilities, trees, and shrubs during trench excavation.
   - **b.** Place excavated material away from trench.
   - **c.** Grade spoil piles to drain. Do not allow spoil piles to obstruct drainage.

4. Unsuitable backfill material:
   - **a.** If unsuitable backfill material is encountered, notify the Engineer.
   - **b.** Remove rock, rubbish, boulders, debris, and other unsuitable backfill materials at least 6 inches (150 mm) below and on each side of the pipe.
   - **c.** Keep unsuitable backfill material separated from suitable backfill material and topsoil.
   - **d.** Restore trench to design dimensions using bedding or stabilization material.

B. Rock or Unstable Soils in Trench Bottom.

1. Notify the Engineer prior to over-excavation.

2. The Engineer will determine the need for over-excavation and trench foundation stabilization prior to installation of pipes and structures.

3. Refer to the contract documents for details of over-excavation of rock and wet or soft foundations.

C. Trench Protection.

1. Install adequate trench protection (sheeting, shoring, and bracing) to prevent ground movement or damage to adjacent structures, pipelines, and utilities.

2. Move trench boxes carefully to avoid disturbing pipe, bedding, or trench wall.

D. Dewatering.

Submit a dewatering plan to the Engineer for approval.

1. Maintain water levels below the bottom of trench excavation.

2. Perform the dewatering operation according to the dewatering plan approved by the Engineer. Dewatering plan may be modified to meet actual field conditions, with approval of the Engineer.

3. Ensure operation of the dewatering system does not damage adjoining structures and facilities. Cease dewatering operations and notify the Engineer if damage is observed.

4. Discharged water:
   a. Do not discharge water into sanitary sewers.
   b. Discharging water into storm sewers requires the Engineer's approval.
   c. Obtain permission of adjacent property owner prior to discharging water onto their property.
   d. Maintain and control water discharge as necessary to prevent a safety hazard for vehicular and pedestrian traffic.
   e. Direct water discharge away from electrical facilities or equipment.
   f. Use dewatering equipment that will minimize disturbance from noise and fumes.
   g. Protect discharge points from erosion. Provide sediment control for sediment contaminated water discharged directly from trench.

E. Pipe Bedding and Backfill Material.

1. **General.**
   a. Bedding and backfill material used for pipe installation will depend on:
      1) Type of installation (water main, sanitary sewer gravity main, sanitary sewer force main, or storm sewer).
      2) Pipe material.
      3) Depth of bury.
      4) Pipe diameter.
   b. After pipe installation, place remaining bedding material and immediately place backfill material in trench.
   c. Adjust the moisture content of excessively wet, but otherwise suitable, backfill material by spreading, turning, aerating, and otherwise working material as necessary to achieve required moisture range.
   d. Adjust the moisture content of excessively dry, but otherwise suitable, backfill material by adding water, then turning, mixing, and otherwise blending the water uniformly throughout the material until the required moisture range is achieved.
   e. Hydraulic compaction (flooding with water) is not allowed unless authorized by the Engineer.

2. **Pipe Bedding.**
   a. **Granular Material.**
      1) Class I granular material is required for all gravity mains. Use when specified for pressure pipes.
      2) Place bedding material in the bottom of the trench in lifts no greater than 6 inches (150 mm) thick. Consolidate and moderately compact bedding material.

3) Shape bedding material to evenly support pipe at the proper line and grade, with full contact under the bottom of the pipe. Excavate for pipe bells.
4) Install pipe and system components.
5) Place, consolidate, and moderately compact additional bedding material adjacent to the pipe to a depth equal to 1/6 the outside diameter of the pipe.

b. Suitable Backfill Material.

1) Only use with pressure pipe.
2) Use suitable backfill material to shape trench bottom to evenly support pipe at the proper line and grade, with full contact under the bottom of the pipe. Excavate for pipe bells.

c. Special Pipe Embedment and Encasement Materials.

1) If required in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other bedding materials.
2) Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

3. Haunch Support.

Place from the top of the pipe bedding to the springline of the pipe.

a. Granular Material.

1) Place Class I material in lifts no greater than 6 inches (150 mm) thick.
2) Consolidate and moderately compact by slicing with a shovel or using other approved techniques.

b. Suitable Backfill Material.

1) Place in lifts no greater than 6 inches (150 mm) thick.
2) For Class II backfill material, consolidate and moderately compact by slicing with a shovel or using other approved techniques.
3) For Class III and Class IVA backfill materials, compact to at least 90% of Standard Proctor Density. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

c. Special Pipe Embedment and Encasement Materials.

1) If required in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other haunch materials.
2) Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

4. Primary and Secondary Backfill.

a. General.

1) For primary backfill, place from the springline of the pipe to the top of the pipe.
2) For secondary backfill, place from the top of the pipe to 1 foot (300 mm) above the top of the pipe.

b. Granular Material.

1) Place in lifts no greater than 6 inches (150 mm) thick.
2) Compact to at least 65% relative density.

c. Suitable Backfill Material.

1) Place in lifts no greater than 6 inches (150 mm) thick.

2) For Class II backfill material, compact to at least 65% relative density.

3) For Class III and Class IVA backfill materials, compact to at least 95% of Standard Proctor Density. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

d. Special Pipe Embedment and Encasement Materials.

1) If specified in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other primary or secondary backfill materials.

2) Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

5. Final Trench Backfill.

a. Place suitable backfill material from 1 foot (300 mm) above the top of the pipe to the top of the trench.

1) Use no more than 8 inch (200 mm) thick lifts for backfill areas more than 3 feet (1 m) below the bottom of pavement.

2) Use no more than 6 inch (150 mm) thick lifts for backfill areas less than or equal to 3 feet (1 m) below the bottom of pavement.

b. Place backfill material after recording locations of connections and appurtenances or at the Engineer's direction.

c. Class I and Class II backfill material:

1) Compact to at least 65% relative density within right-of-way.

2) Compact to at least 50% relative density outside right-of-way.

d. Class III and Class IVA backfill material:

1) Compact to at least 95% of Standard Proctor Density within right-of-way.

2) Compact to at least 90% of Standard Proctor Density outside right-of-way.

3) Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

e. In areas to remain unpaved, terminate backfill material 8 inches (200 mm) below finish grade. Use topsoil for the final 8 inches (200 mm) above trench backfill material.

f. Terminate backfill material at subgrade elevation in areas to be paved.

F. Trench Compaction Testing.

1. General.

When trench compaction testing is specified in the contract documents as the Contractor's responsibility, provide testing of trench backfill material using the services of an independent testing laboratory approved by the Engineer.

2. Soil Testing.

a. Cohesive soils.

1) Determine moisture-density relationships by ASTM D 698 (Standard Proctor). Perform at least one test for each type of cohesive soil used.

2) Determine in-place density and moisture content. Use ASTM D 1556 (sand-cone method) and D 2216 (laboratory moisture content), or use ASTM D 6938 (nuclear methods for density and moisture content).

b. Cohesionless soils.

1) Determine maximum and minimum index density and calculate relative density using ASTM D 4253 and D 4254.

2) For Class I granular bedding material, determine gradation according to ASTM C 136.

3. Field Testing.

a. Testing Frequency and Locations.

Perform testing of the final trench backfill, beginning at a depth of 2 feet (600 mm) above the top of the pipe, as follows:

1) Coordinate the timing of testing with the Engineer.

2) The Engineer will determine the location of testing.

3) For each 2 vertical feet (600 mm) of consolidated fill, provide tests at a maximum horizontal spacing of 200 feet (60 m) and at all street crossings.

4) Additional testing may be required by the Engineer in the event of non-compliance or if conditions change.

5) If necessary, excavate to the depth and size as required by the Engineer to allow compaction tests. Place backfill material and recompact.

b. Test Failure and Retesting.

Rework, recompact, and retest as necessary until specified compaction and moisture content is achieved in all areas of the trench. In the event of failed tests, the Engineer may require retesting as deemed necessary.

2552.04 METHOD OF MEASURMENT.

A. Rock Excavation.

Measurement will be by cubic yards (cubic meters) of rock removed.

B. Trench Foundation.

Measurement will be in tons (megagrams) for the quantity of stabilization material required to replace material removed by over-excavation. Measurement will be based on the scale tickets for the material delivered and incorporated into the project. Trench foundation required to correct unauthorized over-excavation will not be measured.

C. Replacement of Unsuitable Backfill Material.

Measurement will be in cubic yards (cubic meters) for the quantity of backfill material required to replace unsuitable backfill material remove during standard trench excavation. Measurement will be based on compacted material in place.

D. Special Pipe Embedment or Encasement.

Measurement will be by the linear foot (meter) along the centerline of pipe for each type of special embedment or encasement.

E. Trench Compaction Testing.

1. The Contractor is not responsible for trench compaction testing or payment unless specified otherwise in the contract documents.

2. If the contract documents specify that the Contractor is responsible for trench compaction testing performed by an independent testing laboratory hired by the Contractor, measurement will be a lump sum.

2552.05 BASIS OF PAYMENT.

A. General.
The following items are incidental to the underground utility being installed and will not be paid for separately:

1. Standard trench excavation.

2. Removal and disposal of unsuitable backfill material encountered during standard trench excavation.

3. Removal of abandoned private utilities encountered during trench excavation.

4. Furnishing and placing granular bedding material.

5. Placing and compacting backfill material.

6. Dewatering.

7. Sheeting, shoring, and bracing.

8. Adjusting the moisture content of excavated backfill material to the range specified for placement and compaction.

B. Rock Excavation.
Payment will be at the contract unit price per cubic yard (cubic meter) for the quantity of rock removed.

C. Trench Foundation.

1. Payment will be at the contract unit price per ton (megagram) for the quantity of stabilization material furnished and placed.

2. Payment is full compensation for:
   - Removal and disposal of over-excavated material required to stabilize trench foundation, and
   - Furnishing, hauling, and placing stabilization material.

D. Replacement of Unsuitable Backfill Material.

1. Payment will be at the contract unit price per cubic yard (cubic meter) for the quantity of backfill material furnished.

2. Payment is full compensation for furnishing, hauling, and placing backfill material.

E. Special Pipe Embedment or Encasement.

1. Payment will be at the contract unit price per linear foot (meter) for each type of special pipe embedment or encasement.

2. Payment is full compensation for furnishing and placing all required special pipe embedment or encasement materials.

F. Trench Compaction Testing.

1. If the contract documents specify that the Contractor is responsible for trench compaction testing performed by an independent testing laboratory hired by the Contractor, payment will be at the contract unit price for the lump sum.

2. The Contractor will be responsible for payments associated with all retesting resulting from failure of initial tests.

Section 2553. Trenchless Construction

2553.01 DESCRIPTION.

This section was developed in conjunction with Section 3020 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Excavate launching and receiving pits.

B. Install casing or carrier pipe by trenchless methods.

C. Install carrier pipe inside casing pipe (if required).

D. Place backfill material in excavations.

2553.02 MATERIALS.

A. Carrier Pipe.

1. **Carrier Pipe Installed within Casing Pipe.**
   - **a. Sanitary Sewer Gravity Main.**
     Apply Article 4149.02, A.
   - **b. Sanitary Sewer Force Main.**
     1) **Restrained Joint Ductile Iron Pipe:** Apply Article 4149.02, B.
     2) **Restrained Joint PVC Pipe:** Apply Article 4149.02, B.
   - **c. Storm Sewer.**
     Apply Article 4149.03.
   - **d. Water Main.**
     1) **Restrained Joint Ductile Iron Pipe:** Apply Article 4150.02, A.
     2) **Restrained Joint PVC Pipe:** Apply Article 4150.02, A.

2. **Carrier Pipe Installed without a Casing Pipe.**
   a. **Sanitary Sewer Gravity Main.**
      1) **Reinforced Concrete Pipe:** Apply Article 4149.02, A.
      2) **Vitrified Clay Pipe:** Apply Article 4149.02, A.
      3) **Restrained Joint Ductile Iron Pipe:** Apply Article 4149.02, B.
      4) **Restrained Joint PVC Pipe:** Apply Article 4149.02, B.
   b. **Sanitary Sewer Force Main.**
      1) **Restrained Joint Ductile Iron Pipe:** Apply Article 4149.02, B.
      2) **Restrained Joint PVC Pipe:** Apply Article 4149.02, B.
   c. **Storm Sewer.**
      1) **Reinforced Concrete Pipe:** Apply Article 4149.03.
      2) **Reinforced Concrete Arch Pipe:** Apply Article 4149.03.
      3) **Reinforced Concrete Elliptical Pipe:** Apply Article 4149.03.
      4) **Reinforced Concrete Low Head Pressure Pipe:** Apply Article 4149.03.
   d. **Water Main.**
      1) **Restrained Joint Ductile Iron Pipe:** Apply Article 4150.02, A.
      2) **Restrained Joint PVC Pipe:** Apply Article 4150.02, A.

B. Casing Pipe.

1. **Pipe.**
   Use only new steel pipe meeting the requirements of ASTM A 139/A 139M, Grade B; ASTM A 252, Grade 2; or ASTM A 53/A 53M, Grade B. Pipe may be welded or seamless. Wall thickness will be as specified in the contract documents.

2. **Joints.**
   a. Comply with American Welding Society Code D1.1M/D1.1. Weld all joints with full penetrating weld. Welders shall be qualified according to Materials I.M. 560. Welds shall comply with Materials I.M. 558.
   b. Upon approval of the Engineer, an interlocking casing pipe connection system may be used in lieu of field welding the sections of casing pipe.

3. **Pipe Diameter.**
   Casing Pipe Minimum Wall Thickness: Refer to Table 2553.02-1.

C. Casing Spacers.

1. Use manufactured casing spacers to position carrier pipe in casing. Do not use wood skids.

2. Meet the following material requirements:
   a. **HDPE Band/Panel and Riser:** ASTM D 638.
   b. **Stainless Steel or Carbon Steel Band/Panel and Riser:** Type 304 stainless steel according to ASTM A 240/A 240M or carbon steel according to ASTM A 36/A 36M.
      1) **Liner:** Elastomeric PVC per ASTM D 149.
      2) **Spacer Skid/Runner:** Abrasion resistant polymer with a low coefficient of friction.

3) **Fasteners:** Type 304 (18-8) stainless steel per ASTM A 193/A 193M.

D. Backfill Material for Abandoned Tunnels.

1. **Option 1:** Use Class C concrete, approximately 4 inch (100 mm) slump.

2. **Option 2:** Flowable mortar or CLSM according to Article 2435.02, E.

E. Backfill Material.

1. **Excavated Materials.**
   Apply Section 2435 for classification of excavated materials. Use only suitable material for backfill material.

2. **Special Fill Materials.**
   For use where specified in the contract documents.
   a. **PCC:** Use Class C concrete, approximately 4 inch (100 mm) slump.
   b. **Flowable Mortar:** Apply Section 2506.02.
   c. **Controlled Low Strength Material (CLSM):** Apply Article 2435.02, E.

F. Casing End Seal.

1. **Manufactured:** Minimum 1/8 inch (3.0 mm) thick manufactured synthetic rubber casing end seal with stainless steel bands and fasteners.

2. **PCC:** Apply Section 2403. Do not use PCC casing end seals with flexible carrier pipes.

2553.03 CONSTRUCTION.

A. Excavation.

1. Notify the Engineer prior to the start of excavation activities.

2. Remove topsoil to minimum depth of 12 inches (300 mm) and stockpile.

3. Excavate the minimum size pits necessary to safely and properly perform the work.
   a. Protect existing facilities, trees, and shrubs during excavation.
   b. Place excavated material away from trench.
   c. Grade and shape spoil piles to drain and protect adjacent areas from runoff. Do not allow spoil piles to obstruct drainage. Stabilize stockpiles with seeding and provide sediment control around stockpiles.

4. Remove rock, rubbish, debris, and other materials not suitable for use as backfill material.

B. Sheeting Shoring, and Bracing.
Apply Article 2435.03, C.

C. Dewatering.
Apply Article 2435.03, D.

D. Trenchless Installation.

1. General.
Select a method of installation that is appropriate for the soil conditions anticipated and will: 1) allow the pipe to be installed to the desired line and grade within the specified tolerances; 2) prevent heaving or settlement of the ground surface or damage to nearby facilities; and 3) prevent damage to the carrier pipe and lining materials within the carrier pipe.

a. Installation Methods.

1) Auger Boring: A method that utilizes a rotating cutting head to form the bore hole and a series of rotating augers inside a casing pipe to remove the spoil.

2) Directional Drilling: A method for installing pipe from a surface launched drilling rig. A pilot bore is formed and then enlarged by back reaming and removing the spoil material. The pipe is then pulled in place.

3) Open-ended Pipe Ramming: A method that involves driving a steel casing pipe with a percussive hammer. The front end of the casing pipe is open ended. Spoils are removed from the pipe.

4) Pipe Jacking: A method in which pipe is pushed into the ground with hydraulic jacks while soil is simultaneously excavated. Excavation is normally completed with a tunnel boring machine.

5) Microtunneling: A method of pipe jacking using a remote controlled tunnel boring machine.

6) Utility Tunneling: A method of forming large diameter tunnels. As excavation takes place at the front of the tunnel, a liner is constructed to temporarily support the tunnel. Upon completion of the tunnel the pipe is pushed in place.

7) Other: Other methods may be allowed with the Engineer's approval.

b. Line and Grade.

1) Install pipe at line and grade that will allow the carrier pipe to be installed at its true starting elevation and grade within a maximum alignment deviation of the pipe centerline.

2) When no deviation tolerances are specified in the contract documents, apply the following maximum deviations to the carrier pipe:

a) Gravity pipe:

(1) Horizontally: ± 1.0 foot per 100 feet (0.3 m per 30 m).

(2) Vertically: ± 0.2 feet up to 100 feet (0.06 m per 30 m). An additional ± 0.1 foot per 100 feet (0.03 m per 30 m) thereafter. Backfall in pipe will not be allowed.

b) Pressurized pipe:

(1) Horizontally: ± 2.0 feet (0.6 m).

(2) Vertically: ± 1.0 foot (0.3 m). Maintain the minimum depth specified in the contract documents.

c) Greater deviation or interference with other identified facilities may be cause for rejection.

c. Deviation from Line and Grade.

1) Provided adequate clearance remains for proper installation of the carrier pipe, the Contractor will be allowed to correct deviations in grade of a casing pipe in order to achieve design grade of the carrier pipe by:

- Pouring an invert in the casing pipe, or
- Shimming the carrier pipe with casing spacers to a uniform grade.

2) Installations deviating from the specified tolerances that cannot be adjusted to conform to the specified tolerances may be rejected by the Engineer. If a non-conforming installation is not rejected, provide all additional fittings, utility accesses, or appurtenances needed to accommodate horizontal or vertical misalignment, at no additional cost to the Contracting Authority.

3) Abandon rejected installations and place special fill materials, at no additional cost to the Contracting Authority. Replace abandoned installations, including all additional fittings, manholes, or appurtenances required to replace rejected installations.

2. Casing Pipe or Un-cased Carrier Pipe Installation.

a. Install pipe by approved methods.

b. Use a jacking collar, timbers, and other means as necessary to protect the driven end of the pipe from damage.

c. Do not exceed the compressive strength or tensile capacity of the pipe during pushing or pulling operations.

d. Fully support bore hole at all times to prevent collapse. Insert pipe as soil is removed, or support bore with drilling fluid.

e. Fully weld all casing pipe joints. Use an interlocking connection system when approved by the Engineer.

f. Fill space between the inside of the bore hole and the outside of the pipe with special fill material if the space is greater than 1 inch (25 mm).

3. Carrier Pipe Installation through Casing.

a. Clean dirt and debris from the interior of the casing pipe after installation.

b. Install casing spacers on carrier pipe sections as necessary to support the pipe barrel according to the pipe manufacturer's recommendations subject to the following minimum requirements:

1) Install a spacer within 1 foot (0.3 m) of each side of the carrier pipe joint and at a maximum spacing of 6 feet (1.8 m).

2) Do not support pipe by joint bells.

3) Lubricate casing spacers with drilling mud or flax soap. Do not use petroleum-based lubricants or oils.

c. Ensure that thrust loads will not damage carrier pipe joints. Provide thrust collars between joint shoulders of concrete pipe.

d. Provide timbers for sufficient cushioning between the end of the pipe pushed and the jacking equipment to prevent damage to the pipe. Do not allow the steel jack face to thrust against the unprotected pipe end.

e. Position jacks so that resultant force is applied evenly to the entire end of the pipe.

f. Assemble pipe joints in the jacking pit before pushing the carrier pipe into the casing.

g. Close the end of the casing pipe around the carrier pipe with a casing end seal.

h. When specified in the contract documents, fill the annular space between the carrier and casing pipe with flowable mortar or CLSM.

E. Pit Restoration.

1. Remove installation equipment and unused materials from the launching and receiving pits.

2. When the carrier pipe extends beyond the limits of trenchless installation and into the bore pit, place bedding and backfill material according to Section 2435.

3. Place suitable backfill material in the pit. Apply the testing requirements of Section 2435.

4. Restore the site to original condition or better.

2553.04 METHOD OF MEASUREMENT.
Trenchless Construction will not be measured for payment. Excavation for boulders less than or equal to one-third the diameter of the pipe being installed, or parts of existing structures identified in the contract documents will not be measured for payment, but are to be considered incidental to the price bid for trenchless construction. Excavation and removal of boulders larger than one third the diameter of the pipe being installed, or parts of existing structures not identified in the contract documents, will be paid for in accordance with Article 1109.03, B.

2553.05 BASIS OF PAYMENT.
Trenchless Construction is incidental to the underground utility pipe being installed and will not be paid for separately.

Section 2554. Water Mains, Valves, Fire Hydrants, and Appurtenances

2554.01 DESCRIPTION.
This section was developed in conjunction with Division 5 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct water mains and building service pipes.

B. Install valves, fire hydrants, and appurtenances for water mains.

C. Test and disinfect water mains, valves, fire hydrants, and appurtenances.

2554.02 MATERIALS.

A. Pipe, Fittings, Valves, Fire Hydrants, and Appurtenances.
Apply Section 4150.

B. Testing and Disinfection.

1. Liquid Chlorine: according to AWWA B300 and AWWA B301.

2. Sodium Hypochlorite: according to AWWA B300.

3. Calcium Hypochlorite: according to AWWA B300.

4. All disinfecting agents to be NSF 60 certified. Supply and store in original container.

2554.03 CONSTRUCTION.

A. Pipe and Fittings.

1. Pipe Installation.

a. General.

1) Do not use deformed, defective, gouged, or otherwise damaged pipes or fittings.
2) Keep trench free of water. Clean pipe interior prior to placement in the trench.
3) Install pipe with fittings and valves to the lines and grades specified in the contract documents.
4) Clean joint surfaces thoroughly and apply lubricant approved for use with potable water and recommended by the manufacturer.
5) Push the pipe joint to the indication line on the spigot end of the pipe before making any joint deflections.
6) Limit joint deflections to one degree less than pipe manufacturer's recommended maximum limit.
7) Tighten bolts in a joint evenly around the pipe.
8) Install concrete thrust blocks on fittings 16 inches (400 mm) in diameter or smaller. For fittings larger than 16 inches (400 mm), install restrained joints, and when specified in the contract documents, also install concrete thrust blocks.
9) Keep exposed pipe ends closed with rodent-proof end gates at all times when pipe installation is not occurring.
10) Close ends of installed pipe with watertight plugs during nights and non-working days.
11) Do not allow water from the new pipeline to enter existing distribution system piping until testing and disinfection are successfully completed.

b. Trenched.

1) Excavate trench and place pipe bedding and backfill material as specified in Section 2552.
2) Provide uniform bearing along the full length of the pipe barrel. Provide bell holes.

c. Trenchless.
Apply Section 2553.

2. Additional Requirements for DIP Installation.

a. Utilize full length gaged pipe for field cuts. Alternatively, field gage pipe selected for cutting to verify the outside diameter is within allowable tolerances.

b. Cut the pipe perpendicular to the pipe barrel. Do not damage the cement lining. Bevel cut the ends for push-on joints according to the manufacturer's recommendations.

c. Encase all pipe, valves, and fittings with polyethylene wrap according to Article 2554.03, A, 5.

3. Additional Requirements for PVC Pipe Installation.

a. Cut the pipe perpendicular to the pipe barrel. Deburr and bevel cut the spigot end of the pipe barrel to match the factory bevel. Remark the insertion line.

b. When connecting to shallow depth bells, such as on some cast iron fittings or valves, cut the spigot end square to remove the factory bevel. Deburr the end and form a partial bevel on the end.

4. Additional Requirements for Prestressed Concrete Cylinder Pipe Installation.

a. Install according to AWWA M9.

b. Relieve gasket tension by inserting a small rod between the gasket and the gasket groove and running the tool around the pipe twice.

c. Check gasket position using a metal feeler gage after the joint has been assembled.

d. Complete joint exterior grouting after pipe has been properly positioned using non-shrink grout.

5. Polyethylene Encasement Installation.

a. Apply polyethylene encasement to buried ductile iron pipe and to buried fittings, fire hydrants, and appurtenances. The polyethylene encasement is to prevent contact between the pipe and the bedding material, but it need not be airtight or watertight.

b. Install polyethylene encasement according to AWWA C105, using tubes for flat sheets, and the pipe manufacturer's recommendations.

c. Do not expose the polyethylene encasement to sunlight for long periods before installation.

d. Remove lumps of clay, mud cinders, and so forth on the pipe surface before encasing the pipe. Prevent soil or bedding material from becoming trapped between the pipe and polyethylene.

e. Lift polyethylene encased pipe with a fabric type sling or padded cable.

f. Secure and repair encasement material using polyethylene tape, or replace as necessary.

6. Tracer System Installation.

a. Install with all buried water main piping. Refer to the contract documents for details of tracer wire installation.

b. Begin and terminate the system at all connections to existing mains.

c. Install wire continuously along the lower quadrant of the pipe. Do not install wire along the bottom of the pipe. Attach wire to the pipe at the midpoint of each pipe length. Use 2 inch (50 mm) wide by 10 mil (250 µm) thick polyethylene pressure sensitive tape.

d. Install splices only as authorized by the Engineer. Allow the Engineer to inspect all below grade splices of tracer wire prior to placing the backfill material.

e. Install ground rods adjacent to connections to existing piping and at locations specified in the contract documents.

f. Bring two wires to the surface at each fire hydrant location and terminate with a tracer wire station.

g. Final inspection of the tracer system will be conducted at the completion of the project and prior to acceptance by the Engineer. Verify the electrical continuity of the system. Repair discontinuities.

7. Conflicts

a. General.

1) Provide temporary support for existing water, sewer gas, telephone, power, and other utilities or services that cross the trench.

2) Compact backfill material under existing utility crossing as specified in Section 2552, or construct utility line supports where specified in the contract documents..

b. Horizontal Separation of Gravity Sewers from Water Mains.

1) Separate gravity sewer mains from water mains by a horizontal distance of at least 10 feet (3 m) unless:

- The top of a sewer main is at least 18 inches (450 mm) below the bottom of the water main, and
- The sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth at a minimum horizontal separation of 3 feet (1 m) from the water main.

2) When it is impossible to obtain horizontal clearance of 3 feet (1 m) and a vertical clearance of 18 inches (450 mm) between sewers and water mains, the sewers shall be constructed of water main materials meeting the requirements of Article 4150.02, A. However, provide a linear separation of at least 2 feet (600 mm).

c. Separation of Sewer Force Mains from Water Mains.

Separate sewer force mains and water mains by a horizontal distance of at least 4 linear feet (1.2 m).

d. Separation of Sewer and Water Main Crossovers.

1) Vertical separation of sanitary sewers crossing under any water main should be at least 18 inches (450 mm) when measured from the top of the sewer to the bottom of the water main. If physical conditions prohibit the separation, the sewer may be placed not closer than 6 inches (150 mm) below a water main or 18 inches (450 mm) above a water main. Maintain the maximum feasible separation distance in all cases.

2) Where the sewer crosses over or less than 18 inches (450 mm) below a water main, locate one full length of sewer pipe of water main material so both joints are as far as possible from the water main. The sewer and water pipes shall be adequately supported and have watertight joints. Use a low permeability soil for backfill material within 10 feet (3 m) of the point of crossing.

8. Transitions in Piping Systems.
Where the specified material of a piping system entering or exiting a structure changes, make the change at the outside of the structure wall, beyond any wall pipe or wall fitting required, unless specified otherwise.

9. Structure Penetrations.

a. Wall Pipes.

1) Install where pipes penetrate and terminate at a wall or floor surface of a concrete structure, or where the pipe protrudes through the concrete wall or floor and the protrusion is otherwise unsupported.

2) Provide a waterstop flange near the center of the embedment length. The waterstop shall be cast integrally with the wall pipe, or fully welded to it around the pipe circumference.

b. Wall Sleeves.

1) Install where a pipe passes through a structure wall.

2) Sleeves in concrete walls are to be supplied with a waterstop collar, fully welded, and cast-in-place in the concrete.

10. Water Service Stub.

a. Install water service pipe, corporations, stops, and stop boxes according to the contract document.

b. Install 1 inch (25 mm) and smaller corporation valves tapped at 45 degrees above horizontal at a minimum distance of 18 inches (0.5 m) from pipe bell, or other corporation. Install 1 1/2 inch (38 mm) and 2 inch (50 mm) corporation valves tapped horizontal a minimum distance of 24 inches (600 mm) from pipe bell or other corporation.

c. Construct trench and place backfill material according to Section 2552.

B. Valves, Fire Hydrants, and Appurtenances.
Remove valves, fire hydrants, and appurtenances contaminated with mud and surface water from the site. Do not use in construction unless thoroughly cleaned, inspected, and approved by the Engineer.

1. General.

a. Install according to the contract documents.

b. Apply polyethylene wrap to all iron pipe, valves, fire hydrants, and fittings.

c. Set tops of valve boxes to finish grade.

d. Check the working order of all valves by opening and closing through entire range. Before opening the valves, check with the Engineer on operating requirements.

e. Test and disinfect all valves, fire hydrants, and appurtenances as components of the completed water main according to Article 2554.03, C.

2. Flushing Device (Blowoff).
Install and construct as specified in the contract documents.

3. Fire Hydrant.
a. Install according to the contract documents.
b. If the fire hydrant valve is positioned adjacent to the water main, attach it to an anchor tee.
c. If the fire hydrant valve is positioned away from water main, restrain all joints between the valve and water main.
d. Fire Hydrant Depth Setting:
1) Use adjacent finished grade to determine setting depth.
2) Set bottom of breakaway flange between 2 and 5 inches (25 and 125 mm) above finished grade.
3) If finished grade is not to be completed during the current project, consult with the Engineer for proper setting depth.
e. Coordinate installation with tracer wire installation.
f. Orient fire hydrant nozzles as directed by the Engineer.

4. Adjustment of Existing Valve Box or Fire Hydrant.
a. Minor Valve Box Adjustment.
For existing adjustable boxes that have sufficient adjustment range to bring to finished grade, raise or lower valve box to finished grade.
b. Valve Box Extension.
For existing valve boxes that cannot be adjusted to finished grade, install valve box extensions as required.
c. Valve Box Replacement.
For existing valve boxes that cannot be adjusted to finished grade, remove and replace the valve box.
e. Fire Hydrant Adjustment.
1) Add extension barrel sections and stems as necessary to set existing fire hydrant at finished grade.
2) Paint exterior of new barrel section to match existing fire hydrant unless otherwise specified.

C. Testing and Disinfection.
Notify the Engineer at least 2 working days in advance of testing or disinfection operations to coordinate the operations. The Engineer will be in attendance during testing or disinfection.

1. Sequence of Testing and Disinfection
Perform operations according to AWWA C651 in the sequence below. Successfully complete each operation before continuing to the next operation. The Engineer will provide reasonable quantities of water for flushing and testing.

a. Continuous Feed or Slug Method (After Water Main Installation).
The sequence of testing and disinfection may be modified with approval of the Engineer.
1) Perform initial flush.
2) Perform disinfection.
3) Flush after disinfection.
4) Perform pressure and leak testing.

b. Tablet Method (Concurrent with Water Main Installation).
Use this method only if approved by the Engineer. Modify the procedure for flushing, disinfection, and pressure and leak testing as needed if tablet method is used.
1) Perform disinfection.
2) Flush after disinfection.
3) Perform pressure and leak testing.

2. Initial Flushing.

a. Flushing.
1) Coordinate flushing with the Engineer.
2) Flush pipe prior to disinfection using potable water.
3) Measure flushing velocity.
4) Obtain a minimum flushing velocity of 2.5 feet (0.76 m) per second in the pipe to be disinfected.

b. Minimum Flushing Rate.
According to AWWA C651, Table 3, based on 40 psi (276 kPa) residual pressure (see Table 2554.03-1 below).

Table 2554.03-1: Minimum Flushing Rate

Pipe Diameter, inches (mm)	Flow Rate for Flushing, gallons/minute (L/s)	Number of Taps[b]			Number of 2 1/2 inch (63.5 mm) Fire Hydrant Outlets[a]
		1 inch (25 mm)	1 1/2 inch (38 mm)	2 inch (50 mm)	
4 (100)	100 (6.3)	1	-	-	1
6 (150)	200 (12.6)	-	1	-	1
8 (200)	400 (25.2)	-	2	1	1
10 (250)	600 (37.9)	-	3	2	1
12 (300)	900 (56.8)	-	-	2	2
16 (400)	1600 (100.9)	-	-	4	2

(a) With a 40 psi (276 kPa) pressure in the main with the hydrant flowing to atmosphere, a 2 1/2 inch (63.5 mm) fire hydrant outlet will discharge approximately 1000 gallons (3780 L) per minute; and a 4 1/2 inch (115 mm) fire hydrant will discharge approximately 2500 gallons (9460 L) per minute
(b) Number of taps on pipe based on discharge through 5 feet (1.5 m) of galvanized iron pipe with one 90 degree elbow.

c. Property Protection.
Protect public and private property from damage during flushing operations.

3. Disinfection.

a. General.

1) Disinfect according to AWWA C651. The tablet method contained in AWWA C651 shall not be used unless approved by the Engineer.

2) Keep piping to be chlorinated isolated from lines in service and from points of use.

3) Coordinate disinfection and testing with the Engineer.

4) Obtain and test water samples, unless otherwise provided by the Engineer.

b. Procedure.

1) Induce a flow of potable water through the pipe.

2) Introduce highly chlorinated water to the pipe at a point within 5 pipe diameters of the pipe's connection to an existing potable system, or within 5 pipe diameters of a closed end, if there is no connection to an existing system.

3) Introduce water containing a minimum of 25 mg/L free chlorine until the entire new pipe contains a minimum of 25 mg/L free chlorine.

4) Retain chlorinated water in the pipe for at least 24 hours and no more than 48 hours.

4. Final Flushing.

a. Flush pipe using potable water until chlorine residual equals that of the existing potable water system.

b. Dispose of chlorinated water to prevent damage to the environment. Dechlorinate highly chlorinated water from testing before releasing into the ground or sewers. Obtain Engineer approval prior to flushing activities.

1) Check with the local sewer department for the conditions of disposal to the sanitary sewer.

2) Chlorine residual of water being disposed will be neutralized by treating with one of the chemicals listed in Table 2554.03-2:

Table 2554.03-2: Amounts of Chemicals Required to Neutralize Various Residual Chlorine Concentrations in 100,000 Gallons (378,500 L) of Water

Residual Chlorine Concentration	Sulfur Dioxide (SO_2)	Sodium Bisulfite ($NaHSO_3$)	Sodium Sulfite (Na_2SO_3)	Sodium Thiosulfate ($Na_2S_2O_3 + 5H_2O$)	Ascorbic Acid ($C_6O_8H_6$)
mg/L	pounds (kg)	pounds (kg)	pounds (kg)	pounds (kg)	pounds (kg)
1	0.8 (0.36)	1.2 (0.54)	1.4 (0.64)	1.2 (0.54)	2.1 (0.95)
2	1.7 (0.77)	2.5 (1.13)	2.9 (1.32)	2.4 (1.09)	4.2 (1.91)
10	8.3 (3.76)	12.5 (5.67)	14.6 (6.62)	12.0 (5.44)	20.9 (9.48)

50	41.7 (18.91)	62.6 (28.39)	73.0 (33.11)	60.0 (27.22)	104 (47.17)

5. Pressure and Leak Testing.

a. Remove debris from within pipe. Clean and swab out pipe if required.

b. Secure unrestrained pipe ends against uncontrolled movement.

c. Isolate new piping from the existing water system.

d. Fill and flush all new piping with potable water. Ensure all trapped air is removed.

e. Pressurize the new pipe to the test pressure at the highest point in the isolated system. Do not pressurize to more than 5 psi (34 kPa) over the test pressure at the highest point in the isolated system.

f. Test and monitor the completed piping system at 1.5 times the system working pressure or 150 psi (1035 kPa), whichever is greater, for 2 continuous hours.

g. If at any time during the test the pressure drops to 5 psi (34 kPa) below the test pressure, repressurize the pipe by pumping in potable water in sufficient quantity to bring the pressure back to the original test pressure.

h. Accurately measure the amount of water required to repressurize the system to the test pressure.

i. Maximum allowable leakage rate according to AWWA C600:

English Units

$$L = \frac{(N)(D)(P)^{0.5}}{7400}$$

Where:
L = allowable leakage, in gallons per hour.
N = number of pipe joints in pipe test section.
D = pipe diameter, in inches.
P = average test pressure, in pounds per square inch.

Metric Units

$$L = \frac{(N)(D)(P)^{0.5}}{130{,}400}$$

Where:
L = allowable leakage, in liters per hour.
N = number of pipe joints in pipe test section.
D = pipe diameter, in millimeters.
P = average test pressure, in kilopascals.

Table 2554.03-3 assumes an average test pressure (P) of 150 psi (1035 kPa) and number of pipe joints (N) per 1000 feet (300 m) of test section based on 18 foot (5.5 m) pipe lengths and no fittings:

Table 2554.03-3: Maximum Allowable Leakage Rate

Pipe Diameter		Maximum Allowable Leakage Rate	
inches	**mm**	**gallons/hour/1000 feet of pipe**	**liters/hour/300 meters of pipe**
4	100	0.37	1.32
6	150	0.55	1.99
8	200	0.74	2.65
10	250	0.92	3.31
12	300	1.10	3.98

14	350	1.29	4.64
16	400	1.47	5.30
18	450	1.66	5.97
20	500	1.84	6.63
24	600	2.21	7.96
30	750	2.76	9.95
36	900	3.31	11.94

j. If the average measured leakage per hour exceeds the maximum allowable leakage rate, repair and retest the water main.

k. If the measured pressure loss does not exceed 5 psi (34 kPa) the test will be considered acceptable.

l. Repair all visible leaks regardless of the amount of leakage.

6. Bacteria Sampling.
Test water mains according to AWWA C651. If the initial disinfection procedure fails to produce satisfactory bacteriological results or if other water quality is affected, repeat the disinfection procedure.

7. Putting Water Main in Service
Put the completed water system in service only after obtaining permission of the Engineer.

2554.04 METHOD OF MEASUREMENT.

A. Pipe and Fittings.

1. Water Main.

a. Trenched.
Measurement for each type and size of pipe installed in an open trench will be in linear feet (meters) along the centerline of the pipe, including the length through the fittings.

b. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods will be in linear feet (meters) along the centerline of the casing pipe.

2. Water Main with Casing Pipe.

a. Trenched
Measurement for each type and size of pipe with a casing pipe installed in an open trench will be in linear feet (meters) along the centerline of the casing pipe from end of casing to end of casing.

b. Trenchless.
Measurement for each type and size of pipe installed by trenchless methods with a casing pipe will be in linear feet (meters) along the centerline of the casing pipe.

3. **Fittings.**
   One of the following methods will be specified for measurement of water main fittings:
   a. **Fittings by Count.**
      Measurement for each type and size of fitting installed as specified in the contract documents or as required for proper installation of the water main will be counted.
   b. **Fittings by Weight (Mass).**
      Measurement for each type and size of fitting installed as specified in the contract documents or as required for proper installation of the water main will be counted. Determine the total weight (mass) of fittings counted in pounds (kilograms) based on the standard fitting weights (masses) published in AWWA C153 for ductile iron compact fittings.

4. **Water Service Stubs.**
   Each type and size of water service and stub from the water main to the stop box will be counted.

B. Valves, Fire Hydrants, and Appurtenances.

1. **Valve (Butterfly or Gate).**
   Each type and size of valve will be counted.

2. **Tapping Valve Assembly.**
   Each size of tapping valve assembly will be counted.

3. **Fire Hydrant Assembly.**
   Each fire hydrant assembly will be counted.

4. **Flushing Device (Blowoff).**
   Each size of flushing device will be counted.

5. **Valve Box Adjustment, Minor.**
   Minor adjustment of an existing valve box by raising or lowering the adjustable valve box will not be measured.

6. **Valve Box Extension.**
   Each existing valve box adjusted to finished grade by adding a valve box extension will be counted.

7. **Valve Box Replacement.**
   Each existing valve box replaced with a new valve box will be counted.

8. **Fire Hydrant Adjustment.**
   Each existing fire hydrant adjusted to finished grade by addition of an extension barrel section and stem will be counted.

C. Testing and Disinfection.
None.

2554.05 BASIS OF PAYMENT.

A. Pipe and Fittings.

1. Water Main.

a. Trenched.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of pipe.

2) Payment is full compensation for trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, tracer system, testing, disinfection, and polyethylene wrap for ductile iron pipe and ductile and gray iron fittings.

b. Trenchless.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of pipe.

2) Payment is full compensation for:

- Furnishing and installing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Tracer system,
- Testing, and
- Disinfection.

2. Water Main with Casing Pipe.

a. Trenched.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of water main.

2) Payment is full compensation for furnishing and installing both water main and casing pipe, trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, casing spacers, furnishing and installing annular space fill material, tracer system, testing, and disinfection.

b. Trenchless.

1) Payment will be the contract unit price per linear foot (meter) for each type and size of water main.

2) Payment is full compensation for:

- Furnishing and installing both water main and casing pipe,
- Trenchless installation materials and equipment,
- Pit excavation, dewatering, and placing backfill material,
- Casing spacers,
- Furnishing and installing annular space fill material,
- Tracer system,
- Testing, and
- Disinfection.

3. Fittings.

One of the following methods will be specified for payment of water main fittings:

a. Count.
Payment will be the contract unit price for each type and size of fitting. Payment is full compensation for restrained joints and thrust blocks.

b. Weight (Mass).
Payment will be made at the contract unit price per pound (kilogram). Payment is full compensation for restrained joints and thrust blocks.

4. Water Service Stubs.

a. Payment will be made at the contract unit price for each type and size of water service stub.

b. Payment is full compensation for corporation, service pipe, stop, and stop box.

B. Valves, Fire Hydrants, and Appurtenances.

1. Valve (Butterfly or Gate).

a. Payment will be the contract unit price for each type and size of valve.

b. Payment is full compensation for all components attached to the valve or required for its complete installation, including underground or above ground operator, square valve operating nut, valve box and cover, valve box extension, and valve stem extension.

2. Tapping Valve Assembly.

a. Payment will be the contract unit price for each tapping valve assembly.

b. Payment is full compensation for tapping sleeve, tapping valve, the tap, valve box and cover, valve box extension, and valve stem extension.

3. Fire Hydrant Assembly.

a. Payment will be the contract unit price for each fire hydrant assembly.

b. Payment is full compensation for the fire hydrant, barrel extensions sufficient to achieve proper bury depth of anchoring pipe and height of fire hydrant above finished grade, and components to connect the fire hydrant to the water main, including anchoring pipe, fittings, thrust blocks, pea gravel or porous backfill material, and fire hydrant gate valve, except tapping valve assembly if used.

4. Flushing Device (Blowoff).
Payment will be at the contract unit price for each flushing device.

5. Valve Box Adjustment, Minor.
Minor adjustment of an existing valve box by raising or lowering the adjustable valve box is incidental.

6. Valve Box Extension.
Payment will be at the contract unit price for each valve box extension.

7. Valve Box Replacement.

a. Payment will be at the contract unit price for each valve box replacement.

b. Payment is full compensation for:

- Removal of existing valve box,
- Excavation,
- Furnishing and installing new valve box,
- Furnishing and placing backfill material,
- Compaction, and
- All other necessary appurtenances.

8. Fire Hydrant Adjustment.

a. Payment will be at the contract unit price for each adjustment of an existing fire hydrant.

b. Payment is full compensation for:

- Removal and reinstallation of the existing fire hydrant,
- Furnishing and installing the extension barrel section and stem, and
- All other necessary appurtenances.

C. Testing and Disinfection.

Testing and disinfection of water systems is incidental to the construction of pipe and fittings.