DIVISION 24. STRUCTURES

This work consists of constructing various types of wood, steel, or concrete structures for bridges, viaducts, grade separations, retaining walls culverts, or other structures, according to the contract documents and requirements for the respective types in the sections listed below. Clearing and grubbing, channel change, and revetment will be constructed, measured, and paid for as provided in Sections 2101, 2104, and 2507, respectively.

For work involved in Division 24, use equipment complying with the appropriate part of Division 20 and as further provided in the particular section.

After completing projects involving work of any section of Division 24, place all portions of right-of-way disturbed by the Contractor's operations in acceptable condition. Apply Article 1104.08.

2401. Removal of Existing Structures.
2402. Excavation for Structures.
2403. Structural Concrete.
2404. Reinforcement.
2405. Foundations and Substructures.
2406. Concrete Structures.
2407. Precast and Prestressed Concrete Bridge Units.
2408. Steel Structures.
2409. Timber Structures.
2410. Plank Decks.
2411. Laminated Wood Decks.
2412. Concrete Bridge Decks.
2413. Bridge Deck Surfacing, Repair, and Overlay.
2414. Railings.
2415. Concrete Box, Arch, and Circular Culverts.
2416. Rigid Pipe Culverts.
2417. Corrugated Culverts.
2420. Structural Plate Pipes, Pipe Arches, and Arches.
2422. Unclassified Pipe Culverts.
2423. Support Structures for Highway Signs, Luminaires, and Traffic Signals.
2424. Shotcrete.
2425. Precast Prestressed Concrete Deck Panels.
2426. Structural Concrete Repair.
2427. Bridge Cleaning.
2428. Smoothness of Bridge Decks and Bridge Deck Overlays.
2429. Pre-Engineered Steel Truss Recreational Trail Bridge.
2430. Modular Block Retaining Wall.
2431. Segmental Retaining Wall.
2432. Mechanically Stabilized Earth (MSE) Retaining Wall.
2433. Concrete Drilled Shaft.
2434. Disc Bearing Assembly.
2435. Sanitary and Storm Sewer Structures.

Section 2401. Removal of Existing Structures

2401.01 DESCRIPTION.

A. Remove all portions of an existing structure from the project, except the portions that may be required or permitted to be left in place.

B. Unless provided otherwise, all structures or parts of structures to be removed become the Contractor's property.

2401.02 MATERIALS.

None.

2401.03 CONSTRUCTION.

A. Notification for Complete Removal of Bridges.

1. Notify the Iowa DNR by mail and the Engineer, with the "Notification of Demolition" form, no less than 10 business days prior to the start of bridge demolition.

2. If unable to begin work on the original intended start date, notify the Iowa DNR and the Engineer, by sending a revised "Notification of Demolition" form, of the new intended start date. Provide notification of the inability to commence work on the intended start date no later than 1 business day prior to the original intended start date. Failure to notify the Engineer of a change in start date 1 business day prior to the original intended start date will result in the need for a new 10 business day notification to the Iowa DNR and the Engineer.

3. The Contracting Authority has inspected the existing bridge for asbestos. Unless otherwise indicated in the contract documents, no asbestos was found, or it has been removed prior to the letting. The Contractor may use this information to complete the "Notification of Demolition" form.

B. Removal of Superstructures.

1. Dismantle and remove steel structures which may be re-erected in new locations in a manner that will avoid damage to any of the members.
- **a.** Separate members at field connections.
- **b.** Clearly and neatly match mark all members of trusses with white paint before dismantling. Similarly mark all pins, nuts, loose plates, and so on to indicate their proper location in the structure.
- **c.** Clean and coat all pins, pin holes, and machined surfaces with waterproof National Lubricating Grease Institute, No. 3 multipurpose grease, or an approved equal.
- **d.** Wire all loose parts to adjacent members or pack in suitable containers.

2. Concrete superstructures which are to be completely removed may be removed by any means consistent with regulations regarding safety and

protection of adjacent property. Complete all operations which might endanger new work before constructing the new structure.

C. Removal of Substructures.

1. Remove substructures of existing structures to 1 foot (0.3 m) below natural stream bottom, unless otherwise provided or ordered. Remove those parts outside the stream to 1 foot (0.3 m) below natural ground surface. Where these portions of existing structures lie wholly or in part within limits for a new structure, remove as necessary to accommodate construction of the proposed structure.

2. Prior to placing new work, complete blasting or other operations which are necessary for removal of an existing structure or obstruction and which may damage new construction.

D. Remodeling of Structures.

1. On remodeling projects, match mark steel superstructure parts that are to be removed and reused. Store as designated in the contract documents. Dismantle and handle in such a way to not impair strength or usefulness of the material.

2. When contract documents require removal of existing concrete, carefully and accurately remove to lines indicated. Do not damage adjacent concrete, exposed reinforcing, or structural steel which the contract documents require to be incorporated into the remodeled structure. Saw match lines 3/4 inch (20 mm) deep where concrete floors are to be partially removed. This depth may require adjustment to ensure that the existing reinforcing steel is not damaged.

3. Demolition by impact methods with wrecking ball, pile hammer, and so on, or by explosives will be permitted only when superstructures are designated in the contract documents as unfit for re-erection. Apply Article 2403.03, I, when bonding new and old work. Do not use explosives for removing a part of a structure to which an addition is to be made, except in the case of massive sections and only with the Engineer's written permission. When explosives have been used, remove the concrete for at least 6 inches (150 mm) beyond the point of visible damage using methods that will not damage the concrete that is to remain.

E. Removal of Steel.

1. Store structural steel members specified to remain the Contracting Authority's property in neat piles at locations specified in the contract documents or within the right-of-way in the vicinity of the work at points the Engineer designates.

2. Neatly store members of structures which are to be re-erected on skids above the surface of the ground.

3. When the contract documents specify that the removed steel is to become the Contractor's property, the contract documents will show an indication of total lead and total chromium in the existing paint system.

F. Removal of Concrete and Masonry.
Unless otherwise provided, concrete and masonry removed from old structures will become property of the Contractor. Remove according to Article 1104.08.

G. Lumber.

1. If designated for salvage, remove lumber from structures by methods which preserves its usefulness. Remove nails, spikes, bolts, and other hardware from lumber, and pile the lumber in neat piles at locations designated by the Engineer.

2. If not designated for salvage, lumber becomes the Contractor's property. Remove according to Article 1104.08.

H. Other Structures.

1. Remove pipe culverts and other small structures which are designated in the contract documents as suitable for salvage using methods which preserves their usefulness. Store these items nearby within the right-of-way.

2. If not so designated, these materials become the Contractor's property. Remove from the site.

I. Part or All of an Old Structure Lying Outside New Construction Limits.
Unless otherwise specified, for any excavation below finished grade line for the purpose of removing the old structure, place suitable earth backfill material to the original level or to the finished grade line (whichever is the lower) according to Article 2402.03, H.

2401.04 METHOD OF MEASUREMENT.

Lump sum. No method of measurement.

2401.05 BASIS OF PAYMENT.

A. When the contract includes an item for Removal of Existing Structures, payment will be the Lump Sum contract price. When provisions in the contract documents do not cover payment for removal of a structure, including encased culvert pipe, footings, or other unforeseen obstacles to be removed, payment for their removal will include placement of backfill material made necessary by their removal. This payment will be as provided in Article 1109.03, B.

B. The payment for removal of an existing structure is full compensation for:

- Furnishing all material, equipment, and labor and for performance of all work necessary for proper storage of salvaged material or for removal of the old structure from the project, and

- Placement of backfill material made necessary by these operations.

Section 2402. Excavation for Structures

2402.01 DESCRIPTION.

A. Remove all material necessary for construction of the work included in the contract, in conformity with the contract documents.

B. Furnish, place, and remove all cofferdams, shoring, and bracing.

C. Remove all surplus material.

D. Sounding and test boring data shown in the contract documents were accumulated for design and estimating purposes. Their appearance in the contract documents does not constitute a guarantee that conditions other than those indicated will not be encountered in the excavation or in material penetrated by piling.

2402.02 MATERIALS.
As required in Article 2402.03.

2402.03 CONSTRUCTION.
Provide a safe slope for construction in the conditions encountered.

A. Clearing and Grubbing.

1. Remove all trees, stumps, and brush existing on the site of the work which shall be removed for completion of the work. As part of the contract for a structure, the Engineer may order trees and stumps which are near, but not on, the site of the work to be removed, if:
- Their presence will interfere with completion of adjacent parts of the improvement of which the structure is a part, and
- Their later removal by usual methods would endanger the structure.

2. No blasting within 50 feet (15 m) of any completed part of the structure.

3. Refer to Section 2101 for the work and payment for clearing and grubbing.

B. Elevations and Dimensions of Footings.
Under normal construction conditions, construct footings to elevations shown in the contract documents. The Engineer may order, in writing, changes necessary in dimensions or elevations of footings to secure a satisfactory foundation.

C. Treatment of Foundations.

1. If a footing on rock is specified, perform excavation in a manner to allow the rock to be exposed and prepared according to Article 2405.03, C. If the footing shall rest on firm earth, take special care not to disturb the

bottom of the excavation. If the footing excavation bottom is wet, wait until just before placing the footing to complete final finishing.

2. Control drainage in the foundation area to reduce moisture and mud problems to a practical minimum. Prepare and maintain the area in an acceptable condition prior to and during placement of concrete. The Engineer may require improved drainage, removal of mud, filling with suitable material, or other procedures to obtain a reasonably suitable condition in the area. This requirement is not to be construed as an order for foundation treatment material or as a basis for extra compensation.

3. If the foundation material is unsuitable, the Engineer may direct that the foundation be over excavated and backfill consisting of granular surfacing materials approved by the Engineer be placed. Place backfill material according to Article 2402.03, H.

D. Construction of Cofferdams.
Construct cofferdams according to Article 2405.03, A.

E. Removal of Cofferdams.
Unless shown otherwise in the contract documents, remove cofferdams, sheeting, and bracing.

F. Inspection of Excavation.

1. After each excavation is completed, notify the Engineer, who will inspect the depth of excavation and character of foundation material.

2. Do not place concrete until after the Engineer has approved the depth of excavation and character of foundation material.

3. The Contracting Authority will be responsible for delays caused by failure to make inspection within 24 hours after the Contractor has given notice to the Engineer.

G. Removal of Excavated Material.

1. Use all material excavated for bridge and culvert work suitable for placing backfill material or foreslope construction for that purpose. If material is unsuitable due to excessive moisture, dry it prior to placement.

2. Do not use unsuitable material for either placing backfill materials or in approach fills. Remove excess material from the project according to Article 1104.08.

H. Placing Backfill Materials.

1. Place backfill material next to completed structures according to the following provisions or according to Section 2506. Use excavated material when flowable mortar or granular backfill material is not

specified in the contract documents. Place backfill to natural ground line unless there is an inadequate quantity of suitable excavated material. If there is an inadequate quantity of suitable excavated material, continue placing backfill until the suitable material is depleted.

2. Use backfill material free from organic material, boulders, or broken concrete over 8 inches (200 mm) in the greatest dimension; or frozen material.

3. Ensure moisture content for soil is suitable for compaction at the time it is placed for backfill material. When compaction with moisture control is required by the contract documents, increase or reduce the moisture content in backfill material, as necessary, to bring the moisture within the designated moisture limits prior to and during placement and compaction.

4. When granular backfill material is specified, use backfill material meeting the requirements of Section 4133. When the volume of material excavated exceeds that of backfill material required by the contract documents, increase the quantity of granular backfill material furnished to provide backfill material for the excess volume of excavation. Place granular backfill material in layers no more than 8 inches (200 mm) thick. Thoroughly tamp or vibrate each layer to insure compaction. The Engineer may require granular backfill material to be moistened with water while being placed.

5. Except as provided in Article 2403.03, N, allow at least 14 calendar days to elapse after concrete has been placed before placing backfill material against:
- Concrete culverts, abutments, piers, arches, and wingwalls, or
- Timber abutments or wingwalls which depend on cast-in-place concrete anchors.

6. Do not place backfill material against timber abutments or wingwalls until all required anchor rods are in place and ready to function. Do not place backfill material against timber abutment or wingwall designed to gain support from a superstructure until the superstructure is in place and permanently fastened to the substructure.

7. Backfill material may be placed in water only when removal of water from the area in which backfill material is to be placed is impractical, for example:
- Around piers or abutments located within the waterway, or
- In other deep excavations where removal of cofferdams is required before placing backfill material, and such removal prevents dewatering.

8. Backfill material placed in water need not be consolidated. Use granular backfill material when placing material under water and over which an embankment is to be placed.

9. When placing backfill material above the water line, place it in layers no more than 8 inches (200 mm) in loose thickness. Thoroughly compact each layer material before the next layer is placed. Except as noted below, accomplish all compaction by rolling with an approved roller or by tamping with a mechanical tamper. Operate pneumatic tampers according to the manufacturer's recommendations.

10. Place backfill material in layers no more than 8 inches (200 mm) in loose thickness when moisture control is required by the contract documents. Level and thoroughly compact each layer before the next layer is placed. Use a tamping type roller described in Article 2001.05, A. Compact at no less than one roller passage per inch (25 mm) of loose thickness. In areas inaccessible to the roller, use a mechanical tamper described in Article 2001.04 for each layer. Excavate to a width to accommodate the roller to be used and provide a reasonably level area for the roller operation for the first and all subsequent layers.

11. Where backfill material is required on both sides of a concrete wall, abutment, or other monolithic structure, fill on both sides of the structure simultaneously so that the two fills are kept at approximately the same elevation at all times. For the purposes of this paragraph, consider concrete boxes, arches, and circular culverts and rigid frame bridges, except wingwalls, to be monolithic structures.

12. Where backfill material is to be placed on one side only of retaining walls, or wingwalls of culverts 8 feet (2.5 m) high or more, do not perform rolling operations within 3 feet (1 m) of the wall face. Compact the 3 feet (1 m) closest to these walls or wing faces using pneumatic or hand tampers only.

13. Remove material excavated for concrete culvert construction as provided in Article 2402.03, G, and within 7 working days after concrete can be subjected to flexural stresses as provided in Article 2403.03, N, 2. Prepare the site for placing the adjacent embankment. The Engineer may extend the time period for removing excavated material if the extension will not interfere with work of others or the public. For culvert extensions on roads open to traffic, complete backfill material placement to the top of the culvert within 14 working days after the curing period has expired.

I. Embankments Adjacent to Bridges, Culverts, or Structures.
Apply Article 2107.03, O, when the contract requires construction of an embankment adjacent to a bridge, culvert, or other structure unless the contract documents require the placement of flowable mortar according to Section 2506.

J. Classification of Excavation.
Excavation for structures will be classified as Class 20, Class 21, Class 22, Class 23, or Class 24, as follows:

1. **Class 20 Excavation.**
   Includes excavation for bridges above the excavation classification line shown in the contract documents and not classified as Class 22 excavation. Also includes all excavation for culverts not classified as Class 22, 23, or 24 excavation. None of the excavation for culverts is to be classified as Class 21 excavation.

2. **Class 21 Excavation.**
   Includes excavation for bridges below the excavation classification line shown in the contract documents and not classified as Class 22 excavation.

3. **Class 22 Excavation**
   Includes the measured volume of granite, trap, quartzite, chert, limestone, sandstone, hard shale, or slate in natural ledges. Also includes the estimated or measured volume of rock fragments or boulders having a volume of 1 cubic foot (0.03 m^3) or greater.

4. **Class 23 Excavation.**
   Includes excavation included in the definitions of Classes 20, 21, and 22 and any other material encountered regardless of its nature, except for removal of old structures or parts of structures.

5. **Class 24 Excavation.**
   Includes the additional excavation necessary to provide material for backfills, approach fills, berms, or a roadway over the structure when material resulting from other classes of excavation for the structure is of insufficient quantity or of unsatisfactory quality for these purposes.

2402.04 METHOD OF MEASUREMENT.

A. General.

1. If a single contract involves both channel excavation and excavation for structures, excavation included within the volume limits of channel excavation, as shown in the contract documents, will not be included in measurement of excavation for structures.

2. Excavation for structures to the limits indicated in this article is for pay quantities only.

3. Quantities of Class 20, 22, 23, and 24 excavation will be measured in cubic yards (cubic meters) by the cross section method or other appropriate method. Boulders may be measured after excavation. Class 21 excavation will be computed in cubic yards (cubic meters) within the boundaries specified and from data shown in the contract documents.

4. When the location of part or all of an existing structure scheduled to be removed falls within the planes describing the excavation volume for either structures or culverts (Article 2402.04, B and C), the volumes of excavation performed for payment on the new structure will include any

volume of excavation performed as part of the removal of the existing structure which is:

- Above the elevation of the bottom of footings, and
- Within the excavation limits described below.

5. All other excavation performed in conjunction with removal of structures will be considered incidental to removal. Additional payment will not be made. Reduction in excavation quantity will not be made for portions of existing structures removed from the excavation limits of new structures.

B. Excavation for Structures.

1. The quantity of Class 21 excavation measured, unless modified in Article 2402.05, will be shown in the contract documents.

2. For other classes of excavation, the quantity measured for payment will be that actually removed except as provided in this article for culverts. Unless required by the contract documents or ordered by the Engineer, measurement will not be made of material removed outside areas bounded by vertical planes parallel to the boundaries of the structure or part of structure and located as follows:

a. For concrete structures and parts of structures without footings, 18 inches (0.5 m) outside the horizontal projection of the structure.
b. For concrete structures with footings, 18 inches (0.5 m) outside the footings.
c. For timber abutments and wingwalls, 24 inches (0.6 m) behind the backing plank.
d. For anchor rods, 12 inches (0.3 m) on each side of the rod.
e. For buried anchors, the face of the buried anchor on one side and 24 inches (0.6 m) outside the buried anchor on the other face.

3. For roadway pipe culverts, the amount of excavation measured for payment will be computed from an excavation centered on the center line of the pipe, to the required depth, length, and a width of 42 inches (1 m) plus the specified diameter of the pipe in inches (millimeters). The vertical plane as described above will be changed to a 1:1 slope from the bottom of the excavation sloping away from the structure. When the 1:1 slope is used, it is to extend the length of the structure unless indicated otherwise in the contract documents. This does not apply to culvert extensions unless indicated in the contract documents. Modification will not be made in the quantity shown in the contract documents for variations in wall thickness of the pipe. Modification will be made for changes in location or flow line as provided in this section.

4. For cast-in-place culverts the amount of excavation measured for payment will be computed from an excavation centered on the center line of the culvert, to the required depth, length, and a width 2 feet (0.6 m) greater than the width of the footing. The vertical plane as described above will be changed to a 1:1 slope from the bottom of the excavation sloping away from the structure. When the 1:1 slope is used, it will extend the length of the structure unless otherwise indicated in the contract documents. This does not apply to culvert extensions unless

indicated in the contract documents. Modification will be made for changes in location or flow line as provided in this section.

5. When moisture control is required by the contract documents, the amount of excavation measured for payment will be computed for an excavation to the required depth and length and a width extending 6 feet (2 m) beyond the limits of the structure.

6. The Engineer may require a 48 hour notice prior to beginning excavation so necessary measurements of the existing ground may be made. Payment will not be made for material removed before these measurements are made.

7. In the case of two or more footings supporting a pier or similar structure which is continuous between footings at any elevation below the excavation classification line, the planes described above will be located as if the footings were continuous and of the width of the footings to be built.

8. When the quantity of Class 20 excavation is based on the assumption that prior Class 10 excavation by a grading contractor will be made, the depth of Class 20 excavation, if removed by the bridge contractor, will be increased by the depth of Class 10 excavation (grading) not completed prior to commencement of the Class 20 excavation, if the Class 10 excavation is not in actual progress or completed by the starting date of the bridge contract. This increase will not apply if the projects involving Class 10 (grading) and Class 20 (bridge) excavation are part of the same contract.

9. The estimated quantities of excavation are computed from data available when plans are prepared. Unless contract quantities are agreed to, estimated quantities are not to be used as the measured quantity, except for Class 21 excavation and as specified below for culvert excavation.

C. Excavation for Culverts.

1. When a culvert is built without a change in location, dimensions, or elevation, the quantities of Class 24 and Class 20 or Class 23 excavation as shown in the contract documents will be the quantity for which payment is made.

2. When the location, width, length, or flow line elevation of a culvert has been changed from that specified in the contract documents, the quantities of excavation will be measured by the Engineer as indicated above.

D. Embankments.

1. Construction of embankments adjacent to bridges, culverts, or structures will not be measured for payment, but will be considered incidental to the type of excavation specified.

2. Materials removed from old fills or embankment for the convenience of the Contractor to facilitate use of rolling or hauling equipment will not be measured for payment.

E. Granular Backfill.

1. The quantity of granular backfill material shown in the contract documents will be the quantity for which payment is made.

2. Granular backfill material required and furnished for structural concrete placement at bridge abutments will not be measured separately for payment.

F. Foundation Treatment Material.

1. The Engineer will compute the quantity of foundation treatment material measured for payment in cubic yards (cubic meters) from measurements of the space to be excavated and backfill material placed, or it may be measured in the transporting vehicle or weighed.

2. Foundation treatment material not ordered placed by the Engineer or quantities in excess of the quantity ordered placed by the Engineer will not be measured for payment.

3. When weighing is accepted as the method of measurement and the material is weighed prior to delivery, the cubic yards (cubic meters) will be determined by the method outlined in Article 2312.04, A.

G. Compaction with Moisture Control (Structures).
Compaction with moisture control (structures) will be the number of cubic yards (cubic meters) of backfill material placement or embankment, or both, placed with moisture control, as required, regardless of the class of excavation.

H. Flowable Mortar.
When flowable mortar is specified in the contract documents, it will be measured as specified in Section 2506.

2402.05 BASIS OF PAYMENT.

A. General.

1. Payment for the quantities of Class 20, Class 21, Class 22, Class 23, and Class 24 excavation, measured as provided above, will be the contract unit prices per cubic yard (cubic meter) except as provided in the following Paragraphs B, C, D, and E.

2. Payments in all cases are full compensation for:

- Removing, transporting, and cleaning up all excavated material as provided above,
- Pumping,

- Placing and removing all cofferdams except as provided in Article 2402.05, B and C,
- Shoring and bracing,
- Placing and consolidation of backfill material, including granular backfill material and foundation treatment material, and
- Leveling and shaping abutment berms to the elevation and dimensions shown in the contract documents.

3. When the contract documents do not provide for payment for removal of old structures or parts of structures, this removal is considered as extra work and payment will be as provided in Article 1109.03, B.

4. Payment for dressing of slopes outside the area of the structure not disturbed by the Contractor's operations will be as provided in Article 1109.03, B.

B. Extra Depth Excavation for Structures Other than Culverts.

1. Upon written order of the Engineer, excavate for footings to depths below those shown in the contract documents. When the extra depth of excavation does not exceed 6 feet (1.8 m), payment will be made for extra depth at percentages shown in Table 2402.05-1 of the contract unit price for the excavation to the footing elevation shown in the contract documents.

Table 2402.05-1: Percentages for Payment for Extra Depth

Depth	Excavation Above Classification Line	Excavation Below Classification Line
First foot (0 to 0.3 m)	100%	100%
Second foot (0.31 m to 0.60 m)	120%	140%
Third foot (0.61 m to 0.9 m)	130%	160%
Fourth foot (0.91 m to 1.2 m)	140%	180%
Fifth foot (1.21 m to 1.50 m)	150%	200%
Sixth foot (1.51 m to 1.80 m)	160%	220%
Note: If the bridge plans fail to show an excavation line, low water elevation as shown in the contract documents is to be considered as the excavation classification line for the above purpose.		

2. When the extra depth excavation exceeds 6 feet (1.8 m), all excavation below the elevation of the bottom of the footing, as shown in the contract documents, payment will be as extra work as provided in Article 1109.03, B.

3. When the extra depth excavation necessitates removal and reconstruction of a cofferdam which complied with Article 2405.03, A, the cost of removal of the old cofferdam and construction of the new one will be paid for as provided in Article 1109.03, B.

C. Excavation for Changes in Horizontal Dimensions of Footings.
On written order of the Engineer, construct footings having horizontal dimensions other than those shown in the contract documents. When such a change necessitates removal and reconstruction of a cofferdam which complies fully with the requirements of Article 2405.03, A, the cost of removal of the old cofferdam and construction of the new ones will be paid for as provided in Article 1109.03, B. Payment for excavation will be made at the same unit prices as if there had been no change in dimensions of the footings.

D. Overhaul.

1. Material from classes of excavation other than Class 24 will ordinarily be deposited within 200 feet (60 m) from the point of excavation as directed by the Engineer. Payment for overhaul beyond the free haul limit of 200 feet (60 m) will be as provided in Article 1109.03, B.

2. Payment for overhaul on Class 24 excavation will be as provided in Section 2108, except the free haul limit will be 500 feet (150 m).

E. Unexpected Rock Excavation.

1. When the contract documents provide unit prices for Class 20 and Class 21 excavation, but do not provide a price for Class 22 excavation, payment for any material required to be excavated which conforms to the definitions for Class 22 excavation will be at 3.5 times the contract unit price for the class of excavation in which it is encountered, subject to the provisions for extra depth as provided in Article 2402.05, B.

2. When the contract provides a unit price for Class 23 excavation only, payment will not be made for unexpected rock.

F. Foundation Treatment Material.
Payment for foundation treatment material furnished according to Article 2402.03, C, will be at the Contractor's unit delivered cost per cubic yard (cubic meter) plus the applicable contract unit price for the class of excavation treated, but not to exceed $25 per cubic yard ($33 per cubic meter) for the combined cost of excavation and treatment.

G. Granular Backfill.
Payment for granular backfill material will be at the contract unit price per cubic yard or ton (cubic meter or megagram). The cost of granular backfill material required and furnished for structural concrete placement at bridge abutments is included in the contract unit price for the structural concrete.

H. Compaction with Moisture Control (Structures).
Payment for the quantity of backfill material or embankment, or both, placed with moisture control, will be the contract unit price per cubic yard (cubic meter).

I. Flowable Mortar.
When flowable mortar is specified in the contract documents, payment will be according to Section 2506.

Section 2403. Structural Concrete

2403.01 DESCRIPTION.
Portland Cement Concrete used for constructing bridges and other structures. For PCC Pavement, refer to Section 2301.

2403.02 MATERIALS.

A. General.

1. Meet the requirements for the respective items in Division 41.

2. Unless otherwise specified, use Class 2 durability coarse aggregate, or better, as defined in Section 4115.

3. Unless otherwise specified, use the following:
- **a.** Class BR or Class C concrete for bridge barrier rails.
- **b.** Class X concrete for seal courses.
- **c.** Class C concrete for all other structural concrete, including concrete for bridge curbs, bridge medians, and bridge sidewalks. Refer to Article 2412.02 for concrete used for one course bridge floors and the first course of two course bridge floors.

B. Proportions.

1. General.
- **a.** Materials for structural concrete may be mixed in proportions for any of the mixes allowed for the class of concrete specified in the contract documents and the current Materials I.M. 529, provided the gradation of each aggregate conforms to the gradation required for that proportion.
- **b.** The contract documents will indicate where each class shall be used and the approximate quantities of each class.
- **c.** Class D or Class M mixtures may be substituted for Class C proportions, except in bridge floors.

2. Water and Consistency.
- **a.** Place with a slump between 1 and 3 inches (25 and 75 mm) as a target range, allowing a maximum of 4 inches (100 mm) as a tolerance.
- **b.** If the characteristics of the materials used are such that the total quantity of water used (including free water in aggregate) to secure the required consistency reduces, by more than 2%, the batch volume computed on the basis of absolute volumes of the batch quantities used, the proportions may be adjusted accordingly.
- **c.** If the characteristics of the materials used are so that the required consistency is not secured within the specified maximum water

content, increase the proportions of cement to aggregate as necessary to secure the required consistency within the specified maximum water content. Additional cement will be considered as incidental, and no additional payment will be allowed. Free moisture in the aggregate plus the total mixing water shall not exceed that shown in Table 2403.03-1.

Table 2403.03-1: Mixing Water and Free Moisture

Class of Concrete	Pounds (kg) of Water per Pound (kg) of Cementitious Material
C Separated Aggregate	0.488
X Separated Aggregate	0.444
C with Class V Aggregate	0.444
X with Class V Aggregate	0.422
D57	0.437

3. Entrained Air Content.
Use an approved air entraining agent complying with Section 4103 to accomplish air entrainment. Air content will be tested according to Materials I.M. 318. The intended air entrainment is 6%. To allow for loss during placement, use a target value of 6.5%, with a maximum variation of -1.0% and +1.5%, for the air content of fresh, unvibrated structural concrete.

4. Other Admixtures.

a. Other approved admixtures may be used with the Engineer's approval.

b. Approved retarding admixture complying with Section 4103 may be required by the contract documents or by the Engineer. Add the retarding admixture in amounts recommended by the manufacturer for conditions which prevail on the project and as approved by the Engineer. When used, introduce it into the mixer after all other ingredients are in the mixer. The Engineer may approve other procedures.

c. Ensure retarding admixtures are compatible with the air entraining agent used. Previous experience, satisfactory to the Engineer, will be required to indicate the approximate adjustments necessary by the addition of the admixture and compatibility with other materials to be used. Agitate the retarding admixture prior to and during its use.

d. Calcium chloride will not be allowed where reinforcing steel is used.

5. Use of Fly Ash and GGBFS.
The Contractor may use fly ash or GGBFS as a substitute for a portion of the Portland cement in structural concrete. Use fly ash and GGBFS meeting the requirements of Section 4108. The maximum allowable substitution rates are 20% for fly ash and 35% for GGBFS with a maximum total mineral admixture substitution rate of 50%.

C. Proportions for Lightweight Structural Concrete.
When lightweight concrete is specified, the aggregate quality, proportions, mixture characteristics, and controls will be included in the contract documents.

D. Proportioning and Mixing of Concrete.
Apply the respective paragraphs of Article 2301.02, C, to storage and handling of cement, fly ash, aggregates, measurement of materials, and ready mixed concrete, except for the truck dumping area required in Article 2301.02, C, 1, c.

1. Mixing of Materials.
Thoroughly mix materials in an approved mixer at the site of placement or by an approved ready mix plant. The Engineer may withhold approval for using ready mixed concrete from any plant with a previous record of unsatisfactory performance.

2. Concrete Mixed on the Site.
a. When using approved mixers at the site of placement, mix materials according to the specific requirements for the equipment used. Use a mixing capacity so that finishing operations can proceed at a steady pace with final finishing completed before concrete starts its initial set.
b. Ensure concrete discharged from the mixer is uniform in composition and consistency. Thoroughly discharge each batch of concrete from the mixer before the next batch is introduced. Thoroughly clean and flush the mixer upon cessation of mixing for any considerable length of time.

3. Heating Aggregates.
When aggregates are heated, heat and handle them to avoid damage by overheating and to ensure uniform moisture content of aggregate entering the mixer. Aggregates may be heated by steam pipes or coils through aggregate piles. Do not heat aggregates by direct, dry heat unless they are mechanically agitated during the heating process.

2403.03 CONSTRUCTION.

A. Equipment General.
Use equipment meeting the requirements of Section 2001 and the following:

1. Weighing and Proportioning Equipment.
Apply Article 2001.20.

2. Mixing Equipment.
Apply Article 2001.21.

3. Bins.
Apply Article 2001.06.

B. Placing and Finishing Equipment.
Use equipment complying with the following requirements:

1. Above Water or Dry Placement Equipment.

a. Tremies.

When required, use a tremie to deposit concrete in the dry. Use a tremie that:

- Is no more than 12 inches (300 mm) in diameter,
- Has no aluminum parts in contact with the concrete, and
- Is of sufficient length to extend to the bottom of the placement area.

b. Chutes.

Use chutes for depositing concrete that are constructed of metal or have a metal lining, and:

- Have no aluminum in contact with the concrete,
- Are of sufficient length for the delivery point to be as close as possible to the point of deposit, and
- Provide a slope to allow the concrete to flow slowly without segregation.

2. Underwater Placement Equipment.

a. Place concrete under water using a tremie, pump, or other equipment which meets the Engineer's approval.

b. Use a tremie that:

1. Is constructed to be water tight and readily discharge concrete.

2. Is no more than 12 inches (300 mm) in diameter.

3. Has no aluminum parts in contact with concrete.

4. Has the discharge end constructed to prevent water intrusion and permit free flow of concrete during placement operations.

5. Is of sufficient weight (mass) and length to rest on the bottom of the placement area prior to start of concrete placement.

c. Support the tremie so that it can be raised or lowered to increase or reduce the discharge of concrete.

3. Consolidation.

a. Use vibrating units to vibrate all concrete for box and arch culverts, bridge substructures, bridge decks, and bridge deck overlays. Operate all vibrators at speeds no less than 3500 vibrations per minute.

b. Furnish adequate vibration equipment to avoid delays due to breakdown.

c. Use a sufficient number of vibrating units to properly consolidate the concrete placed.

d. Use vibrator heads covered with rubber or other resilient material approved for consolidation when consolidating concrete reinforced with epoxy coated bars.

4. Heating and Protection Equipment.

Meet the following requirements whenever heating is done:

a. Equip the attendant with no less than one non-freezing fire extinguisher of adequate capacity.

b. To prevent movement or overturning, adequately support, anchor, and guy any heating equipment involving combustion in or near the space to be heated.
c. Use of a salamander or other type of open flame heating unit is prohibited.
d. Use heating equipment constructed with a shield so that metal in direct contact with the open flame is not exposed.

5. Forms.
a. Use forms that are:
- Metal, surfaced lumber, plywood, masonite, hard pressed composition board, or other approved material backed by suitable studding, walers, and so on, and
- Are free from knotholes, cracks, splits, warps, or other defects which would prevent it from producing the strength, accuracy, and appearance necessary in the finished concrete surface.

b. Construct forms with mortar tight joints. Use material sufficient in strength to hold concrete without bulging between supports.
c. Design forms for strength as specified in Article 2403.03, O. Use metal, plywood, fiberglass, or hard pressed water resistant composition board no less than 3/16 inch (5 mm) thick to line wood forms for all exposed surfaces, except:
- wingwalls parallel to the culvert barrel,
- headwalls, and
- such portions as may be completely covered by a single board.

d. Use forms in good condition. Make joints in the lining mortar tight. Smoothly cut and break joints with the form lumber. Small irregular areas may be formed with lumber against concrete to be rubbed, provided there is no joint in lumber used on any flat surface of concrete except at angles, ribs, bevels, molding, and so on where there is a juncture between two surfaces. Place blocks, ribs, bevels, moldings, and so on for ornamental effect on lined surfaces inside the lining.
e. Design and construct forms so that they may be removed without damage to the concrete. Remove blocks and bracing with the forms. In no case leave any portion of wood forms in the concrete.
f. Construct forms so that the finished concrete is of the form and dimensions shown in the contract documents, and true to line and grade. Fillet forms 3/4 inch (20 mm) at all sharp corners (90 degrees or sharper). Give a draft in the case of all projections, such as girders, copings, and so on, sufficient to insure their easy removal. Ties and bracing shall be sufficient to support the expected load.
g. When forms appear to be insufficiently braced or unsatisfactorily constructed either prior to or during placement of concrete, the Engineer will order the work stopped until defects have been corrected.
h. Coat forms with an approved form release agent prior to the placement of concrete. Thoroughly wet forms with water immediately prior to concrete placement. Thoroughly clean reused forms and ensure they are free of bulges, splits, warps, or bends.

i. Use stay-in-place forms only when specified in the contract documents.

C. Placing Concrete.

1. Place concrete mixed at the site of the work immediately after mixing. Place ready mixed concrete as soon as practical after delivery, but in all cases within the specified time limit for the equipment used for delivery.

2. Place concrete in a manner which will avoid segregation or separation of the ingredients. In placing concrete, observe all the following precautions:

a. In handling concrete from the mixer to the place of deposit, take care to avoid segregation.

b. When concrete is deposited through a chute, slope the chute to allow concrete to flow slowly without segregation. Place the delivery point of the chute as close as possible to the point of deposit. Keep chutes and spouts clean. Thoroughly flush them with water before and after each run. Discharge the water outside the forms. Do not pump concrete through aluminum conduit or tubing.

c. A tremie is not required when filling steel pipe piles or encasing steel H-piles. Use a tremie whenever the distance through which other concrete must be dropped vertically exceeds 6 feet (2 m). Do not exceed a drop of 3 foot (1 m) for bridge floors and culvert slabs. A tremie is not required for concrete placement of elements which have a maximum dimension no greater than 12 inches (300 mm) provided that Paragraph d below is adhered to and concrete is placed in lifts.

d. Do not deposit concrete in large quantities at a single point, causing it to flow along inside the forms.

e. In depositing concrete, take care to fill the form entirely without bulging the form or disturbing its alignment.

f. Manipulate and vibrate concrete in a manner to bring a thick layer of mortar into contact with forms and reinforcement and to prevent formation of pockets of coarse aggregate.

g. Do not place concrete in flowing water within the area of a footing. Control such flowing water in pipes or trenches outside the forms. In extreme cases, a seal course may be ordered to overcome this difficulty.

h. Protect concrete placed when the air temperature is at or below 40°F (4°C) as provided in Article 2403.03, I.

3. Maintain an adequate supply of water suitable for washing testing equipment at a convenient location, as directed by the Engineer, near the site of concrete placing operations.

4. When concrete is being placed during cold weather, provide an approved, conveniently located shelter (enclosed on at least three sides and covered), suitable for use in performing on the site tests of the concrete being placed. Place the shelter to provide maximum protection from the weather.

D. Vibration of Concrete.

1. Manipulate vibrators through all available space in the mass of concrete, with particular attention to corners and faces of concrete against forms and joints. Use caution to prevent the vibrator from penetrating any portion of previously set concrete.

2. Vibrate each batch of concrete as it is placed in the form to settle and thoroughly consolidate the concrete into close contact with the forms, reinforcement, and previously placed concrete. Discontinue vibration before segregation or localized areas of grout form. Ensure placement and consolidating operations result in concrete that, upon removal of forms, is smooth and dense and free from all honeycomb or pockets of segregated aggregate.

3. Design forms to withstand effects of vibration without appreciable distortion from the desired shape or position.

E. Protection and Curing of Concrete.

1. Protect concrete which has been placed from external stress between the time it ceases to be plastic and the time it may be stressed, as provided in Article 2403.03, Q.

2. Ensure runways for transporting materials over concrete floors less than 7 calendar days old are supported directly over structural members, piers, or abutments so the floor concrete is subjected to compressive stress only.

3. Ensure runways built over portions of formed, but unpoured floors are supported on floor forms or beams.

4. Unless concrete is protected as specified in Article 2403.03, I, protect exposed surfaces, including surfaces from which forms have been removed less than 60 hours after the concrete has been placed, in the following manner for at least 4 calendar days after concrete is placed:

- **a.** Coat the surface immediately after required finishing operations are completed with white pigmented curing compound, meeting requirements of Article 4105.05, applied at a rate of no more than 135 square feet per gallon (3.3 m^2/L).
- **b.** As alternatives, the surfaces may be covered with paper or plastic film, meeting requirements of Section 4106, or the surface may be covered with burlap, straw, or sand kept continuously wet.

5. Do not use white pigmented curing compound on surfaces against which concrete is to be placed or which will receive a sealer. When the Contractor elects to use white pigmented curing compound on any part of an integral unit, the Engineer may require use of the curing compound on adjacent areas of the integral unit so that each pier, abutment, or other surface visible after construction presents a uniform and pleasing appearance.

6. Cure concrete floors as provided in Article 2412.03, E.

7. Cure barrier railing as provided in Article 2414.03, A.

F. Placing and Protection in Cold Weather.

1. Do not place concrete, without notifying the Engineer, when the air temperature is 40°F (4°C) or less.

2. Do not use frozen materials in the concrete.

3. Do not place concrete against frozen forms, earth, or rock or against other concrete having a temperature below 40°F (4°C).

4. In addition to protecting the concrete against chilling or freezing, heat the water or aggregates, or both, so that when placed the concrete will have a temperature appropriate for the mass and dimensions of the portion of the structure being placed, but from 45°F (7°C) or to 80°F (27°C).

5. Before concrete is placed at ambient air temperatures below 40°F (4°C) or when these temperatures might occur during the protection period, provide heating or protecting facilities, or both, meeting requirements of Article 2403.03, B, 4, adequate to protect the work as follows:

- **a.** Maintain the concrete temperature at no less than 50°F (10°C) for the first 48 hours after placing. Then gradually reduce the concrete temperature at a rate not exceeding 25°F (15°C) in 24 hours. When heating and housing is used, locate temperature monitors in the concrete at the furthest and closest point from the heat source. Do not allow the maximum temperature of the monitor point closest to the heat source to exceed 150°F (65°C).
- **b**. In lieu of protection involving housing and heating, the Contractor may protect concrete by the use of forms insulated with a commercial insulating material adequate to maintain the concrete temperature at no less than 50°F (10°C) for the first 48 hours after placing. Leave these insulated forms undisturbed for the next 48 hours, after which they may be removed. When forms are insulated, protect exposed horizontal surfaces with a similar layer of the insulating material or an adequate layer of hay or straw, properly secured.
- **c.** Make suitable provision, including cast-in-wells for thermometers, to provide a means for determining the temperature of the concrete.
- **d.** Whenever heating is done, firmly secure combustible material to prevent contact with any source of heat, and take adequate precautions to prevent fires.
- **e.** If all the concrete is at least 1 foot (0.3 m) below ground water level, it may be placed at a temperature no less than 40°F (4°C) and flooded to a minimum depth of 1 foot (0.3 m) in lieu of other methods of protection and curing. Ensure that concrete cured in this manner is not subjected to freezing temperatures within 10 calendar days after it is placed. In lieu of flooding, culvert footings

may be protected from freezing by an adequate layer of straw or hay for at least 5 calendar days.

G. Placing Large Volumes of Concrete.
Whenever the volume is too great to be placed in one continuous operation, subdivide the work as shown in the contract documents or as directed by the Engineer.

H. Bonding Construction Joints.

1. When concrete placement in any section of a structure must be interrupted, locate the construction joint as specified in Article 2403.03, R. Leave the surface of the concrete in horizontal joints rough (except in the area near the form) to increase the bond with concrete that is to be placed later. Finish the top surface of the concrete adjacent to the forms to a horizontal 3/4 inch (20 mm) bevel strip.

2. Embed keyways no less than 1 1/2 inches by 3 inches (35 mm by 75 mm) into the surface of the concrete. Form tapered sections, which would otherwise result in a feather edge, by an insert so that the succeeding layer of concrete will end in a section no less than 6 inches (150 mm) thick. In addition to the key notches in concrete that is not reinforced, set steel dowels no smaller than 3/4 inch (20 mm) around the edge of the section at intervals no greater than 2 feet (0.6 m). Set the dowels to project at least 1 foot (0.3 m) on each side of the joint.

I. Bonding New and Old Work.

1. When new concrete is placed in contact with existing concrete, first thoroughly clean the existing concrete surface of laitance, loose particles of concrete, dirt, or other foreign materials by sandblasting followed by an air blast. Next, place forms against the existing concrete, using care to avoid contamination of the cleaned surface. Finally, place fresh concrete against the clean, dry surface and thoroughly consolidate it to ensure a tight joint and a good bond.

2. Bonding agent may be required as specified in the contract documents.

J. Displacing Water with Concrete.
Do not place concrete into or under flowing water. Concrete may be placed in still water only under the following conditions and under the Engineer's supervision.

1. The Contractor may place the concrete starting at a point most removed from the sumps and progressing toward the sumps, shoving and displacing water as the placement progresses if:
- Water courses and sumps are provided outside the area over which concrete is placed, and
- It is demonstrated that the water elevation can be controlled to an elevation at or near the elevation of the bottom of the concrete to be placed to the extent that no appreciable or objectionable flow crosses said area.

2. Maintain the water elevation within the forms at the start of placing at substantially the same elevation through the pour by bailing or pumping. Direct pumping from inside the forms will not be permitted in excess of the pumping necessary to remove the quantity of water displaced by concrete.

3. The Contractor may slowly displace entrapped water with concrete during placement if:
- There are required excavations or trenches within the area, the bottoms of which are below the general elevation of the area, and
- It is impossible or impractical to provide gravity drainage to the sumps.

4. The Contractor may be required to bail or otherwise dewater the trench immediately prior to or during the placement. A prerequisite to placing concrete in excavations or trenches is that the depth of water shall not appreciably exceed 30% of the depth of concrete being placed.

5. Place seal courses in the following manner if other methods for placement are not provided in the contract documents:
- **a.** When possible, place seal courses in one continuous operation. Place concrete to approximately the required depth. Progress from one end over the entire area in such a manner that the volume of concrete will be gradually expanded without dropping the concrete through water. Minimize agitation. Ensure the surface of the seal course is approximately level. Place sumps or depressions for pumping out the water outside the area of the footing.
- **b.** Place concrete using equipment described in Article 2403.03, B, 2. In operating a tremie, keep the tremie filled at all times. Raise the discharge end only an amount sufficient to permit the concrete to be discharged.
- **c.** When pile encasements are placed by use of a tremie and the bottom of the encasement is below the controlled water level, provide drain holes no less than 1 inch (25 mm) in diameter in the encasement form at intervals of 1 foot, 2 feet, and 3 feet (0.3 m, 0.6 m, and 0.9 m) above the controlled water elevation. Place the concrete in this area at a rate so no free water is entrapped inside the form above the top drain hole.

K. Laitance.

Remove laitance from the surface of seal courses before the footing is placed. Use care in placing other concrete to prevent formation of laitance on the surface of the concrete. Entirely remove laitance by means of shovels, stiff wire brooms, or by other suitable methods before the succeeding layer of concrete is placed.

L. Design and Construction of Forms and Falsework.

1. General.
- **a.** Have a Professional Engineer licensed in the State of Iowa design and certify falsework plans.

b. Materials for forms and falsework may be either new or used. It is the Contractor's responsibility to ensure that materials are suitable for the use intended. Material which the Engineer determines to be damaged, defective, or otherwise unsuitable will be rejected.

2. Construction of Forms.

a. Use materials, and construct forms that will be in direct contact with concrete, as specified in Article 2403.03, B.

b. For wall or column forms, use studs, wales, and ties designed to withstand the maximum fluid pressure discussed below.

c. Use prefabricated form systems certified for the expected pressures.

d. Guy, shore, and/or brace forms for walls and columns to withstand wind loads and to prevent alignment shift resulting from construction live load.

3. Construction of Falsework.

a. Build falsework used to support construction of reinforced concrete superstructures, reinforced beams, and substructure cantilevers, on sufficiently strong foundations to carry the loads safely and without significant deflection. Drive ample falsework piling to support falsework which cannot be founded on rock, shale, thick deposits of compact gravels, coarse sand, or the firm clays in natural beds. On the soils materials listed above, mudsills or other spread footings may be used. Determine their sizes considering the applied loads and the bearing value of the soil.

b. Determine bearing values of all piles used to support falsework as provided in Section 2501. Bearing values are to be at least equal to the applied loads.

c. Transversely sway brace pile bents exceeding 10 feet (3 m) in height to resist lateral loads. Longitudinally brace pile bents exceeding 10 feet (3 m) in height to resist construction live loads, unless the bents are secured to longitudinal members which are secured against longitudinal movement. Bracing and connections are to be shown on falsework plans. The Engineer will review adequacy of bracing and connections.

d. Secure pile caps to each pile. Ensure blocks, wedges, and jacks for height adjustment are secure and stable. The Engineer will review them before concrete placement. Hold transverse joists against individual collapse. Use a positive spreader system over each support of a longitudinal stringer.

e. Secure continuous members against uplift from unbalanced concrete placement. Place concrete in a manner which will minimize unequal loads on hanger legs.

4. Design Loads.

Design formwork and falsework for the following loads:

a. Vertical load of concrete with a density of 150 pounds per cubic foot (2400 kg/m^3).

b. Horizontal load of fresh concrete as a liquid with a density of 150 pounds per cubic foot (2400 kg/m^3) for the depth of plastic concrete.

c. Vertical load of forms and falsework.
d. Construction live load equal to 50 pounds per square foot (2.4 kPa) of horizontal projection.
e. Wind loads on walls and columns according to the requirements of the ACI.

5. Design Stresses.

a. Design formwork and falsework using working stresses and a normal duration of load, as for a permanent structure. Calculate lumber strength on the basis of dressed size and, except for sheathing, a dry condition. Publications of the ACI and the National Forest Products Association will be considered standard references for design and analysis of timber falsework.
b. Do not exceed 50 times the dimension of the least side for the unsupported length of wooden columns and compression members. Analyze the member as a column.
c. Unless the Contractor certifies a higher stress grade or value, adequacy of falsework material will be checked on the basis of the following values:
1) Structural steel stresses per AASHTO for 30,000 psi (207 MPa) yield strength and 22,500 psi (155 MPa) maximum working stress.
2) Plywood sheathing stresses per American Plywood Association for concrete form grade, Class I, wet use, permanent loading, span-perpendicular-to-face grain. Orientation of plywood panels must be shown on drawings if advantage is taken of greater strength with span-parallel-to-face grain.
3) Stresses for lumber 4 inches (100 mm) or less in thickness, in psi (MPa) as follows:

f_b, bending	= 1000 (6.90)
f_t, tension	= 625 (4.30)
f_v, shear	= 120 (0.83)
f_c, perpendicular to grain	= 345 (2.40)
f_c, parallel to grain	= 1050 (7.20)
E, modulus	= 1,500,000 (10,300)

4) Stresses for lumber 5 inches (125 mm) thick and thicker in psi (MPs) as follows:

f_b, bending	= 1200 (8.30)
f_t, tension	= 1000 (6.90)
f_v, shear	= 120 (0.83)
f_c, perpendicular to grain	= 390 (2.70)
f_c, parallel to grain	= 1000 (6.90)
E, modulus	= 1,600,000 (11,000)

5) Safe bearing value of coarse sand, gravel, very firm clay, and other similar confined soils in thick beds at 1500 pounds per square foot (72 kPa) unless recommended otherwise by a Professional Engineer licensed in the State of Iowa. Safe bearing value of compacted berms at 2000 pounds per square foot (96 kPa).

6. Deflection.

a. Ensure falsework for slab and girder bridges provides for slight settlements, deformations of members, crushing, and closing of joints. Sag in excess of 1 inch (25 mm) or 1/800 of the span length, whichever is greater, in the soffit of a girder or slab may be cause for rejection.

b. Limit deflection of sheathing and joists to 1/360 of the span length. Calculate deflection of falsework stringers. Adjust screed guides to compensate.

7. Falsework Plans.

a. Submit plans for falsework and centering on all concrete slab and cast-in-place concrete girder bridges according to Article 1105.03. Submittal of forming details for bridge decks on concrete beam and steel beam bridges is not required unless specified in the contract documents.

b. The Engineer may require calculations or evidence of adequacy. The Engineer may require revised plans later because of unforeseen site conditions, unusual construction procedures, or deviation from original falsework plans.

M. Removal of Forms and Falsework.

Remove forms and falsework, unless otherwise indicated in the contract documents. Normally, they may normally be removed according to the following provisions. However, in cool or unfavorable weather, the Engineer may require forms to remain in place for longer periods.

1. Forms Which May be Removed in Less than 5 Calendar Days.

a. Forms for ornamental work, railings, parapets, curbs, and any other vertical surfaces may be removed whenever the concrete will not be damaged by doing so, but no less than 12 hours after the concrete is placed.

b. Do not remove forms for concrete open railing less than 24 hours after concrete placement.

c. Forms for roofs of culverts may be removed when the concrete has attained an age of 3 calendar days and a flexural strength of:

- 350 psi (2.4 MPa) for spans of 4 feet (1.2 m) or less,
- 400 psi (2.8 MPa) for spans 4 to 6 feet (1.2 m to 1.8 m), and
- 450 psi (3.1 MPa) for spans exceeding 6 feet (1.8 m).

d. When Maturity Method (according to Materials I.M. 383) for strength determination is used, the above stated flexural strengths will be required. The days of age will depend on the Maturity Curve for the concrete mix used.

2. Forms Which Shall Remain in Place 5 Calendar Days or Longer.

a. Except when form removal is permitted in less than 5 calendar days, forms may be removed as soon after 5 calendar days as the concrete has attained the strength required in Article 2403.03, Q, 2. When Maturity Method (according to Materials I.M. 383) for strength determination is used, the flexural strength of 550 psi (3.8 MPa) will be required. The days of age will depend on the Maturity Curve for the concrete mix used.

b. When strength is not determined, forms for box culverts 4 feet (1.2 m) or less in width may be removed after the concrete has attained an age of 7 calendar days. Forms for other concrete may be removed after the concrete has attained an age of 14 calendar days.

c. Remove forms and supporting falsework for continuous concrete slabs, concrete girders, and rigid frame structures in the following manner:

Ensure there is at least one span for which the concrete has attained the age (or age and strength) specified above between the span from which forms are about to be removed and any span for which the concrete has not attained the age (or age and strength) specified above.

3. Falsework and Falsework Piling.

Remove falsework and falsework piling in the berm slope fill, extended to the streambed, to at least 1 foot (0.3 m) below the finished berm line or berm line extended. For falsework and falsework piling in the channel area:

a. For structures spanning natural streams or overflow channels of natural streams, removal to at least 1 foot (0.3 m) below streambed elevation will be required.

b. For structures spanning drainage channels constructed under the drainage laws of Iowa, removal to at least 4 feet (1.2 m) below streambed elevation will be required unless complete removal is specified.

N. Subjecting Concrete to Exterior Loads.

Concrete may not be subjected to loads other than the load caused by the weight (mass) of the concrete itself except as follows:

1. Loads Producing Simple Compressive Stress Only.

Concrete may be subjected to simple compressive stress as soon as it sets sufficiently to prevent the surface being marred or the edges being chipped from the effect of such loads.

2. Loads Producing Flexural Stresses.

a. Unless otherwise indicated in the contract documents, concrete may be subjected to loads due to placing backfill material or to legal traffic when the concrete has reached the minimum age stipulated in Table 2403.03-2 and developed a flexural strength of at least 550 psi (3.8 MPa).

Table 2403.03-2: Minimum Age for Concrete

Portland cement (Type I and Type II with or without Class C fly ash)	7 calendar days
With Class F fly ash substitution	8 calendar days
Class M mix (with or without Class C or Class F fly ash)	3 calendar days

If strength is not determined (regardless of type of cement or class of fly ash)	14 calendar days

b. Determine flexural strength by testing (according to Materials I.M. 316) specimens of concrete used in the part of the structure in question, cured under conditions similar to those of the concrete in the structure.

c. Footings for piers supported by piling may be subjected to loads of subsequent pier stem concrete placement no less than 18 hours after footing placement is complete, with no minimum strength requirements.

d. Unless otherwise specified in the contract documents, the Contractor may request, the time for subjecting to loads to be determined through the use of the Maturity Method as described in Materials I.M. 383. When the Maturity Method is used, the time for loading will be based on strength requirements only, as specified above. Furnish labor, equipment, and materials necessary for the development of the maturity-strength relationship as described in Materials I.M. 383.

e. Determining sufficient strength has been achieved for loading a part of a structure remains the Engineer's responsibility when the Maturity Method is used. The Contractor's maturity testing may be used as the basis for this determination. Provide sufficient documentation of maturity testing before loading a part of a structure or opening to traffic.

f. Apply the following when the Maturity Method is used:

1) Should circumstances arise beyond the Contractor's or Engineer's control and strength cannot be determined by the Maturity Method, the minimum age, minimum flexural strength, and fly ash restrictions apply. Cure flexural strength specimens under conditions similar to those of the concrete in the structure.

2) Any changes of a material source or proportion in the concrete mixture require a new maturity curve.

g. Perform maturity testing using a Level 1 PCC Certified Technician with training for maturity testing. This technician may supervise other persons who may then perform the temperature testing.

O. Joints.

Unless otherwise provided in the contract documents, construct joints in the following manner:

1. Construction Joints.

a. Place construction joints between successive layers of concrete as provided in Article 2403.03, K.

b. The location of required or optional construction joints in the structure will be shown in the contract documents. If the volume of concrete is too great to be placed without use of additional construction joints, locate and construct these joints in a manner not impairing the strength and appearance of the structure.

c. Locate construction joints in planes perpendicular to principal lines of stress and at points the Engineer designates.

2. Expansion Joints.
Construct expansion joints as shown in the contract documents.

P. Surface Finish.
Finish and seal concrete surfaces exposed, or will likely be exposed, after the structure is completed as follows:

1. Finish concrete floors and concrete sidewalks as provided in Sections 2412, 2413, and 2511, respectively.

2. Provide a Class 1, finish to horizontal surfaces not cast against a form and not subject to wear (for example, bridge seats, tops of backwalls, piers, abutments, wingwalls, retaining walls, spandrel walls, struts between pedestal piers, and horizontal surfaces of curbs and sidewalks of the bridge). For all other surfaces required to be finished, provide a Class 2, finish to low water line or 1 foot (0.3 m) below the finished ground line. Provide a Class 3, finish to those areas designated in the contract documents.

a. Class 1, Floated Surface Finish.
Overfill forms with concrete. Strike off concrete to the required elevation with a template and thoroughly work the surface with a wood float until the surface is uniformly smooth, dense, and true.

b. Class 2, Strip Down Surface Finish.
Immediately after removal of the forms, complete the following:

1) Remove rods and other devices used as form ties to the extent contemplated in their design.

2) Remove paper or fiber tubes used to facilitate removal of rod ties.

3) Except as designated below, cut off wires used as form ties flush with the surface of the concrete and drive them 1/4 inch (5 mm) below the surface.

4) Remove all fins and irregular projections from the concrete surfaces required to be finished.

5) On surfaces, thoroughly clean the cavities produced by form ties and all other holes, honeycomb spots, and broken corners and edges. After being saturated with water, carefully fill, point, and true with a mortar of cement and fine aggregate of the same kind as that which was used in the concrete being finished. Shallow voids, other than honeycomb, which appear on the formed surface after proper consolidation will not be considered as holes and need not be filled unless they appear in an abnormal concentration.

6) Clean the entire surface required to be finished of stains from form oil or other substances.

7) Ensure the resulting surfaces are true and uniform.

8) Clip off flush with the surface wire ties or reinforcing steel chairs protruding through culvert barrels or the bottom of bridge floors.

9) Leave construction and expansion joints in the completed work carefully tooled and free from mortar and concrete.

10) Leave expansion joint filler exposed for its full length and thickness and with clean true edges.

c. Class 3, Special Surface Finish.

This operation shall obtain a surface reasonably smooth and uniform in texture and appearance.

1) Apply a bonding agent mixed with standard or commercially packaged mortar. More than one application may be necessary. Products approved for this use are identified in Materials I.M. 491.10. Use the same materials and methods for all surfaces to be given a Class 3 finish.

2) The Class 3 finish requirements do not relieve the Contractor of the responsibility for performing the Class 2 finish as specified prior to commencing Class 3 finish operations.

3) Do not commence application of the Class 3 finish until:

- All other work which may mar the surface finish has been completed, or
- Finishing operations can be carried on continuously from beginning to completion on any one bridge or structure.

3. Concrete Sealer.

a. Use sealer material meeting the requirements of Article 4139.01, B, when designated in the contract documents.

b. The contract documents may designate a sealer for the bridge seat surface or tops of piers or both. This surface includes bridge seat steps and edge fillets. The contract documents or the Engineer may also designate other concrete surfaces to be sealed.

c. All surfaces to be sealed shall be sound, clean, and dry. For existing surfaces, the Engineer may require removal of unsound material by hand methods or sandblasting, or both. As a minimum, all designated surfaces, both existing and new, shall receive a light sandblast (brush blast), followed by air cleaning. Clean sufficiently to remove road film and contamination from existing concrete and form oil from new concrete.

d. Perform application procedures according to the manufacturer's recommendations. Unless otherwise required in the contract documents, apply sealer material at the coverage rates in Materials I.M. 491.12.

2403.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Structural Concrete:

1. Quantity shown in the contract documents.

2. The Engineer will compute in cubic yards (cubic meters) the total volume of the respective classes of structural concrete placed using dimensions shown in the contract documents, along with the changes

that have been made according to a written order from the Engineer. From this volume, 0.8 cubic foot (0.075 m^3) will be deducted for each linear foot (meter) of concrete, steel shell, or wood piling projecting into the footings or caps. Deductions from the volume of concrete will not be made for the volume of concrete displaced by the steel reinforcement, floor drains, expansion joints, shear lugs, beam flanges, H-piles, or metal strips for sealing joints.

3. Additional concrete required to bring floors, curbs, and handrails to the required elevation will not be measured for payment if such addition is made necessary by inaccuracies in the shape or placement of steel or concrete beams or by distortion of falsework.

B. Reinforcing Steel and Structural Steel: according to Sections 2404 and 2408, respectively.

C. The surface area on which concrete sealer is applied to structural concrete: not measured separately for payment.

D. Subdrains, porous backfill material, and granular backfill material required and furnished for structural concrete placement at bridge abutments: not measured separately for payment.

2403.05 BASIS OF PAYMENT.
Payment will be as follows:

A. Net volume of Structural Concrete as specified above:

1. Contract unit price per cubic yard (cubic meter).

2. For concrete placed within the contract period between November 15 and April 1, additional payment will be made for heating or protecting or both; however, no payment will be made when winter work is specified in the contract documents.

3. Payment for heating will be made when materials which are proportioned and mixed at the site are heated to meet requirements of Article 2403.03, I, or when heating is charged by the supplier of ready mixed concrete. For concrete proportioned and mixed at the site, the additional payment for heating will be $5.00 per cubic yard ($6.60 per cubic meter). For ready mixed concrete, the additional payment for heating will be the customary amount charged for heating, and separately identified on the invoice, with a maximum of $5.00 per cubic yard ($6.60 per cubic meter). Heating, protection, or both, required outside the above dates, will be paid for when approved by the Engineer.

4. Payment for protection will be made when heated housing or insulated forms are used to meet requirements of Article 2403.03, I. The additional payment for protection will be $7.00 per cubic yard ($9.25 per cubic meter). If a footing is protected by flooding with water, no payment will be made. If footings are protected with coverings of burlap, hay,

straw, plastic, insulation, and/or other materials sufficient to meet the temperatures and time specified in Article 2403.03, I, payment for protection will be made.

B. Reinforcing Steel and Structural Steel: according to Sections 2404 and 2408, respectively.

C. Concrete sealer application to structural concrete: included in the contract unit price for structural concrete.

D. Subdrains, porous backfill material, and granular backfill material required and furnished for structural concrete placement at bridge abutments: included in the contract unit price for the structural concrete.

E. When an admixture is required to be added by the contract documents or the Engineer for the purpose of retarding the set, the cost of the retarding admixture is incidental to the contract unit price per cubic yard (cubic meter) of structural concrete

F. Payment is full compensation for:

- Furnishing all materials, including materials for filling and sealing joints, but not including structural steel or steel reinforcement.
- Furnishing, constructing, and removing all forms, ties, and falsework.
- Incidental work necessary for completion of the work in conformance with the contract documents.

Section 2404. Reinforcement

2404.01 DESCRIPTION.

Furnish and place all reinforcing bars and fabrics used in concrete according to the contract documents.

2404.02 MATERIALS.

Use reinforcement meeting the requirements of Section 4151.

2404.03 CONSTRUCTION.

A. Cleaning.

1. Ensure that reinforcement is free from dirt, detrimental scale, rust, paint, oil, or other foreign substances.

2. For uncoated bars, thin powdery rust and tight rust is not considered detrimental and need not be removed.

3. Appreciable reduction in section caused by corrosion is sufficient cause for rejection of reinforcement.

B. Fabrication.

1. Exercise care so reinforcement is not damaged during bending. Employ proper appliances and competent workers for the work.

2. Ensure reinforcement is cold bent, except in shops where accurate control of temperature is provided.

3. Ensure Grade 60 (Grade 400) or higher deformed bars, and bars of No. 8 (No. 25) size and larger, are shop bent.

4. Ensure reinforcement is accurately bent to the dimensions and shapes shown in the contract documents. Do not field bend bars partially embedded in concrete except as shown in the contract documents.

5. When galvanized reinforcement is required, ensure cutting and bending are completed before galvanizing.

6. When epoxy coated reinforcement is required, ensure fabrication is completed according to Article 4151.03, C.

7. Ensure fabrication of reinforcement, including bending details, is completed according to ACI Code 318.

8. Ensure bar reinforcement is shipped in standard bundles, tagged, and marked according to the CRSI Manual of Standard Practice.

C. Straightening.
Straighten reinforcement that may have become bent during shipment or handling before placing in the work. Straighten without heating in a manner that minimizes damage to any coating.

D. Placing and Fastening.

1. Place reinforcement in the position indicated in the contract documents. Ensure reinforcement is held securely in place during placing and hardening of the concrete.

2. Tie reinforcement bars at all intersections except where spacing is less than 1 foot (300 mm) in each direction, in which case tie alternate intersections.

3. The Engineer will inspect and approve the locations, fastening, and condition of reinforcement before concrete is placed around it.

4. Welding of reinforcing steel will not be permitted unless specified in the contract documents or approved by the Engineer.

5. In floors of culverts and in other footings without piling, suspend reinforcement from cross wales above the tops of the forms or support on steel stakes driven into the subgrade or on chairs.

6. Install dowels, deformed bars, inserts, or other articles into existing pavements and structures as shown in the contract documents. When installed with epoxy material, complete the procedure according to Article 2301.03, E. Cut reinforcing steel, in the field, using mechanical methods. Do not flame cut.

E. Reinforcing Supports and Spacers.

1. Support horizontal reinforcement using support devices, or tie to vertical reinforcing steel.

2. Position vertical reinforcement using side-form spacers. Use support devices and side-form spacers, either plastic or steel, meeting the requirements of Materials I.M. 451.01.

3. Hold epoxy coated reinforcing steel in place with epoxy or plastic coated bar supports, and epoxy or plastic coated tie wires.

4. Do not use concrete block inserts, bricks, stones, wood blocks, wood stakes, and similar materials to support reinforcement if by their use they may become embedded in the concrete.

5. Space support devices according to the manufacturer's recommendations or as recommended by the current CRSI Manual of Standard Practice. Use a support system with spacing not to exceed 4 feet (1.2 m) in each direction for bolsters or continuous high chairs and 3 feet (0.9 m) in each direction for individual bar chairs.

6. Rest the base of chairs and support bolsters on the supporting false work. Use supporting chairs that have either upturned legs or a horizontal bar spot welded at the base of the leg.

7. Cross-tie legs at their bases or nail them to the forms if necessary to prevent spreading of upturned legs.

8. For situations where two or more separate mats of reinforcing steel are required, support each mat independently using an approved support system.

9. Place side-form spacers at intervals sufficient to ensure that all reinforcing is at the required clearance.

F. Splicing.

1. Splice reinforcement only at points shown in the contract documents or when approve by the Engineer. When lapped splices are used in reinforcement in which the critical design stress is tensile, do not use splices at points of maximum stress. Place bars in close contact and wire tightly in a manner that the specified clear distance to the surface of the concrete is maintained.

2. Lap reinforcing steel for the minimum length according to that specified in AASHTO Standard Specifications for Highway Bridges.

2404.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the weight (mass) in pounds (kilograms) of reinforcement from the theoretical weight (mass) of the nominal sizes and actual lengths of the various sizes of reinforcement shown in the contract documents.

B. No adjustment will be made for galvanizing or epoxy coating.

C. If a greater or lesser quantity of reinforcement than shown in the contract documents is directed by the Engineer, the quantity will be recomputed from the theoretical weight (mass) of the reinforcement actually used.

D. The weight (mass) of reinforcement, shown in the contract documents, will be presumed to be correct and will provide the quantity used as the basis of payment; however, if the Contractor presents evidence that the weight (mass) computed is in error by more than 1.0%, the Engineer will re-compute the weights (mass).

2404.05 BASIS OF PAYMENT.

A. Payment will be at the contract unit price per pound (kilogram) for the weight (mass) of Reinforcing Steel, Galvanized Reinforcing Steel, and Epoxy Coated Reinforcing Steel computed as specified above.

B. Payment is full compensation for furnishing and placing the reinforcement, ties, and supports as may be required to hold the reinforcement in proper position.

Section 2405. Foundations and Substructures

2405.01 DESCRIPTION.

A. Bases or supports upon which a superstructure rests and they may consist of abutments and piers with or without piling or drilled shafts.

B. Do not apply the requirements of this section to culverts.

2405.02 MATERIALS.
Refer to the materials requirements for Sections 2401, 2402, 2403, 2404, 2408, 2414, and 2501.

2405.03 CONSTRUCTION.
Construct foundations and substructures complying with the contract documents and with requirements of this section and various sections applying to the type of construction designated. Apply the provisions of Sections 2401, 2402, 2403, 2404, 2408, 2414, and 2501 as well as the provisions of this section.

A. Construction of Cofferdams.

1. Construct the cofferdams used for construction of foundations and substructures in a manner capable of resisting earth and water pressure without appreciable displacement.

2. If submittal for review is designated in the contract documents or requested by the Engineer, furnish details to show the cofferdams will meet these requirements. Submit cofferdam plans, including the computations and drawings, according to Article 1105.03. Do not start work prior to receiving the agreed upon plans. This review does not relieve the Contractor of responsibility for satisfactory results and safety of the workers on the project.

3. For cofferdams use steel sheeting of such length that it may be driven to a depth to prevent unstable material from flowing into the excavation. Ensure the sheeting will form a safe and adequate cofferdam. Strongly brace cofferdams, but place the bracing so it will not be encased in the concrete of the structure, except as provided in the following paragraphs and with the Engineer's approval:

- **a.** If the bracing is at elevations that it will not be exposed in the finished structure, cut the bracing off flush with the surface of the concrete. If the bracing is at elevations that it will be exposed in the finished structure, recess it and cut off at least 4 inches (100 mm) inside the face of the concrete.
- **b.** Form pockets around the bracing. Neatly fill these pockets with concrete after the bracing is cut off. Small openings may be left in diaphragm walls and other thin sections to provide for cofferdam bracing, provided these openings are not located to interfere with the structural integrity of the structure and are located in places where they can be filled later in a satisfactory manner.
- **c.** Do not place cofferdam bracing to bear against heavy concrete sections less than 3 calendar days old. In the case of thin sections or unfavorable weather conditions, this time may be increased at the Engineer's discretion.

4. Provide a clear space of at least 18 inches (0.5 m) on all sides between the footing and the cofferdam. Except for seal courses, do not use the cofferdam as a form for the concrete footing. Build an independent form for the footing. Use sheeting for the cofferdam of such a type, and drive the sheeting, to prevent as nearly as possible water entering through the walls of the cofferdam. Provide pumps of sufficient capacity to keep the excavation free from water, according to Article 2403.03, J, until the concrete has reached initial set.

5. After the foundation is in place, place backfill material in all excavated areas in and around cofferdams to the original ground surface or streambed with materials meeting the provisions for the appropriate required regulatory permits. If additional material has been added adjacent to the pier sites, remove this material to the ground line or streambed.

B. Seal Courses.

1. The Engineer may require the Contractor to seal the cofferdam with concrete if:

- The material encountered at the designed elevation of the bottom of the footing is so porous that water enters at a rate that it is impractical to lower the water level to this elevation by pumping, or
- The material cannot be prevented from flowing into the excavation by driving sheeting to reasonable depths.

2. Place the seal course below the elevation of the bottom of the footing in the manner prescribed in Article 2403.03, J. The cost of this work will be paid for according to Article 1109.03. After placement of the seal course, do not dewater the cofferdam until test beams show a flexural strength of no less than 500 psi (3.5 MPa).

C. Footings.

1. Construct footings as shown in the contract documents or as the Engineer orders in writing. Anchor footings resting upon solid rock by extending the footing at least 6 inches (150 mm) into the solid rock. Adjustment in quantities will not be made for extending the dimensions horizontally beyond the neat lines shown in the contract documents. Remove all loose boulders and fragments of rock before the footing is placed.

2. Do not place concrete in a footing until the Engineer has inspected and approved the depth of excavation and integrity of the foundation materials, and has given permission to proceed.

3. When the contract includes an item for Excavate and Dewater, construct the footings for piers in the dry using either:

- Steel sheet pile cofferdams and tremie concrete seal courses, or
- Other means of maintaining a dry excavation, as may be developed by the Contractor and approved by the Engineer.

4. Prevent water from seeping through the bottom of the excavation during placement of the footing concrete. Prevent unbalanced water pressure from acting on the bottom of the footing during curing of the footing concrete.

5. Approval of the Contractor's recommended procedure does not relieve the Contractor from responsibility to place the footing and pier concrete in the dry. The Engineer reserves the right to require the Contractor to provide cofferdams and tremie concrete seal courses if, during construction, the Engineer determines that the excavation cannot be satisfactorily dewatered by the Contractor's recommended procedure.

D. Class of Concrete.

1. Construct foundations and substructures using Class C concrete unless specified otherwise in the contract documents.

2. For concrete in seal courses use Class X concrete (not air entrained) mixed with sufficient water to provide a satisfactory mix having a slump of no more than 8 inches (200 mm).

E. Placing Concrete.

1. Apply the provisions of Section 2403 to concrete placed in foundations and substructures.

2. In reinforced concrete substructures, securely fasten in position reinforcement extending into footings.

3. Request the Engineer inspect before any concrete is placed.

4. Use suitable wood or metal forms to enclose footing concrete, except for extension into rock as provided in Article 2405.03, C.

F. Construction Joints.

1. In general, construct each footing as a monolith.

2. If construction joints are required, construct them as specified in Article 2403.03, H.

G. Ice Breakers.

1. Set ice breakers true to alignment and with correct batter.

2. Place the anchorage before placing concrete.

3. The ice breaker is considered part of the substructure.

H. Anchor Bolts for Bridge Bearings and Foundations.

1. General.

a. Use bolts, nuts and washers, galvanized according to ASTM A 153, Class C; or ASTM B 695, Class 50.

b. Use full-length galvanized anchor bolts that:

- Meet the requirements of ASTM F 1554, Grade 36.
- Are Unified Coarse Thread Series, and
- Have Class 2A tolerance.

c. Color code in blue the end of each anchor bolt intended to project from the concrete in order to identify the grade. Use galvanized washers that meet the requirements of ASTM F 436. Use heavy hex, galvanized nuts that meet the requirements of ASTM A 563,

DH. Nuts may be over-tapped in accordance with the allowance requirements of ASTM A 563.

2. Bridge Bearings.

Unless otherwise specified in the contract documents, set anchor bolts to be embedded in concrete in drilled holes. Set them prior to the time the concrete is placed, when specified in the contract documents.

a. Anchor Bolts Set in Drilled Holes.

1) In clean, dry holes accurately set anchor bolts for bridge bearings perpendicular to the plane of the bridge seat. Vary the locations of anchor bolts in relation to slotted holes in expansion shoes to compensate for the temperature of the structure. Adjust the nuts on anchor bolts at the expansion bearings of spans to permit movement of the span with changes in temperature. Set anchor bolts with a hydraulic cement or polymer grout.

2) When hydraulic cement grout is used, use one that meets the requirements of Materials I.M. 491.13. Make the diameter of the hole 1/2 inch (13 mm) larger than the bolt diameter. Slightly overfill the annular space with grout.

3) When polymer grout is used, use one meeting the requirements of Materials I.M. 491.11. Make the diameter of the hole 1/8 inch (3 mm) larger than the bolt diameter. Fill the annular space with the grout according to the manufacturer's recommendations and limitations, as approved by the Engineer.

b. Preset Anchor Bolts.

1) When specified by the contract documents, set the anchor bolts for bridge bearings during the placing of concrete.

2) Per Article 2405.03, H, 3.

3. Foundations.

a) Hold the bolts firmly in a rigid template which spans the concrete with sufficient clearance to permit proper finishing of the surface of the concrete. Obtain a template from the manufacturer/fabricator for proper placement of the anchor bolts. Do not weld anchor bolts.

b) Leave the template in place until the concrete has hardened.

c) Accurately set anchor bolts, plumb to within 1/4 inch (6 mm) per 12 inches (300 mm), at points specified in the contract documents.

I. Finish.

Finish surfaces of concrete foundations and substructures as provided in Article 2403.03, P.

J. Placing Superstructure.

Apply the provisions of Article 2403.03, N, to placing superstructures on piers and abutments.

K. Reconstruction of Substructures.

1. When the work involves reconstruction of an existing substructure, submit to the Engineer detailed plans for supporting the superstructure according to Article 1105.03.

2. Securely shore or guy the superstructure at all times while it is raised off the substructure to prevent overturning or slipping from the temporary supports.

L. Pile Substructures.

1. When designated in the contract documents, construct the substructure by driving piling for abutments and piers. Drive piles according to Section 2501.

2. Support earth approaches laterally by sheet piling or by backing planks resting against the abutment piling.

3. Complete wood, steel, and concrete construction in connection with pile substructures according to Sections 2403, 2407, 2408, or 2409.

2405.04 METHOD OF MEASUREMENT.

A. Measurement for the quantities involved in foundations and substructures, will be as provided in the following sections:

1. Excavation for Structures: Section 2402.04 applies.

2. Structural Concrete: Section 2403.04 applies.

3. Reinforcement: Section 2404.04 applies.

4. Precast and Prestressed Concrete: Section 2407.04 applies.

5. Structural Steel: Section 2408.04 applies.

6. Timber and Lumber: Section 2409.04 applies.

7. Piles: Section 2501.04 applies.

B. No measurement will be made for Excavate and Dewater.

2405.05 BASIS OF PAYMENT.

A. Payment for the quantities involved in foundations and substructures will be as follows:

1. Excavation for Structures: Section 2402.05 applies.

2. Structural Concrete: Section 2403.05 applies.

3. Reinforcement: Section 2404.05 applies.

4. Precast and Prestressed Concrete: Section 2407.05 applies.

5. Structural Steel: Section 2408.05 applies.

6. Timber and Lumber: Section 2409.05 applies.

7. Piles: Section 2501.05 applies.

B. Payments are full compensation for furnishing materials, equipment, and labor and for performance of work necessary to complete the substructure in conformance with the contract documents.

C. When the contract documents do not provide a separate price for Class X concrete, payment for this concrete, when ordered by the Engineer, will be per Article 1109.03, B. The quantity paid for is limited to that concrete placed within 18 inches (0.5 m) of the footing, as shown in the contract documents.

D. When the contract includes an item for Excavate and Dewater, payment will be made at the contract lump sum price each for Excavate and Dewater. Payment is full compensation for:

- Class 20 and Class 21 excavation,
- Cofferdams and tremie concrete seals, if used,
- Costs of other procedures required to dewater the excavations,
- Pumping,
- Bailing and drainage, and
- Materials, work, labor, and equipment required to place the footings and piers in the dry, including the cost of furnishing design computations and drawings.

E. Additional compensation will not be allowed for any delays resulting from compliance with the above requirements.

Section 2406. Concrete Structures

2406.01 DESCRIPTION.

A. Apply the provisions of this section to bridge structures for which the main members spanning the various supports are composed of concrete.

B. Place the concrete superstructure on a substructure constructed according to Section 2405.

C. Also, in addition to this section, apply the provisions of Sections 2403, 2404, 2405, 2407, 2412, 2413, and 2414.

2406.02 MATERIALS.

Refer to the materials requirements for Sections 2403, 2404, 2405, 2407, 2412, 2413, and 2414.

2406.03 CONSTRUCTION.

A. Falsework and Forms.

1. Construct falsework and forms to conform to Articles 2403.03, B, 5 and 2403.03, L.

2. Notify the Engineer at least 24 hours before placing any concrete in the superstructure of a concrete bridge so the Engineer may inspect the falsework and forms for conformance with falsework plans, alignment, and general fitness. Do not place concrete until the Engineer has inspected the falsework and forms.

3. Ensure falsework and forms provide for the full camber and roadway crown specified in the contract documents. Remove forms according to Article 2403.03, M.

B. Placing Concrete.

Place concrete as provided in Section 2403 and the following:

1. Placing Concrete in Slab Superstructures.

a. Place concrete for each span to its full depth in one continuous operation and without joints except as provided in the contract documents.

b. The Contractor will be required to provide adequate material, labor, and equipment to assure that the concrete required to be completed in a single, continuous operation can be placed in 10 hours.

2. Placing Concrete in Deck Girder Superstructures.

a. Place concrete for each girder continuously for the entire length of the girder in level, horizontal layers, unless provided otherwise in the contract documents.

b. Place concrete for the floor to the required thickness in a single placement. Place the floor as quickly as possible after completion of its supporting girders. Complete the floor within the same working day as the girders.

C. Joints.

Construct joints in the locations shown on the plans and according to Article 2403.03, H.

D. Drainage.

1. Construct and place floor drains at the locations shown on the plans.

2. Install drains behind abutments, wingwalls, and similar structures as specified in Section 2502.

E. Surface Finish.

1. Finish concrete superstructures according to Article 2403.03, P.

2. Finish concrete floors according to Section 2412.

2406.04 METHOD OF MEASUREMENT.

A. Measurement for the quantities involved in concrete structures will be as provided in the following sections:

1. Structural Concrete: Article 2403.04 applies.

2. Reinforcement: Article 2404.04 applies.

3. Structural Steel: Article 2408.04 applies.

4. Precast and Prestressed Concrete Units: Article 2407.04 applies.

B. The volume of concrete displaced by floor drains, expansion joints, or metal strips for sealing joints will not be measured.

2406.05 BASIS OF PAYMENT.

A. Payment for the quantities involved in concrete structures will be as provided in the following sections:

1. Structural Concrete: Article 2403.05 applies.

2. Reinforcement: Article 2404.05 applies.

3. Structural Steel: Article 2408.05 applies.

4. Precast and Prestressed Concrete Units: Article 2407.05 applies.

B. Payments are full compensation for:
- Furnishing all materials, equipment, and labor, and
- Performance of all work necessary to complete the concrete structure in conformance with the contract documents.

C. Deduction will not be made for the volume of concrete displaced by floor drains, expansion joints, or metal strips for sealing joints.

D. The cost of all bituminous expansion joint material, metal strips for sealing joints, and other small miscellaneous items is included in the price per cubic yard (cubic meter) for structural concrete.

E. The weight (mass) of structural steel paid for will include all steel expansion plates, castings of steel or iron, or welded shapes for floor drains, bearing plates, anchor bolts, fasteners, and other steel parts except steel reinforcement for concrete.

Section 2407. Precast and Prestressed Concrete Bridge Units

2407.01 DESCRIPTION.

A. Provide prestressed and precast concrete bridge units produced in a plant for which equipment, procedures, and quality of concrete have been approved by the Contracting Authority.

B. Provide, or have the fabricator provide, technical personnel experienced and skilled in the application of the prestressing system being used. Ensure technical personnel cooperate fully with the Engineer in all technical aspects of the work.

C. Apply the provisions of this section to production and construction of precast concrete and prestressed concrete as defined in Section 1101.

D. Unless modified elsewhere in the contract documents, all fabrication is required to be done only in precast fabrication plants that are approved prior to the letting as per Materials I.M. 445.

2407.02 MATERIALS.

Use materials in prestressed and precast concrete meeting the requirements of Division 41 for the respective material, and the following:

A. Aggregates.

1. Apply Sections 4110 and 4115, except the gradation requirements of Articles 4110.02 and 4115.03. If high performance concrete (HPC) is being used for prestressed concrete beams, use a coarse aggregate consisting of crushed limestone meeting class 3 durability or better.

2. Submit aggregate gradations and proportions with the mix design to the District Materials Engineer for approval.

3. Use aggregates similar to Class V only when 30% or more of the total weight (mass) of aggregate is limestone.

B. Admixtures.
When authorized by the Engineer, approved admixtures complying with Section 4103 may be used.

C. Steel for Prestressing.
Apply Article 4151.05.

D. Reinforcement.
Apply Article 4151.03.

E. Steel Sole and Masonry Plates.
Apply Section 2508 and Articles 2408.03, B, 2408.03, E, and 4152.02.

F. Neoprene Bearing Pads.
Apply Article 4195.02.

G. Bolts and Other Metal Fastenings.

1. Unless indicated otherwise in the contract documents, use non-high-strength fasteners meeting requirements of Article 4153.06.

2. For other fastenings use structural steel meeting the requirements of Article 4152.02, except for anchors and ties for diaphragm connections and hold down devices for deflected tendons. These items will generally be proprietary products and will require the Engineer's approval. The Engineer will approve only those samples that show an ultimate strength of 50% in excess of the manufacturer's advertised safe loads. Use fastenings that are of a type to be cast in the concrete.

3. Use bolts, nuts, washers, and other metal fastenings that have been galvanized as specified for steel structures in Article 4100.07.

H. Cement.
Apply Section 4101. If the use of Type III Portland cement has been authorized, use it in the same proportions as specified for Type I Portland cement.

I. Supplementary Cementitious Materials.

1. Apply Section 4108.

2. Fly ash may be substituted for Portland cement. Use a substitution rate of no more than 15% by weight (mass).

3. GGBFS may substituted for Portland cement. Use a substitution rate of no more than 35% by weight (mass) for GGBFS as a mineral admixture.

2407.03 CONSTRUCTION.

A. Equipment.
Use equipment meeting the requirements of Section 2001 and the following:

1. Casting Beds.
- **a.** For precast concrete and prestressed concrete, use casting beds rigidly constructed and supported so that under the weight (mass) of the concrete and the vertical reactions of holdups and hold downs there will be no vertical deformation of the bed.
- **b.** For pretensioned work use end anchorages, whether self anchored or supported horizontally by the bed, capable of resisting the maximum prestress force to which they will be subjected without permanent displacement.

2. Forms.
- **a.** Use forms for precast and prestressed concrete true to the dimensions as shown in the contract documents, true to line, mortar tight, and of sufficient rigidity to not sag or bulge out of shape under placement and vibration of concrete. Ensure inside surfaces are

smooth and free of any projections, indentations, or offsets that might restrict differential movements of forms and concrete.

b. On long beds for multiple pretensioned beam production where continuous forms and pallets are used, take necessary precautions to prevent damage to the beams from differential movements of forms and concrete due to temperature changes.

3. Stressing Equipment.

a. To tension tendons, use equipment of a type so the prestressing force may be accurately known. Use load cells, dynamometers, and hydraulic gages of hydraulic pump and jacking systems capable of measuring the force applied to the tendons within 2% of the actual force. Calibrate this equipment at least once every 12 months or anytime the tensioning system indicates erratic results. Calibrate hydraulic gages, pumps, hoses and connections as a system.

b. Perform all tensioning equipment calibrations using load cells calibrated by a testing laboratory or calibration service. For calibration purposes use equipment that has current calibration references. Allow the Engineer the opportunity to witness calibration of equipment during the Engineer's normal working hours or at a mutual agreeable time.

4. Weighing and Proportioning Equipment.

Apply Article 2001.20, except that a vibrator will not be required on the cement batch hopper.

5. Mixing Equipment.

Apply Article 2001.21.

6. Bins.

Apply Article 2001.06.

B. Concrete.

1. For precast and prestressed construction, use at least than 610 pounds (360 kg) of total cementitious material per cubic yard (cubic meter) of concrete. Do not exceed the maximum water-cementitious ratio, including free moisture in the aggregate, of 0.450 pound per pound (0.450 kg/kg).

2. If the units will form curbs or floors of structures, add an approved air-entraining admixture. The intended air entrainment of the finished concrete is 6%. To allow for loss during placement, use a target value of 6.5% for the air content of fresh unvibrated concrete, with a maximum variation of ± 1.0%.

3. Properly proportion, mix, place, and cure concrete within these limits to produce concrete of a minimum compressive strength specified in Table 2407.03-1 at the designated age.

Table 2407.03-1: Concrete Strength

Classification	Concrete Strength Before Moving or Prestressing, psi (MPa)	Concrete Strength at Age 28 calendar days, psi (MPa)
Precast Sheet or Bearing Piles	3500 (24)	4500 (31)
Precast Bridge Deck Units	3500 (24)	5000 (35)
Prestressed Piles	4000 (28)	5000 (35)
Prestressed Deck Panels	4000 (28)	5000 (35)
All Other Prestressed Concrete[(a)]	4500 (31)	5000 (35)
[(a)] Unless noted otherwise in the contract documents. NOTE: Do not ship beams until the concrete has attained the 28 day strength.		

4. If using HPC for prestressed concrete beams, apply the following additional specifications:

a. The Contractor may submit up to two trial batches of concrete per project at no cost. The Contractor will be charged $500 for each additional trial batch submittal or resubmittal. Submit trial batch concrete that is of a size and mix typically used in day-to-day operations and is made at least 60 calendar days prior to placement. Ensure the trial batch concrete design produces a slump within ± 4 inches (100 mm) of placement slump.

b. The District Materials Engineer may waive trial batch testing for a mix, provided the mix was previously tested and resulted in satisfactory mix properties. Adjustments to a previously approved mix, not requiring a new trial batch, will be at the discretion of the District Materials Engineer.

c. Notify the District Materials Engineer, Plant Inspector, and Materials Structural Engineer at least 7 calendar days prior to batching. Ensure the Plant Inspector casts all samples from the trial batch concrete.

d. The Contracting Authority will test trial batch concrete permeability. Two permeability samples will be cast in 4 inch by 8 inch (100 mm by 200 mm) plastic cylinder molds and capped. Within 5 calendar days of casting, the samples will be delivered to the Central Materials Testing Laboratory. The samples will remain in their plastic molds with lids until delivered. The samples will be stripped of their molds and wet cured to an age of 7 days in the moist room. After 7 days, the samples will be submerged in water heated to 100°F (37.7°C) until an age of 28 days or more. Two test specimens will be obtained from each cylinder. Permeability will be tested in accordance with AASHTO T277 at 28 days or more. A coulomb reading of 2500 or less, based on the average of four test results, is considered acceptable.

e. Trial batch materials, proportions, and test results will be reported to the District Materials Engineer for approval.

C. Proportioning, Mixing, and Placing Concrete.

1. Proportion and mix concrete according to the applicable requirements of Article 2403.02, D, 3.

2. Do not place concrete when the ambient temperature is below 35°F (2°C) unless the Engineer has approved the plant for cold weather concrete placement. When necessary, heat the aggregate or water, or both, so that the temperature of concrete when deposited in the forms is 40°F to 90°F (4°C to 32°C). Do not use frozen material in concrete.

3. When a series of units is cast in a line, cast the entire series in one continuous operation, or as directed by the Engineer. Place successive batches before the preceding batch has perceptibly hardened or dried. Do not allow more than 45 minutes to pass between the placement of successive batches of concrete in a unit. Do not retemper the concrete or add water to the interface of the concrete between batches.

4. Carefully work and consolidate concrete around reinforcement without displacing it. Ensure the formation of honeycomb, stone pockets, or similar defects has not occured. Consolidate the concrete using small diameter vibrators or by other means the Engineer approves. Overfill the forms during consolidation. Screed off excess concrete and finish the surface to the desired texture.

5. On specific request and approval, provisions may be made for inserts in beams as an aid to stripping floor forms. Complete this according to the conditions of such approval.

D. Curing.

1. Use a method of curing that prevents loss of moisture and maintains an internal concrete temperature at least 40°F (4°C) during the curing period. Obtain the Engineer's approval for this method.

2. When using accelerated heat curing, do so under a suitable enclosure. Use equipment and procedures that will ensure uniform control and distribution of heat and prevent local overheating. Ensure the curing process is under the direct supervision and control of competent operators.

3. When accelerated heat is used to obtain temperatures above 100°F (38°C):

- **a.** Record the temperature of the interior of the concrete using a system capable of automatically producing a temperature record at intervals of no more than 15 minutes during the entire curing period.
- **b.** Space the systems at a minimum of one location per 100 feet (30 m) of length per unit or fraction thereof, with a maximum of three locations along each line of units being cured.
- **c.** Ensure all units, when calibrated individually, are accurate within ± 5°F (3°C).

d. Do not artificially raise the temperature of the concrete above 100°F (38°C) for a minimum of 2 hours after the units have been cast. After the 2 hour period, the temperature of the concrete may be raised to a maximum temperature of 160°F (71°C) at a rate not to exceed 25°F (15°C) per hour.

e. Hold the maximum temperature for a period sufficient to develop the strength required for release of prestress or for post tensioning, as the case may be.

f. Lower the temperature of the concrete at a rate not to exceed 40°F (22°C) per hour by reducing the amount of heat applied until the interior of the concrete has reached the temperature of the surrounding air.

4. In all cases, cover the concrete and leave covered until curing is completed. Side forms and pans forming the underside of channel shapes may be removed during this period if the cover is immediately replaced. Do not, under any circumstances, remove units from the casting bed until the strength requirements are met.

5. For pretensioned beams, maintain the temperature of the beams and exposed strands at normal curing temperature until the stress has been released from the end anchorages.

E. Placing Reinforcement.

1. Place all reinforcement carefully and accurately and secure in the proper position according to the contract documents. Apply Article 2404.03.

2. Only welders qualified according to Article 2408.03, B, may perform welding if it is employed in placement of reinforcing steel, or the interconnection of plate connectors, sole plates, or masonry plates. Apply Article 2408.03, B, to the period of effectiveness for all welders. For tack welding reinforcing bars, follow all other requirements as outlined in the latest edition of AWS D1.4, including Table 5.2, Minimum Preheat and Interpass Temperature, except do not allow the minimum preheat and interpass temperature to drop below 50°F (10°C). Ensure the minimum preheat and interpass temperatures for structural steel remain as in Article 2408.03, B.

3. Protect prestressing tendons from heat and weld spatter. Tack welding of reinforcing steel at noncritical stress areas in combination with sacrificial reinforcing bars, if required, will be allowed without regard to preheat and interpass temperature restrictions. Obtain the Engineer's approval for any such modification.

F. Removal of Forms.

If forms are removed before the concrete has attained the strength which will permit the units to be moved or stressed, remove protection only from the immediate section from which forms are being removed. Immediately replace the protection and resume curing after the forms are removed. Do not remove protection any time before the units attain the specified

compressive strength when the surrounding air temperature is below 20°F (-7°C).

G. Prestressing Steel Stresses.

1. Position the number and size of individual tendons (7wire strand) according to the contract documents. Prestress to the force shown in the contract documents.

2. If anchored at other than 70°F (20°C), adjust the initial prestressing force as shown in Table 2407.03-2:

Table 2407.03-2: Initial Prestressing Force

Temperature of Strands	Initial Prestressing Force
70°F (20°C) Below 70°F (20°C) Above 70°F (20°C)	As shown in the contract documents Increase 1.0% per 10°F (5°C) Decrease 1.0% per 10°F (5°C)

3. After tendons have been positioned, apply an initial force between 1000 and 4500 pounds (4.5 kN and 20 kN) to each tendon. Measure the initial force within a tolerance of:

- ± 100 pounds (0.5 kN) for initial forces under 3000 pounds (13 kN), and
- ± 200 pounds (1 kN) for initial forces of 3000 pounds (13 kN) or more.

4. The theoretical elongation of the tendons is calculated from material properties furnished by the manufacturer and allowable losses. Allowable losses may include seating losses, bed shortening, abutment movement, and temperature adjustments.

5. Measure the pretensioning by the net elongation of the tendons. Consider the calculated theoretical net elongation to be the target. A tolerance of ±1/2 inch (13 mm) from the calculated net elongation, after seating, may be allowed.

6. Conduct the tensioning procedure so the indicated stress, measured by the tensioning system, is within 5% of the calculated stress, based upon the corresponding elongation. Verify the distribution of the stress is within 5% of the calculated stress at all points along the tendon or when measured at the end of the bed.

7. Temporary overstressing of the tendons is allowed; however, at no time exceed 80% of the specified tensile strength of the tendons. Do not seat tendons in this overstress condition.

8. Tension tendons between fixed end anchorages by means of jacks either separately or in a group. Several units may be cast in one continuous line. In this case tension them simultaneously.

9. Deflected tendons may be tensioned in place. Alternatively, deflected tendons may be partially tensioned and then raised to the predetermined final position at the beam ends, achieving the required prestressing force. Tendons may be raised simultaneously to the predetermined final position or at any one point, in a single lift, provided the sequence of lifting commences at the point nearest the center of the bed and then progresses alternately at points equidistant from the center to the ends.

10. Support tendons at each deflection point on a freely rotating metal pulley no less than 3/4 inch (19 mm) in diameter.

11. Limit the number of broken strand wires to no more than 2% of the total number of strand wires or no more than one broken wire of any one strand.

H. Prestress Transfer.

1. When accelerated heat curing is used, perform prestress transfer immediately after the curing period is completed and while the concrete is warm and moist.

2. Deflected tendons, if any, are to be released first either by:
- Lowering holdup devices at beam ends as nearly simultaneously as practical, or if this is not feasible,
- Flame cutting deflected tendons in each beam interval in rotation until all deflected tendons are released. Obtain the Engineer's approval for the procedure used to flame cut deflected tendons.

3. Next, release the hold down devices and simultaneously and gradually release the straight line tendons using the jack. If this is not feasible, heat the tendons as follows:
- **a.** For each tendon, simultaneously heat a minimum of two locations along the casting bed.
- **b.** Apply heat along the tendon over a minimum 5 inch (125 mm) distance.
- **c.** Control heat application so that failure of the first wire in the tendon does not occur for at least 5 seconds after heat is applied, followed by gradual elongation and failure of the remaining wires. Heat the tendon until failure occurs at each beam interval before proceeding to the next tendon.
- **d.** Sequence prestress transfer between individual tendons so that there is minimum eccentricity of prestress load.
- **e.** Alternate procedures for releasing deflected or straight line tendons may be submitted for the Engineer's approval.

4. Measure the camber due to prestress while the beam is on the bed by checking the beam profile within three hours after prestress transfer.

I. Post Tensioned Prestressed Concrete.
When post tensioned construction is designated, detailed procedures will be included in the contract documents.

J. Tolerances.
Apply the following tolerances for precast and prestressed units:

1. Precast Nonprestressed Units.

a. Limit variation from dimensions shown in the contract documents to no more than 1/8 inch (3 mm). For overruns, greater deviation may be accepted if, in the Engineer's opinion, it does not impair the suitability of the member for its intended use.

b. Ensure beam seat bearing areas at each end of the unit are flat and true and perpendicular transversely to the vertical axis of the beam.

c. Limit the difference of cambers between two adjacent units, as assembled, to no more than 1/8 inch (3 mm).

2. Precast Prestressed Units.
Limit variation from dimensions shown in the contract documents to the tolerances shown in Table 2407.03-3:

Table 2407.03-3: Tolerances

Length	±1/4" per 25' and ±1" max. for beams 100' or longer (±6 mm per 8 m and ±25 mm max. for beams 30 m or longer)
Width (flanges and fillets)	+3/8" or -1/4" (+10 mm or -6 mm)
Depth (overall)	+1/2" or -1/4" (+13 mm or -6 mm)
Width (web)	+3/8" or -1/4" (+10 mm or -6 mm)
Depth (flanges and fillets)	±1/4" (±6 mm)
Bearing plates (ctr. to ctr.)	1/8" per 10' of beam length, max. ±3/4" (1 mm per 1 m of beam length, max. ±20 mm)
Sweep (deviations from straight line parallel to center line of member)	L/80 (L in feet, sweep is in inches) L(L in meters, sweep is in millimeters)
Camber deviation from design camber	±30% of plan camber
Stirrup bars (project above top of beam)	+1/4" or -3/4" (+6 mm or -20 mm)
Individual tendon position	
Straight strands	±1/4" (±6 mm)
Draped strands at end of beam	±1/2" (±13 mm)
Tendon position	
Center of gravity of strand group	±1/4" (±6 mm)
Center of gravity of depressed strand group at end of beam	±1" (±25 mm)
Deviation from net theoretical elongation after final seating	± 1/2 inch (13 mm)
Position of deflection points for deflected strands	5% of beam span toward end of beam
Position of handling devices	±6" (±150 mm)
Bearing plates (ctr. to end of beam)	±3/8" (±10 mm)
Side inserts (ctr. to ctr and ctr. to end)	±1/2" (±13 mm)

Exposed beam ends (deviation from square or designated skew)	
Horizontal	±1/4” (±6 mm)
Vertical	±1/8” per foot of beam depth (±10 mm per 1 m)
Bearing area deviation from plane	±1/16” (±2 mm)
Stirrup bars (longitudinal spacing)	±1” (±25 mm)
Position of post tensioning duct	±1/4” (±6 mm)
Position of weld plates	±1” (±25 mm)
Elongation (standard gauge length to be a minimum of 20 feet (6 m))	±5% (±5%)

K. Handling and Storage.

1. When lifting and handling precast or prestressed units, support them at or near the points designated in the contract documents. Do not allow the overhang to exceed 5% of the length of the beam, unless specified otherwise in the contract documents.

2. Do not lift or strain units in any way before they have developed the strength specified. In storage, support units at points adjacent to the bearings.

3. Support piles near the one-fifth points measured from the ends. In stacking units for storage, arrange the bearings one directly above another.

4. Legibly mark piles with the casting date in fresh concrete near the head of the pile, using numerals only.

5. During fabrication, storage, handling, and hauling take care to prevent cracking, twisting, unnecessary roughness, or other damage. In particular, do not allow tiedowns to come in direct contact with concrete surfaces. Do not subject units to excessive impact. Replace at no additional cost to the Contracting Authority units that are, in the Engineer’s opinion, damaged in a way to impair their strength or suitability for their intended use.

L. Finish.

1. Finish all surfaces which will be exposed in the finished structure as provided in Article 2403.03, P, 2, b, and ensure they are free of honeycomb or surface defects. Submit Structural Repair procedures to the Engineer for approval.

2. Finish the outer surface of exterior beams as follows:
   a. As soon as practical after removal of the forms, remove all fins and other surface projections.
   b. Brush or spray a prepared grout onto the prewetted surface. Use a grout consisting of one part of silica sand and one part of Portland

cement blended with acrylic bonding agent and water to produce a consistency sufficient to fill the cavities. The Engineer may require white Portland cement to be used in amounts necessary to obtain a uniform finish.

c. Immediately after applying the grout, float finish the surface with a cork or other suitable float. Ensure this operation completely fills all holes and depressions on the surface.

d. When the grout is of such plasticity that it will not be pulled from holes or depressions, use a sponge rubber float to remove all excess grout.

e. When the surface is thoroughly dry, rub it vigorously with dry burlap to completely remove excess dried grout.

f. Cure the surface finish in a manner satisfactory to the Engineer. Heat curing may be required in cold weather.

g. Ensure, when finished, the surface is free from stains and has a uniform color.

3. Cut and bend tendon projections as detailed in the contract documents. Cut the tendon off flush with the concrete where the tendon end will be exposed in the complete structure. Clean the end of each cut off tendon to a bright appearance.

4. Coat and seal beam ends exposed in the complete structure with an approved gray or clear epoxy listed in Materials I.M. 491.12, Appendix A. Coat and seal beam ends as indicated on the plans. Apply the epoxy coating and beam end sealing at the fabricating plant.

2407.04 METHOD OF MEASUREMENT.

A. For precast or prestressed structural units, the Engineer will determine the number of units of each of the various respective sizes, lengths, and types from actual count. Measurement of precast sheet piles or precast or prestressed bearing piles will be according to Article 2501.04.

B. For cast-in-place prestressed concrete, measurement for concrete, reinforcing steel, and structural steel will be according to Article 2403.04 for structural concrete, and the prestressing will be a lump sum item.

2407.05 BASIS OF PAYMENT.

A. Payment will be the contract unit price for the number of approved precast or prestressed structural units of each size and length incorporated in the project.

B. Payment is full compensation for:

- Producing and furnishing the units complete as shown in the contract documents, with all plates, pads, bolts, grout enclosures, reinforcing steel, prestressing material, coil rods, hold down devices, and any other items to be cast in the concrete,
- Transporting units to the site and placing them in the structure,

- Furnishing and installing bearing plates and anchor bolts or neoprene pads when specified in the contract documents.

C. Payment for furnishing precast sheet piles or precast or prestressed bearing piles will be as provided in Article 2501.05.

D. Payment for cast-in-place prestressed concrete will be according to Article 2403.05. The prestressing will be paid for as a lump sum item. The lump sum amount is full payment for furnishing and placing the required material and stressing, anchoring, and grouting the prestressing steel according to the contract documents.

Section 2408. Steel Structures

2408.01 DESCRIPTION.

A. Fabrication and erection of:

1. All types of bridge structures for which the main members spanning the various supports are composed of steel.

2. Other structures or parts of structures where the design or intended use of steel is based on physical or chemical properties of the steel.

B. The quality of work and finish is to be equal to the best practice in modern bridge shops. Perform shearing and chipping neatly and accurately. Neatly finish all portions of the work exposed to view.

2408.02 MATERIALS REQUIREMENTS, IDENTIFICATION, AND FABRICATION.

Unless elsewhere modified in the contract documents, all fabrication to which this section applies shall be done in the states, territories, and possessions of the United States and in other locations within the geographic limits of North America and in steel fabrication shops and plants that are approved prior to the letting according to Materials I.M. 557. All main member fabrication, except bearing devices, must be fabricated by plants certified as Category III, Major Steel Bridges, under the provisions of AISC's Quality Certification Program.

A. Base Materials.
Use materials meeting the requirements of Division 41 for the following:

1. Rolled Plates, Shapes, and Eyebars.
Apply Section 4152.

2. Forgings and Castings.
Apply Section 4153.

3. Bronze Metal (rolled or cast).
Apply Article 4190.03.

4. Bolts, Nuts, and Washers.
Apply Article 4153.06.

5. Bearing Pads.
Apply Article 4195.02.

6. Galvanizing.
Apply Article 4100.07.

B. Identification of Steel during Fabrication.

1. Main members of steel structures are defined to include the following. The contract documents may also designate other members as main members.

- Rolled sections or flange and web plates in main beams and girders,
- Floor beams,
- Stringers,
- Abutment diaphragms,
- Cross frames carrying direct live loads,
- Lateral bracing and cross frames in horizontally curved bridges,
- Cover plates, splice plates, and gusset plates,
- Bearing stiffeners and bearing devices, and
- Stiffeners connecting live load carrying members to main beam or girder webs.

2. Before steel, as received, is cut for fabrication, provide the Engineer two copies of certified mill test reports showing chemical and physical test results for the steel involved.

3. For all steels, use a record keeping system for individual pieces, and issue cutting instructions to the shop that will maintain identity of the mill test report number. Generally, this record keeping system consists of cross referencing assembly marks shown on the shop drawings with the corresponding item, covered on the mill purchase order. Provide the inspector with a copy of the cutting instructions.

4. The Contractor may furnish material from stock which can be identified by heat number and mill test report.

5. Identify main members and component parts thereof by heat number, unless the Engineer allows exception. Ensure each piece of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) clearly and legibly shows its proper color code. Maintain these identifications until the steel is cleaned for painting.

6. Provided the heat number or color code remains legible, individually marked pieces of steel may be used without further color coding if they are used in furnished size or reduced from furnished size only by end or edge trim that does not disturb the heat number or color code or leave any usable piece.

7. Before cutting, legibly mark pieces of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) which are to be cut to smaller size pieces with the proper color code.

8. Upon being removed from the bundle or lift, immediately mark with the proper color code individual pieces of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) which are furnished in tagged lifts or bundles.

9. Mark for grade by steel die stamping, or by a firmly attached substantial tag, pieces of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) which, prior to assembling into members, will be subject to fabricating operations, for example blast cleaning, galvanizing, heating for forming, or painting, that might obliterate paint color code marking.

10. During fabrication, up to the point of assembling members, ensure each piece of steel (other than ASTM A 709/A 709M Grade 36 (Grade 250) steel) clearly and legibly shows its specification identification color code as shown in Table 2408.02-1:

Table 2408.02-1: Specification Identification Color Code

Section	Steel Grade	Color Code
ASTM A709/A 709M	100 (690)	Red
ASTM A 709/A 709M	100W (690W)	Red and Orange
ASTM A 709/A 709M	50 (345)	Green and Yellow
ASTM A 709/A 709M	50W (345W)	Blue and Yellow

11. Ensure other steels not covered above and not included in ASTM A 6/A 6M have an individual color code established and on record for the Engineer.

12. Provide an affidavit in the form of a cutting list, listing heat numbers and grade of steel, and a statement certifying that throughout the fabrication operation the identification of steel has been maintained according to this specification.

C. Fasteners.

1. Where indicated in the contract documents, "rough bolted connections" may be used. In these connections, bolts may be hex-head bolts meeting the requirements of ASTM A 307. Ribbed bolts may be used when specified in the contract documents. Under the nut of each ASTM A 307 hex-head bolt, fit one ANSI B18.21.1 helical spring lock washer, except for:
   - Expansion joint bolts that are to be removed after the expansion joint is installed, or
   - Anchor bolts through slotted holes where a cut washer is provided.

2. When rough bolts or ribbed bolts are to be used, furnish 5% more than the number of bolts of each size and length shown in the contract

documents. When turned bolts or high strength bolts are to be used, furnish 2% more than the number of bolts and corresponding washers and nuts shown in the contract documents.

D. Pins and Rollers.

1. Turn pins and rollers to the specified dimensions. Ensure they are smooth, straight, and free from flaws.

2. Forge and anneal pins and rollers more than 9 inches (225 mm) in diameter.

3. For pins larger than 9 inches (225 mm) in diameter, longitudinally bore a 2 inch (50 mm) hole through the center after the forging has cooled below the critical range and before the forging is annealed. Reject pins showing a defective interior condition.

E. Bars and Plates.

1. Unless otherwise noted on the plans, and as excepted below, roll edges of all main stress carrying members composed of plates and all steel material designated on plans as "bar" or "UM plate". They may be thermal cut, provided that with thermal cut plates a smooth surface is secured by the use of a mechanical guide the Engineer approves according to Article 2408.03, B. Web splice plates and bearing stiffeners 5/8 inch (16 mm) or less in thickness may be made of sheared plates.

2. Unless otherwise noted in the contract documents, secondary stress members may be made of sheared plates. If sheared plates are used, dull their exposed sharp corners by grinding.

3. Cut plates so the direction of stress in main members is in the direction of rolling, except web splice plates.

4. For main stress carrying members, use members defined in Article 2408.02, B as main members.

F. Bent Plates.

Use unwelded, cold bent, load carrying, rolled steel plates complying with the following:

1. They are taken from the stock plates so the bend line is at right angles to the direction of rolling.

2. They are bent in such a manner that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in Table 2408.02-2 for all grades of structural steel in this specification.

Table 2408.02-2: Minimum Bend Radii

Thickness in Inches (millimeters)					
	Up to 1/2 (12)	Over 1/2 to 1 (12 to 25)	Over 1 to 1 1/2 (25 to 40)	Over 1 1/2 to 2 1/2 (40 to 60)	Over 2 1/2 to 4 (60 to 100)
Minimum Bend Radii for Metal Thickness (t)	2t	2.5t	3t	3.5t	4t
NOTE: Low alloy steel in thickness over 2 1/2 inch (12 mm) may require hot bending for small radii.					

a. Allowance for springback of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel should be about three times that for structural carbon steel. For brake press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advised.

b. If a shorter radius is essential, hot bend plates at a temperature no greater than 1200°F (650°C), except for ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel. If ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel plates are bent at temperatures greater than 1125°F (610°C), they must be requenched and tempered in accordance with the producing mill's practice. For hot bent plates, conform to Article 2408.02, F, 1.

3. Before they are bent, round the plate corners to a radius of 1/16 inch (1.6 mm) throughout that portion of the plate at which the bending is to occur.

G. Sheared Edge Finish.

Plane, to a depth of 1/4 inch (6 mm), sheared edges of plates more than 5/8 inch (16 mm) in thickness and carrying calculated stress. Grind, if necessary, to secure a finish equivalent to an ANSI 1000 (25 µm) surface roughness. Fillet re-entrant corners to a minimum radius of 1 inch (25 mm) before cutting.

H. Thermal Cutting.

Apply Article 2408.03, B. Thermal cut main stress carrying members only when the steel in the area of the cut is above 40°F (4°C) and in a dry surface condition.

I. Stress Relief Heat Treatment.

1. For structural members which are indicated in the contract documents to be stress relieved, perform finish machining, boring, and straightening subsequent to heat treatment. Perform stress relief heat treatment according to Section 4.4 AASHTO/AWS D1.5M/D1.5-02.

2. Do not anneal or normalize members made of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel. Stress relieve only with the Engineer's approval.

3. For each furnace charge, maintain a record that identifies pieces in the charge and shows the temperatures and schedule actually used. Provide instruments, such as recording pyrometers, for determining the temperature of members in the furnace at any time. Submit the treatment operation records to the Engineer for approval.

4. Unless stated otherwise in the contract documents, stress relieve all members, such as bridge shoes, pedestals, rockers, or other parts, which are built up by welding sections of plate together.

J. Plate Girders.

Fabricate welded plate girders according to the following requirements:

1. Web Plates.

a. Cut edges of a girder web true and straight or to camber and other detailed curvatures with the accuracy necessary to serve a correct fit up to the flange plate.

b. Weld web plates completely in shop separately before assembly with the flange plates as shown in the contract documents.

2. Web Stiffeners.

a. Bearing Stiffeners.

1) Ensure end stiffeners of girders and stiffeners intended as supports for concentrated loads have full bearing on the flanges to which they transmit load or from which they receive load.

2) Mill or grind these surfaces, or on weldable steel in compression areas of flanges, weld as shown in the contract documents.

b. Intermediate Stiffeners.

Ensure intermediate stiffeners (not intended to support concentrated loads) fit sufficiently tight to be in close contact with the flanges, unless shown or specified otherwise.

c. Stiffener Welding.

1) Start the fillet welds connecting the stiffener or connection plate to the web at the end of the stiffener that is adjacent to the tension flange.

2) Progress toward the compression flange.

3) Before welding, ensure no gap exists between the web and the intermediate stiffeners, bearing stiffener, or connection plates in excess of 3/32 inch (2.4 mm).

3. **Flange Plates.**
   - **a.** Fabricate flange plates using universal mill plates or thermal cut plates which are cut according to Article 2408.02, H.
   - **b.** Weld flange plates for welded girders completely in shop separately before assembly with the web plate as shown in the contract documents.
4. **Tack Welding.**
   Submit tack welding and fit up procedures to the Engineer for review and approval.

K. Camber of Rolled Beam and Plate Girder Spans.

1. When specified in the contract documents, camber the rolled beams and plate girders constituting the main supporting members of a span. Unless specified otherwise in the contract documents, camber to a uniform, approximately circular curve for the entire length of the beam or between designated points. Compound or reverse curves may be required on special designs as shown on the plans.

2. Camber of beam spans may be produced either in the rolling mill or in the fabricating shop. Camber of beam spans may also be induced or corrected by local heating. In all cases, ensure beams conform to the specified shape within tolerance limits. Ensure beams are free from kinks, buckles, or other local imperfections. Improper heating or cooling which might affect grain structure, strength, or ductility of the metal are causes for rejection.

3. Rolled beams may be cambered by heating in the following manner:
   - **a.** Complete welding of cover plates before commencing final heating operations.
   - **b.** Support the beam near its ends in such a manner that the side to be made concave faces upward.
   - **c.** Apply heat with an oxyacetylene, butane, natural gas, or other approved gas flame to areas so selected that distortion other than the required camber will not occur. Apply heat by playing the flame over the section to be heated until the metal attains a temperature of 1000°F to 1200°F (540°C to 650°C). Use temperature indicating crayons, liquids, or bimetal thermometers to control the temperature. Notify the Engineer before any heating is done.

4. Use wedge or triangular shaped heated areas with an included angle between 20 and 45 degrees. Locate the vertex of the angle approximately 1 inch (25 mm) above the point on the web midway between flanges. Slowly play the flame from the torch (or torches) over the area to be heated. Commence at the vertex of the angle and finish at the widest part of the heated wedge, which extends across the width of the flange on the side to be made concave. Manipulate the torch (or torches) so that the total area of the heated zone is rapidly brought to the proper temperature at the same time as nearly as practical.

5. Uniformly space the heated sections at short intervals to produce uniform curvature. Heat no fewer than three sections. Heating of

additional sections may be required in the case of unusually long or heavily cambered beams. Air cool the metal slowly and away from wind or drafts. Do not use water to cool the metal. Do not heat any area more than once.

6. Camber plate girders by cutting the web plate to the proper curvature to produce a camber within the allowable tolerance. When cutting the web plate, include an allowance to compensate for the effect of the heat of welding operations to be performed on the girder during fabrication.

7. Do not induce or correct camber in plate girders by local heating without the Engineer's prior approval. Do not heat ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steels.

L. Bolt Holes.

1. General.

a. Drill or punch all bolt holes. Do not punch holes in metal thicker than 3/4 inch (19 mm) for carbon steel and 5/8 inch (16 mm) for alloy steel. Instead, subdrill and ream holes, or drill holes to full size. Subpunch and ream, subdrill and ream, or drill full size holes in main stress carrying members. Punch or drill full size holes for members (other than main stress carrying members) made of metal no thicker than 3/4 inch (19 mm) for carbon steel and 5/8 inch (16 mm) for alloy steel.

b. When reaming is required, subpunch or subdrill all holes. Subdrilling will be required if thickness limitations govern. Subpunch or subdrill holes 3/16 inch (5 mm) smaller than the nominal diameter of the bolts. After assembling, either ream holes to 1/16 inch (2 mm) larger or drill holes full size to 1/16 inch (2 mm) larger than the nominal diameter of the bolts.

c. In steel templates, place hardened steel bushings in holes accurately dimensioned from the centerline of the connections as inscribed on the template. Use the centerline to accurately locate the template from the milled or scribed ends of the members.

2. Punched Holes.

Limit the diameter of the die to at the most 1/16 inch (2 mm) more than the diameter of the punch. If any holes must be enlarged to admit the bolts, do so by reaming. Holes shall be clean cut without torn or ragged edges. The slightly conical hole that naturally results from punching operations is considered acceptable with the Engineer's approval.

3. Reamed or Drilled Holes.

Ream or drill holes cylindrical and perpendicular to the member. Where practical, use mechanical means to direct reamers. Perform reaming and drilling using twist drills, twist reamers or rotobroach cutters. Assemble connecting parts that require reamed or drilled holes and then securely hold while reaming or drilling. Match-mark parts before disassembling.

4. Accuracy of Holes.
Holes fabricated using a drill or reamer of the nominal diameter and not more than 1/32 inch (1 mm) larger in diameter than the true decimal equivalent of the nominal diameter are considered acceptable. Limit the width of slotted holes, produced by flame cutting or a combination of drilling or punching and flame cutting, to no more than 1/32 inch (1 mm) greater than the nominal width. Grind the flame cut surface smooth.

5. Accuracy Before Reaming.
Subpunch or subdrill all holes accurately enough that after assembling (before any reaming is done) a cylindrical pin 1/8 inch (3 mm) smaller in diameter than the nominal size of the hole may be entered perpendicular to the face of the member (without drifting) in at least 75% of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly subpunched or subdrilled pieces will be rejected. Any hole that does not allow a pin 3/16 inch (5 mm) smaller in diameter than the nominal size of the subpunched or subdrilled hole to pass will be rejected.

6. Accuracy After Reaming or Drilling.
Ensure that at least 85% of reamed or drilled holes in a contiguous group show no offset greater than 1/32 inch (1 mm) between adjacent thicknesses of metal.

7. Misplaced Holes.
Misplaced holes may be a basis for rejection. Repair only with the Engineer's approval.

8. Removal of Burrs.
Remove burrs on outside or faying surfaces. If the Engineer requires, disassemble assembled parts to remove burrs.

M. Boring Pin Holes.
Unless otherwise required, bore pin holes to be: 1) true to detailed dimensions; 2) smooth; and 3) straight at right angles with the axis of the member and parallel with each other. Finish cut according to Article 2408.03, E.

N. Reaming Subpunched Field Connections.

1. When subpunched and reamed holes are required for field connections, fully assemble main members of the structure and firmly bolt together.

2. Adjust main members to line and fit before reaming holes in connecting joints.

3. Before parts are disassembled for shipping and handling, match-mark respective pieces with a low stress riser steel stamp so that they can be reassembled in the same position when the structure is erected in the field. Steel stamping on the edges of plates will not be permitted.

4. In lieu of subpunching and reaming holes, the fabricator may drill holes full size, while members are assembled, by any of the following procedures:
- By laying out the location of the holes on the outside plate with center punch marks and drilling full size, or
- By subpunching holes in the outside plate and enlarging subpunched holes by drilling full size, and drilling full size through the remaining plates, or
- By predrilling splice plates or plates full size and using these as a template to drill full size through the remaining plates.

5. Ensure the accuracy of drilled holes is as specified in Article 2408.02, L, 4.

6. Do not interchange reamed parts. Ream connecting joints (such as floor beam and stringer connections not assembled as provided above) to a metal template.

O. Pilot and Driving Nuts.
On pin connected spans, furnish pilot and driving nuts for each size pin, unless provided otherwise in the contract documents.

P. Mill and Shop Inspection.

1. General.
a. Provide the Engineer ample notice of the beginning of work at the mill and shop so inspection may be provided. Mill inspection of rolling will not be required unless the Engineer requests. If inspection of rolling is not requested, provide the Engineer complete test reports of mill inspections, showing chemical and physical tests for each heat of all structural steel sections as specified in Articles 2408.02, A and 4152.02.
b. Notify the Engineer before fabricating material.

3. Inspector's Authority.
a. The inspector has the authority to reject material or work which does not fulfill the requirements of these specifications. In cases of dispute, appeal to the Engineer, whose decision is final.
b. Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility in regard to imperfect material or quality of work and the necessity for replacing the same.

4. Facilities for Inspection.
Furnish facilities for inspection of material and workmanship in the mill and shop. Allow inspectors free access to necessary parts of the premises.

5. Mill Orders and Shipping Statements.
Provide the Engineer with as many copies of mill orders and shipping statements (showing the weights (mass) of individual members) as may be requested.

6. Rejection.
Approval of any material or finished members will not be a bar to their subsequent rejection, if found defective. Promptly replace, or make good, rejected material and work.

Q. Shop Painting.
This portion describes surface preparation and shop painting of weathering and non-weathering structural steel and incidental parts, as well as the requirements for water washing of weathering structural steel. The work includes the following items: preparation of all surfaces to be painted, application of paint, protection, drying of paint coatings, and repairing and repainting of coating damaged in the shop or after erection, or both.

1. Surface Preparation.

a. General.

1) Provide a near white metal blast cleaning to steel surfaces to be painted according to SSPC-SP10. First clean bearing assemblies of any surface contamination using suitable solvents according to SSPC-SP1, and then provide a near white metal blast cleaning according to SSPC-SP10. The standard used for acceptance of the surface preparation will be SSPC-VIS 1, Visual Standard for Abrasive Blast Cleaned Steel.

2) Do not blast clean machined surfaces designated in the contract documents to have a surface roughness of ANSI 125 (3.125 µm) or less. Masking or other protection is required if these parts are subjected to the blast cleaning process.

3) Use a clean, dry abrasive free from organic contamination. After blasting, thoroughly clean the surface to be painted with dry, oil free, compressed air to remove all blast residue.

4) Achieve a sharp, angular blast profile of a minimum 1 mil (25 µm) and maximum 3 mils (75 µm) on all surfaces, including thermal cut edges. When shot is used for blasting, use a blast media containing at least 10% steel grit.

b. Non-weathering Structural Steel Applications.

1) Remove oily or greasy residues with solvent according to SSPC-SP1, Solvent Cleaning, before the top coat is applied.

2) Ensure surfaces to be top coated comply with the specifications and are dry.

c. Weathering Structural Steel Applications.

1) For weathering structural steel applications, provide a Commercial Blast according to specification SSPC-SP6 to surfaces not requiring painting.

2) After blasting, apply at least three uniform applications of water mist (at 24 hour intervals between applications) to all unpainted areas of outside surfaces of the fascia girders to ensure uniform weathering. Apply each application on dry surfaces.

Perform the water mist application within 48 hours after the painted surfaces have been properly cured. Ensure all water mist applications are witnessed by a representative of the Contracting Authority.

2. Painting.

a. General.

1) Perform shop painting only in a facility approved by AISC, SSPC, or the Engineer. Allow only painters who are trained and certified by an independent outside agency for the type of work performed to apply the paint.

2) Prior to painting, ensure all surfaces are free of all moisture, dirt, oxidation products, oil, and other detrimental material, and is of a suitable temperature according to the manufacturer's recommendations. Follow the paint manufacturer's application recommendations regarding mixing, thinning, application, pot life, steel temperature, and weather conditions. Apply paint so the painted areas have a smooth, uniform, adhering coat that is free of over-spray, dry spray, mud cracking, runs, sags, cracks, holidays, or other defects.

3) Do not paint machined surfaces with small clearances between moving components, such as full circle pins and pin holes, partial circle pins and pin recesses in castings, and similar surfaces. Instead, shop coat these surfaces with an application of waterproof multipurpose grease complying with National Lubricating Grease Institute No. 3, or other approved protective coating. Thoroughly clean machined surfaces before applying grease. Apply protective coating as soon as practical after component parts have been machined, welded if required, and blasted.

4) Before erection, wipe machined surfaces clean and apply a second shop coat of the same grease used above.

b. Non-weathering Structural Steel Applications.

1) General.

a) Use prime coat and topcoat paints manufactured by the same company. Protect painted surfaces to prevent soiling during painting and through the tack-free stage. Take care not to damage the paint system during handling, delivery, storage, and erection of the structural steel. Repair prime coat damage attributable to shop activities according to the paint manufacturer's recommendations before shipment to the field. Repair topcoat damage according to the manufacturer's recommendations.

b) Shop apply a prime coat to structural steel surfaces, including faying surfaces of high strength bolt connections. Also shop apply a prime coat to all bearing assemblies, except galvanized masonry plates and galvanized swedged bolts unless specified otherwise in the plans.

2) Shear Studs.

a) When shear studs are welded to the top of the top flange of a beam or girder after the paint system is applied, grind the paint off in the areas of the weld to facilitate welding.

b) After welding, repair paint damage on the underside of the top flange. Touch-up on the top side of the top flange is not required (this will be covered with PCC).

3) Prime Coat.

a) Apply a coat of zinc silicate paint to all surfaces as soon as possible after blasting and before formation of any surface rust, and no later than 16 hours after blasting the surface. Approved paints are shown in Materials I.M. 482.02, Appendix A. Use a target average dry film thickness of 4 mils (100 µm) with no spot measurement below 3 mils (75 µm) or above 6 mils (150 µm).

b) Perform repairs or build-up of the paint film as soon as possible, and no later than 24 hours from the initial application.

c) Completely reblast and repaint steel members with coating areas measuring less than 3 mils (75 µm) that have not been corrected within 24 hours.

d) Correct, to the Engineer's satisfaction, all defects in application such as runs, sags, mud cracking, over-spray, and dry spray.

e) Excessive coating thickness is as equally undesirable as unacceptably thin coating thickness, and both will be sufficient cause for rejection. Excessive thickness will be evaluated on a case-by-case basis in consultation with the coating manufacturer.

f) Inorganic zinc silicate paint film will be considered cured and ready for shipment after achieving a resistance rating of 4 as verified by 50 Methyl Ethyl Ketone (MEK) rubs as per ASTM D 4752. Moisture misting and plastic tenting may be required during cold application temperatures and low relative humidity conditions to aid in prime coat curing.

4) Top Coat.

a) When designated by the contract documents, shop apply a topcoat of waterborne acrylic paint to all primed surfaces. Paint galvanized fasteners according to Article 2408.02, Q, 2, b, 5, after bolting. It is recommended that application be initiated with a mist coat applied prior to full coat application. To avoid moisture condensation, keep the top coat under a roof, protected from dirt, dust, and moisture, in an area where the temperature is maintained above 40°F (5°C) for a minimum 24 hours after painting is completed.

b) Shield concrete at all junction points of concrete and steel so that application of paint on steel is complete without overspray on the concrete.

c) Approved paints are listed in Materials I.M. 482.05, Appendix A. Ensure the dry film thickness of the top coat is a minimum of 2 mils (50 µm). Unless otherwise specified in the contract documents, use a topcoat color that is Iowa standard foliage green Federal Color Standard Number 14223.

5) Field Repair and Painting.

a) After erection, repair and repaint paint damage due to transportation, handling, or construction activities. Use an approved zinc rich epoxy paint listed in Materials I.M. 482.02, Appendix C, for repairing primer, priming un-galvanized fasteners, and any coating damage to galvanized fasteners.

b) Ensure areas to be repaired and repainted are clean, dry, and free from grease, oil, corrosion products, and other detrimental materials. Do not apply paint to surfaces unless they are free from moisture or frost. Follow the paint manufacturer's recommendations for repair.

c) When designated by the contract documents, include a field applied waterborne acrylic topcoat.

6) Cleaning of Paint Surfaces.
Upon completion of concrete placement, clean exposed structural steel surfaces to remove all concrete and laitance before the concrete sets up.

c. Weathering Structural Steel Applications.

1) Apply a coat of zinc silicate paint to all surfaces as soon as possible after blasting and before formation of any surface rust, and no later than 16 hours after blasting the surface. Approved paints are shown in Materials I.M. 482.02, Appendix A. Ensure the minimum average dry film thickness is 4 mils (100 µm) with no spot measurement below 3 mils (75 µm) or above 6 mils (150 µm). Perform any repairs or build up to the applied prime coat as soon as possible and no later than 24 hours from the initial application.

2) Apply a top coat of waterborne acrylic paint from the approved list shown in Materials I.M. 482.05, Appendix A, to the primed surfaces after the primer has cured to a resistance rating of 4 as verified by 50 MEK rubs as per ASTM D 4752. Use a top coat color matching Federal Color Standard Number 20045. Ensure the top coat covers all the primed surfaces, except faying surfaces of bolted joints, with a uniform film of paint. Apply the top coat in the shop unless otherwise permitted in writing by the Engineer.

3) Paint the following areas:

a) All the weathering steel for a distance of 1.5 times the girder depth on each side of the expansion joints.

b) All the bearing assemblies except galvanized masonry plates and galvanized swedged bolts unless specified otherwise in the plans.

c) Embedded girder ends over the entire embedment length plus an additional distance of 1.0 foot (300 mm). Seal the crevice between the embedded steel and concrete by caulking with a neutral cure and non-sag silicone. Two products meeting these criteria are Dow 888 or CSL 342 joint seal.

d) Prepare exterior surfaces of all galvanized components indicated in the plans to be painted and all galvanized floor drains according to the written recommendations of the paint manufacturer. Paint with the same type of

waterborne acrylic paint used for top coat as noted in this specification.

4) After erection of the bridge, prepare all fasteners in the painted areas using suitable hand tools, mechanical tools, or blasting equipment. Prime with a zinc rich epoxy paint from the approved list shown in Materials I.M. 482.02, Appendix C. Clean the primed surfaces and apply a top coat of waterborne acrylic paint from the approved list shown in Materials I.M. 482.05, Appendix A. Use a top coat color matching Federal Color Standard Number 20045.

5) After completing construction, prepare and repaint defects or damage to the paint system.

6) Ensure all steel surfaces are free of contaminants, including dirt or concrete.

R. Marking and Shipping.

1. Ship pins, small parts, and small packages of bolts, washers, and nuts in boxes, crates, kegs, or barrels. Do not allow the gross weight (mass) of any package to exceed 300 pounds (135 kg). Plainly mark a list and description of the contained material on the outside of the shipping container.

2. Pack bolts of one length and diameter and loose nuts or washers of each size separately. Also pack items from different manufacturers or from different lots separately.

S. Shop Storage of Material.
Store structural material, whether plain or fabricated, above ground upon platforms, skids, or other supports. Keep it free from dirt, grease, and other foreign material.

2408.03 CONSTRUCTION.

Place the steel superstructure on a substructure constructed as provided in Section 2405. Apply the requirements of Sections 2403, 2404, 2410, 2411, 2412, 2413, and 2508 to the various types of construction.

A. Working Drawings, Shop Drawings, Changes, and Substitutions.
Submit detailed shop drawings according to Article 1105.03. Welding procedures will be considered an integral part of shop drawings and will be reviewed for each contract.

1. All material ordered or work done prior to review of the shop drawings is at the Contractor's risk. Ensure shop drawings for steel structures give detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts, such as pins, nuts, bolts, drains, etc.

2. Ensure shop drawings identify each piece that is to be made of steel required to be other than ASTM A 709/A 709M Grade 36 (Grade 250) steel. Ensure pieces made of different grades of steel are not given the same assembling or erecting mark, even though they are of identical dimensions and detail.

3. Sections other than those shown on shop drawings reviewed by the Engineer may be used under the following provisions:
- **a.** The substitute section is equal in strength and stiffness to the section originally shown.
- **b.** The substitution is approved by the Engineer.
- **c.** The substitution is made at no additional cost to the Contracting Authority.

4. Ensure shop drawings for steel structures show accumulated dimensions for each line of beams or girders in laydown. Ensure the accumulated dimensions are shown at the locations of the following details: bearings, welded or bolted splices, stiffeners, gusset plates, and drain connecting holes.

B. Welding.

1. Comply with ANSI/AWS D1.1 Structural Welding Code procedures and requirements for the following items, except comply with AASHTO/AWS D1.5M/D1.5-02 as modified below for filler metal and welder qualification requirements.
- **a.** Bridge Components and Miscellaneous Items. This includes bearing assemblies, sole plates, expansion joint devices, pile and appurtenances, drainage system components, guardrail connections, metal railing, chain link enclosures and wire fence components, conduit systems, and tread plates.
- **b.** Traffic Signal Components.
- **c.** Sign Support Components.
- **d.** Lighting Structure Components.
- **e.** Pre-Engineered Pedestrian Bridges.

2. Comply with AASHTO/AWS D1.5M/D1.5-02, as modified by this specification, for welding and fabricating steel structures.

3. Each of the modifications in this article is referenced by the appropriate paragraph number in AASHTO/AWS D1.5M/D1.5-02, to which it is a modification.

Table of Contents
for
Modifications to ANSI/AASHTO/AWS D1.5 95 Bridge Welding Code

SECTION 1. General Provisions

1.3 Welding Processes

ADD the following Paragraphs after the existing 1.3.1:

1.3.1.1 Welding of main members and welding of attachments thereto shall be performed using only shielded metal arc, flux cored arc, submerged arc, and/or stud welding processes. Unless otherwise approved by the Engineer, all welding of butt splices and flange to web welds and stiffeners to web welds shall be done using the submerged arc process. Shielded metal arc welding may be used for repairs to butt splices and flange to web welds.

1.3.1.2 The WPS shall be initialed by the welder and posted at the welder's workstation at all times during welding operations.

REPLACE Paragraph 1.3.2 with the following:

Electroslag (ESW) and electrogas (EGW) welding are specifically disapproved for use.

SECTION 3. Workmanship

3.2 Preparation of Base Metal

ADD the following paragraph before the existing first Paragraph 3.2.2:

For main members, thermal cutting is limited to oxygen cutting except that plasma arc cutting of web and stiffeners may be used when approved by the Engineer.

DELETE the last sentence of Paragraph 3.2.7 which reads "Excess Camber may be corrected by heating without the engineer's approval."

3.5 Dimensional Tolerances

REPLACE all of the text and tables of Paragraph 3.5.1.3 with the following:

Camber of main members of continuous or simple span bridges with lines composed of rolled beams, beams and girders, or girders, shall be fabricated so that when the members are assembled in laydown with bearing points accurately positioned as shown on the erection diagram, points on any member shall not vary in the offset position from that indicated in the erection diagram by more than ± 1/2 inch (13 mm).

The erection diagram on the shop drawings shall show camber offsets at bearing points and splice points, and at midpoints of individually cambered beams or girders.

REPLACE Paragraph 3.5.1.4 with the following:

Permissible variation in specified sweep for horizontally curved welded beams or girders is

$$\frac{\pm\ 1/8 \text{ in. x No. of ft. of total length}}{10} \quad (\pm\ 1 \text{ mm/m of the total length})$$

provided the member has sufficient lateral flexibility to permit the attachment of diaphragms, cross-frames, lateral bracing, etc., without damaging the structural member or its attachments.

REPLACE Paragraph 3.5.1.14 with the following:

Mechanically connected joints and splices of main members with surfaces intended to be parallel planes shall be nearly parallel after

connection, and the surfaces to be in contact shall have an offset no greater than 1/16 inch (1.6 mm) after all filler plates have been added, if any. The accuracy of the angle of connecting stiffeners, angles, or plates shall be ± 0.5 degrees, when measured at the hole locations.

3.7 Repairs

REPLACE Paragraph 3.7.4 with the following:

Prior approval of the Engineer shall be obtained for repairs to base metal, repair of major or delayed cracks, or for a revised design to compensate for deficiencies.

ADD the following paragraph before the existing Paragraph 3.7.7:

The approval of the Engineer is required for all corrections of mislocated holes.

ADD the following Paragraph after the existing 3.7.7:

3.7.8 The maximum number of repairs to unacceptable defects in a butt splice shall be three, i.e., the times a butt splice may be opened, welded closed, and resubmitted for NDT inspection, unless otherwise approved by the Engineer.

SECTION 5. Qualifications

Part A. General Requirements

5.2 Qualification Responsibility

REPLACE Paragraph 5.2 with the following:

To qualify welding procedures, the Contractor shall produce test weldments, perform nondestructive testing and machine specimens for mechanical testing in accordance with this code. The Contracting Authority will witness the production of test weldments and conduct mechanical tests.

Part B. Welder, Welding Operator, and Tack Welder Qualification

5.21 General Requirements

REPLACE Paragraph 5.21.4 with the following:

Shop welder's, welding operator's, or tack welders qualification herein specified shall be considered as remaining in effect from the end of the month in which the tests were taken, for a period of 1 year. The qualification for the above may be extended annually, based on a letter from the fabricator/Contractor certifying that they have been engaged in the process(es) for which they qualified without interruption of more than 6 months during the preceding twelve months, or by requalification. The

field welder's qualification herein specified will be considered as remaining in effect from the end of the month in which the test was taken, for a period of 1 year. For field welders who have successfully passed their qualification tests without failure for 3 consecutive years, requalification will only be required every 2 years. Requalification may be required at any time there is a specific reason to question a welder's ability to make sound welds.

5.21.6 Responsibility

REPLACE Paragraph 5.21.6.1 with the following:

To qualify welders, welding operators, and tackers, the Contractor shall furnish test weldments, and perform nondestructive testing in accordance with this code. The Contracting Authority shall witness the production of test weldments and conduct mechanical tests. The Contractor may, at no additional cost to the Contracting Authority, engage an outside firm or agency to witness production of test weldments and conduct mechanical tests. The acceptance of work performed by an outside firm or agency is the prerogative of the Contracting Authority.

5.23 Qualification Tests Required

ADD Subparagraph 5.23.1 (5) after the existing 5.23.1 (4):
Plate weld tests may also be accepted for qualification of welding pipe piling of any diameter.

REPLACE Paragraph 5.23.3 with the following:

Tack Welder Qualification. A tack welder shall be qualified by fillet-weld-break specimen made using the same criteria as listed for plate-fillet welder qualification in Table 5.6. The tack welder shall make a 1/4 inch (6 mm) maximum size tack weld approximately 2 inches (50 mm) long on the fillet-weld-break specimen, as shown in Fig. 5.28.

SECTION 6. Inspection

Part A. General Requirements

6.7 Nondestructive Testing

REPLACE Subparagraph 6.7.1.2(1) with the following:

100% of each joint subject to tension or reversals of stress, except that on vertical butt weld splices in beam or girder webs, only 1/3 of the web depth beginning at the point, or points, or maximum tension need be tested. If unacceptable discontinuities are found in the first 1/3, the remainder of the weld shall be tested.

REPLACE Subparagraph 6.7.1.2(2) with the following:

50% of each joint subject to compression or shear in each main member as specified, except that longitudinal butt weld splices in beam or girder webs need not be tested by radiographic or ultrasonic testing unless so specified in contract document. If unacceptable discontinuities are found the first 50% of joint, the entire length shall be tested.

Part B. Radiographic Testing of Groove Welds in Butt Joints

6.10 Radiographic Procedure

ADD the following Paragraph after existing 6.10.5.3:

6.10.5.4 Where areas being radiographed are adjacent to the edge of the plate, edge block shall be used.

6.12 Examination, Report, and Disposition of Radiographs

REPLACE Paragraph 6.12.3 with the following:

Two sets of radiographs shall be taken for welds subject to radiographic testing, including any that show unacceptable quality prior to repair. One radiograph of each test shall, upon completion of Q.C. and Q. A. interpretation, be forwarded to the Office of Materials, Ames, Iowa. The second set of radiographs shall be retained by the Contractor as part of on-site inspection records. Upon completion of the project, this second set will become the property of the Contractor.

C. Shop Assembly.
Assemble the various parts of the structure in the shop as follows:

1. If zinc silicate primer is to be used, clean and shop paint surfaces which will be in contact before assembly according to the contract documents. If zinc silicate primer is not to be used, carefully clean to be free from loose mill scale, dirt, or other foreign material, surfaces which will be in contact. Do not paint before assembly.

2. After assembly, paint and protect all surfaces, except those against which plastic concrete will be placed, as provided in Article 2408.03, X, and the contract documents.

3. Ensure members are free from objectionable twists, bends, or other deformations.

4. Bring members to be welded into correct alignment and hold in position by bolts, clamps, wedges, guylines, struts, tack welds, or other suitable devices, until welding is completed. Use jigs and fixtures where practical. Allow for warpage and shrinkage.

D. Drifting of Bolt Holes.
Allow drifting during assembling only to the extent of bringing the parts into position, but not sufficient to enlarge the holes or distort the metal.

E. Facing Bearing Surfaces.

1. Mill ends of columns and pedestals to true surfaces and correct bevels. Plane warped or deformed base and cap plates to fit accurately.

2. Attach connection angles for base and cap plates to columns before ends are faced. Perform milling only after the member has been fully assembled.

3. Mill bearing surfaces of warped or deformed base and cap plates that are not to be placed in contact with concrete after the plates are attached to the column. Ensure surfaces of base plates that are to be placed in contact with concrete are free from warps and other deformations.

4. All bearing surfaces of castings are to be machined flat. Ensure that:
- Sole plates of beams, girders, and trusses have full contact with the flanges, and the bearing surface is smooth and true and is truly perpendicular to the web of the member.
- Curved sole plates make full line bearing with masonry plates, which line (unless shown otherwise in the contract documents) is at right angles to the axis of the beam, girder, or truss, and with the web of the member.
- Bottom surfaces of masonry plates are free from warps and projections.

5. For bearing material in contact with other material, except as otherwise indicated, apply the following tolerances for flatness:
- 1/32 inch in 12 inches (1 mm in 400 mm), and
- 1/16 inch (2 mm) tolerance overall.

6. The degree of surface finish required will be indicated in the contract documents. Ensure the surface finish of bearing and base plates and other bearing surfaces that are to come into contact with each other or with concrete meet the surface roughness requirements as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part 1. Unless indicated otherwise on the plans, finish the following parts to the degree indicated in Table 2408.03-1:

Table 2408.03-1: Surface Finish

Steel slabs including masonry plates and cast shoes in contact with concrete	ANSI 2,000 (50 µm)
Heavy plates in contact in shoes to be welded	ANSI 1000 (25 µm)
Milled ends of compression members, stiffeners, and fillers	ANSI 500 (12.5 µm)
Bridge rollers, rockers, and top surfaces of masonry plates in contact with rollers and rockers	ANSI 250 (6.25 µm)
Pins and pinholes	ANSI 125 (3.125 µm)
Slide bearings	ANSI 125 (3.125 µm)

7. Ensure surfaces of bronze bearing plates intended for sliding bearings are smooth and free from surface projections.

8. In machining sliding bearing surfaces, set the cut of the tool to be in the direction of movement. In machining nonsliding bearing surfaces, set the cut of the tool to be either parallel or normal to the direction of movement.

F. Abutting Joints.

1. **Ends of Compression Members.**
Accurately face abutting ends of compression members after the members are assembled, to secure an even bearing when assembled in the structure.

2. **Ends of Tension Members.**
Neatly shear or cut ends of tension members at splices with openings not exceeding 1/4 inch (6 mm).

3. **Splices of Continuous Beams and Girders.**
Neatly shear or cut ends of beams and girders to be spliced with a minimum opening of 1/8 inch (3 mm) and a maximum opening not exceeding 1/4 inch (6 mm) for rolled beam spans and 1/2 inch (13 mm) for plate girder spans. This dimension shall be detailed on the shop drawings.

G. End Connection Angles.
Ensure end connection angles of floor beams and stringers are flush with each other and accurately set to position and length of member. In general, do not machine end connection angles unless indicated in the contract documents. However, faulty assembling may be cause for requiring them to be milled. In this case, do not reduce their thickness by more than 1/16 inch (2 mm). Do not reduce their bolt bearing value below the design requirements.

H. Pin Clearance.
Ensure the diameter of the pin hole does not exceed that of the pin by more than 1/50 inch (0.5 mm) for pins 5 inches (125 mm) or less in diameter, or 1/32 inch (0.8 mm) for larger pins.

I. Finished Members.
Ensure pieces forming one built up member are straight and close fitting. Ensure finished members are true to detailed dimensions and free from twists, bends, open joints, or other defects resulting from faulty fabrication or defective work.

J. Shop Erection.

1. Completely assemble the main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames for inspection in the shop when complete assembly is feasible. In lieu of

complete assembly, at the option of the Contractor, progressive truss or girder assembly will be permissible, as follows:

a. Initially for each truss, arch rib, bent, tower face, or rigid frame:
- Assemble at least three contiguous shop sections, or
- In the case of structures longer than 150 feet (45 m), assemble all members in at least three contiguous panels, but no less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices) and no less than 150 feet (45 m).

b. In order that the assembled portion of the structure is never less than specified above, include a sufficient number of sections or chord lengths in each laydown so the assembled portion will remain long enough when the rearward section or chord is removed after inspection of the laydown. At the Contractor's option, the portion of the structure which is retained may be disassembled and reassembled in a new location for the new laydown.

c. Initially for each continuous beam or plate girder line, assemble at least three contiguous shop sections. In the case of structures larger than 150 feet (45 m), assemble no less than 150 feet (45 m) of structure. Accomplish each succeeding laydown in such a manner that at least one contiguous section is retained from the previous laydown, and no less than 150 feet (45 m) of structure is assembled (except that the last laydown in a line may be less than 150 feet (45 m) long). At the Contractor's option, the portion of the structure which is retained may be disassembled and reassembled in a new location for the new laydown.

2. As shop sections are progressively assembled and removed, place each retained section in the new laydown with the same relative orientation to the erection base line as it was found to have in the previous laydown.

3. As shop sections are progressively assembled and removed, scribe suitable marks on the sections remaining so that accurate center to center of bearing dimensions and overall length can be achieved.

K. Field Handling and Storage.

1. Load, transport, unload, and pile structural members so the metal will be kept clean and free from damage by rough handling. Pad shipping supports, lifting devices, and deck form support points to minimize paint damage.

2. Store material in a manner to prevent deterioration by rust or loss of minor parts. Do not pile material to rest upon the ground or in water; instead, place material on suitable skids or platforms. Place girders and beams upright and shore. Ensure skids beneath long members, such as columns or chords, are close enough to prevent damaging the members by deflection.

L. Falsework.

1. Provide detailed plans for falsework or centering, according to Article 1105.03. In no case is the Contractor relieved of responsibility for results obtained by use of these plans or safety of workers on the project. Have the Engineer review and check the adequacy of falsework before erecting the structure which the falsework is to carry.

2. Design falsework for supporting steel during erection to carry, without appreciable settlement or deformation, the full load coming upon it. Use either full length pile bents or framed bents supported by piles or spread footings.

3. Determine bearing values of piles according to Article 2501.03, H, and set them to be at least equal to the loads imposed upon them during construction.

4. To determine the number and size of spread footings or mudsills to be used, use the load to be supported and the bearing value of the soil on which they rest, giving due consideration to soils softening during high water, frozen ground thawing, etc. Do not use mudsills on soils or in situations where scour may occur.

5. Use 1500 pounds per square foot (70 kPa) as a safe bearing value for sand, gravel, firm clay, and other similar confined materials in beds thicker than the falsework footing width.

6. If necessary to extend falsework above the elevation to which piles are driven, cut off at least the majority of all piles in any bent at the same elevation and cap. Construct a framed bent to the required height. Cap each falsework bent transversely at the proper elevation with material of adequate size securely fastened to each pile or post in the bent. Securely brace all bents longitudinally and transversely with diagonal bracing.

M. Preparation of Bearing Area.

1. Ensure column bases, truss and girder pedestals, and shoes have a full uniform bearing upon the concrete of the substructure.

2. Correct bridge seats of piers or abutments which are improperly finished, deformed, or irregular within the bearing area of masonry plates before the plates are placed.

3. Bed the pedestals and shoes for truss and girder spans, as well as columns for steel viaducts, on the bearing area so as to have full and even bearing. Unless otherwise required, use a bedding consisting of a single layer of 1/8 inch (3 mm) sheet lead meeting requirements in Article 4195.01.

N. Handling Members.

1. Handle component parts of a structure using methods and appliances that does not produce damage to the member by twisting, bending, or otherwise deforming the metal.

2. Do not place any member that is slightly bent or twisted into its place until its defects are corrected.

3. Members that have been seriously damaged in handling may be rejected.

O. Straightening Bent Material.

1. When the Engineer permits straightening of plates, angles, other shapes, and built up members, straighten using methods that will not produce fracture or other injury. Straighten distorted members using mechanical means.

2. If the Engineer approves, distorted members may be straightened by the carefully planned and supervised application of a limited amount of localized heat, except perform heat straightening of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel members only under rigidly controlled procedures, with each application requiring the Engineer's approval. In no case allow the maximum temperature of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel to exceed 1125°F (610°C), or allow the temperature to exceed 950°F (510°C) at the weld metal or within 6 inches (150 mm) of the weld metal. Do not apply heat directly on weld metal. In all other steels, do not allow the temperature of the heated area to exceed 1200°F (610°C) (a dull red) as controlled by use of temperature indicating crayons, liquids, or bimetal thermometers.

P. Straightening Material and Placing Members.

1. Rolled material shall be straight when it is laid out for work. If straightening is necessary, do so by means which will not damage the metal.

2. Sharp kinks or bends is sufficient cause for rejection of the material.

3. Perform heat correction only when the Engineer approves. Heat straightening of ASTM A 709/A 709M Grade 100/100W (Grade 690/690W) steel will not be permitted.

4. Unless otherwise shown in the contract documents or ordered by the Engineer, place members which deviate from a straight line by an amount within the tolerance specified in ASTM A 6/A 6M in the structure in such a manner that the stress to be imposed will tend to straighten the member.

5. Heat straighten parts to be substantially free of stress and external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

6. Inspect metal surface following straightening of a bend or buckle for evidence of fracture. Repair or replace members showing fracture.

Q. Assembling Steel.

1. Accurately assemble parts as shown in the contract documents. Follow a match-marking system.

2. Handle material so that parts will not be bent, broken, or otherwise damaged. Do not hammer in a manner which will damage or distort the members.

3. Clean bearing surfaces and surfaces to be in permanent contact before the members are assembled.

4. Ensure important connections in trusses, girders, floor systems, and so forth have at least 25% of the holes on each side of the connection filled with drift pins, and another 25% of the holes on each side of the connection filled with temporary fitting up bolts drawn up snugly before the temporary support is removed. If the ultimate connection is to be made with high strength bolts, these bolts may be used as fitting up bolts. At milled connections of compression chords of truss spans, except the hip connection, the number of drift pins may be reduced to no less than 10% of the number of holes.

R. Alignment.

1. Before placing permanent bolts in field connections, adjust the structure to correct grade and alignment. For truss spans, block up the elevation of each panel point (ends of floor beams) on the falsework to the correct camber as shown in the contract documents and shop drawings. Leave this blocking in place until all tension chord splices are fully bolted and all other truss connections are pinned and bolted.

2. Support splice joints of continuous beams and girders using adequate falsework or other approved means as directed by the Engineer. Adjust as closely as possible to the required position before bolting is started.

S. Bolting.

Make main connections with high strength bolts, nuts, and washers meeting the requirements of Article 4153.06. All other fasteners will be considered non-high strength fasteners and may be used only where shown on the plans.

1. **Length of Bolts.**
   a. Ensure the length of high strength bolts so that, when properly installed in a snug tight condition, the end of the bolt is flush with or outside the face of the nut.

b. Ensure the length of non-high strength bolts so that when tightened there is no less than 1/4 inch (6 mm) of bolt protruding from the nut.

c. Ensure the length of turned bolts so that when the nut is fully threaded there is no more than:
- 1/8 inch (3 mm) of thread within the thickness of metal to be gripped, and
- 1/4 inch (6 mm) of thread protruding from the nut.

d. Furnish ribbed bolts in a variety of diameters and lengths that:
- When installed will result in a drive tight fit, and
- When tightened will fill the nut and protrude no more than 3/16 inch (5 mm).

2. Bolt Holes.
Ensure holes for non-high strength and high strength bolts permit free entry of the bolt without driving. Carefully ream holes for ribbed bolts to provide for a driving fit. Ream holes for ribbed bolts to be cylindrical and to permit entry of the bolts at right angles to the faying surfaces.

3. Storage of High Strength Fasteners.
Protect bolts, nuts, and washers from the elements.

4. Fastener Acceptance Testing.

a. Prior to steel erection and in the presence of the Engineer, test two representative fastener assemblies from each rotational-capacity test lot as described in Materials I.M. 453.06B. A fastener assembly consists of a bolt, nut, and washer from the same rotational-capacity lot as furnished by the supplier.

b. The Engineer may order additional rotational-capacity tests if there is reason to suspect any change in fastener condition or level of lubrication.

c. Failure of rotational-capacity tests will be cause for rejection of that fastener lot.

5. Installing High Strength Fasteners.
Assemble, tension, and inspect high strength fasteners as described below. In special cases other methods may be used with prior approval of the Engineer.

a. Assembly.

1) Ensure that:
- Surfaces of bolted parts adjacent to the bolt head and nuts are parallel.
- Bolted parts fit solidly together when assembled, without containing gaskets or any other flexible material.
- Holes are no more than 1/16 inch (2 mm) in diameter greater than the nominal bolt diameter.

2) For slotted holes, the dimensions will be shown on the plans or shop drawings.

3) For painted applications, clean and prime the faying surfaces with zinc silicate paint. For unpainted applications, blast clean faying surfaces to:
- Remove mill scale, and

- Be free from paint, lacquer, dirt, oil, burrs, pits, or other defects which would prevent the solid seating of parts or would interfere with the development of friction between parts.

4) Ensure the fastener assembly installed in the field is made up of bolts, nuts, and washers from the same rotational-capacity lot number. Assemble fasteners with one hardened washer under the turned element (either bolt head or nut). When galvanized fasteners are specified:
- Furnish nuts that are pre-lubricated with a dyed lubricant according to ASTM A 563, or
- Field lubricate fastener threads with beeswax or other approved wax-based lubricant.

5) Use high strength weathering fasteners for weathering structural steel. Use galvanized high strength fasteners for non-weathering structural steel, with or without a specified field top coat.

6) Properly tighten each fastener to at least the minimum bolt tension shown in Table 2408.03-2:

Table 2408.03-2: Minimum Bolt Tension

Bolt Dia. inches (mm)	Min. Bolt Tension, lbf.[(a)] (kN[(a)])	Bolt Dia. inches (mm)	Min. Bolt Tension, lbf.[(a)] (kN[(a)])
1/2 (12.7)	12,050 (53.6)	1 1/8 (28.6)	56,450 (251.1)
5/8 (15.9)	19,200 (85.4)	1 1/4 (31.8)	71,700 (318.9)
3/4 (19.0)	28,400 (126.3)	1 3/8 (34.9)	85,450 (380.1)
7/8 (22.2)	39,250 (174.6)	1 1/2 (38.1)	104,000 (462.6)
1 (25.4)	51,500 (229.1)		

[(a)] Equal to the proof load (length measurement method) given in ASTM A 325.

7) Tighten high strength bolts using the turn-of-nut method.

8) Ensure impact wrenches (if used) are of adequate capacity and sufficiently supplied with air to develop the minimum tension of each bolt in approximately 10 seconds.

b. Turn-of-Nut Method.

1) Use the turn-of-nut method to provide the minimum bolt tension specified above.

2) Install bolts in all holes of the connection and bring to a "snug tight" condition. Consider bolts to be "snug tight" when tensioned to approximately 20% of the minimum bolt tension listed above and faying surfaces are in full contact. If full contact of faying surfaces is not achieved after all bolts have been tensioned to 20% of minimum tension, submit a corrective procedure to the Engineer for approval.

3) Systematically progress with snug tightening starting at the center of the connection and working out to the free edges. Check the fasteners of the connection in a similar systematic manner. Retighten as necessary until all fasteners are

simultaneously in a "snug tight" condition and the faying surfaces are in full and continuous contact.

4) When all fasteners in the connection are "snug tight", match-mark the face of the connecting part, the nut, and the bolt point using paint, crayon, or other approved means to provide a reference for determining the relative rotation of the parts during final tightening.

5) Following this operation, tighten all fasteners in the connection further by the applicable amount of rotation specified in Table 2408.03-3. Systematically progress with tightening starting at the center of the joint and working out to the free edges. During this operation, do not rotate the part without using the wrench.

Table 2408.03-3: Nut Rotation from "Snug Tight" Conditions[(a)] (Disposition of Outer Faces of Bolted Connections)

Bolt Length (Under side of head to end of bolt)	Both faces normal to bolt axis	One face normal to bolt axis and other slope not more than 1:20 (beveled washer not used)	Both faces sloped not more than 1:20 from normal to the bolt axis (beveled washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters[(b)]	2/3 turn	5/6 turn	1 turn

[(a)] Nut rotation is relative to the bolt, regardless of the element (nut or bolt) being turned. For bolts installed using 1/2 turn and less, use a tolerance of ± 30 degrees. For bolts installed using 2/3 turn and more, use a tolerance of ± 45 degrees.

[(b)] For bolt lengths exceeding 12 diameters, the required rotation must be determined by actual field tests in a suitable tension measuring device which simulates conditions of solidly fitted steel.

c. Inspection.

1) Check bolted connections, after tightening, in the presence of the Engineer for proper installation, applicable rotation, and general joint condition. The inspection of fasteners, with a torque wrench, at connections of steel diaphragms to concrete beams will not be required.

2) Furnish and use an inspecting wrench which is calibrated and capable of measuring torque.

3) To calibrate the inspecting wrench:
- **a.** Select a representative sample of no less than three bolts and nuts of each diameter, length, grade, and turned element, to be tensioned that day.
- **b.** Check the samples prior to inspection in a device capable of indicating bolt tension. Turn the same element during testing that will be turned during actual work.
- **c.** Use the inspecting wrench to tension the bolt and determine the torque necessary to achieve a bolt tension 5% greater than the specified minimum bolt tension.
- **d.** Use the average of the three torque values for the job inspecting torque value(s).

4) Establish the job inspecting torque value(s) at least once prior to each day's inspection. Have an approved testing agency calibrate the tension measuring device at least every 6 months.

5) Inspect installed and tightened fasteners, represented by the above tests, for acceptance by attempting to tighten the fastener using the inspection torque wrench and the predetermined inspection torque value(s). Acceptance will be based on the random checking of at least 10% of the fasteners in each connection. A minimum of two fasteners per connection will be checked. The connection will be accepted as properly tightened if:
- The faying surfaces are in full and continuous contact, and
- No bolt or nut is turned at a torque value less than or equal to the inspection torque value(s).

6) If any bolt or nut is turned at torque values below the inspection torque value(s), check all fasteners in that connection. Tighten and reinspect all bolts or nuts which turn below inspection torque values.

7) Bolts tightened by the turn-of-nut method may reach tensions substantially above the values specified, but this is not cause for rejection.

d. Reuse of Bolts.

1) Do not reuse high strength bolts and nuts. Do not incorporate construction bolts or fit-up bolts into the final connection.

2) Tensioning of fasteners up to a snug-tight condition as described in Article 2408.03, S, 5, will not be considered as reuse.

3) Retightening (touching up) previously tightened bolts which may have been loosened by the tightening of adjacent bolts will not be considered as reuse.

T. Swinging the Span.

After permanent bolting of truss spans has been inspected and accepted, remove the centering and swing the span free on its permanent supports. Fully bolt all main connections before the span is swung, except permanently bolt milled compression chord connections after the span is swung.

U. Adjustment of Pin Nuts.
Adjust nuts on pins to the amount specified in the contract documents. Locate pins in the holes so the members take full and even bearing.

V. Setting Anchor Bolts.

1. Refer to Article 2405.03, H, for setting anchor bolts for bridge bearings.

2. Set anchor bolts, other than those for bridge bearings, in concrete with a polymer grout, according to Article 2405.03, H, or with a mechanical grip system. When the mechanical grip system is used:
- Ensure the diameter of the hole is suitable for the device used,
- Hold the anchor firmly in place using an expanding metal device approved by the Engineer, and
- Fill the annular space with cement grout or other material approved by the Engineer.

W. Setting Rocker Bearings.

1. Adjust rocker bearings at expansion ends of spans to provide for:
- Movement due to temperature,
- Elongation of bottom chord, and
- Probable substructure movement.

2. Assume a mean temperature of 50°F (10°C) when determining temperature movements.

X. Field Painting.
Field paint steel structures or parts of structures as required in the contract documents.

2408.04 METHOD OF MEASUREMENT.

The Engineer will compute the quantity of various items of structural concrete, steel reinforcement, structural steel, and incidental metal parts involved in construction of steel structures as follows:

A. Structural Concrete.
Article 2403.04 applies.

B. Steel Reinforcement.
Article 2404.04 applies.

C. Structural Steel and Incidental Metal Parts.

1. Structural Steel.

a. The weight (mass) of structural steel measured for payment includes the weight (mass) of:
- rolled shapes and plates, as fabricated, and
- incidental parts, such as castings, bearing plates, expansion devices, bolts, and incidental metal parts necessary for completion of the structure.

b. Unless the contract contains a separate item for metal railings, material for such railings is included with structural steel. Incidental materials, such as bronze, wrought iron, lead, castings, and so forth will be classed as structural steel unless covered by a separate item in the contract.

c. Reinforcement for concrete is not included in this item.

2. Weight (Mass).

a. The weight (mass) of structural steel as defined above, for which payment will be made, is the weight (mass) in pounds (kilograms) computed by the Engineer as shown in the contract documents. In the case of a substitution, by the Contractor, of a heavier section than that shown, the weight (mass) of the section shown in the contract documents is the measured quantity.

b. The weight (mass) of structural steel, computed by the Engineer and shown in the contract documents, is presumed to be correct and provides the basis of payment. If the Contractor presents evidence that the weight (mass) computed by the Engineer is in error by more than 0.50%, the weight (mass) will be recomputed.

3. Variation in Weight (Mass).

If the weight (mass) of any member is less than 97.5% of the computed weight (mass), such member may be rejected.

4. Computed Weight (Mass).

a. The Engineer will compute the weight (mass) of structural steel on the basis of the following assumptions:

1) Steel: 490 pounds per cubic foot (7850 kg/m^3)

2) Cast Iron: 450 pounds per cubic foot (7210 kg/m^3)

b. The weight (mass) of rolled shapes and plates is computed on the basis of their nominal weights (mass) and dimensions as shown in the contract documents, deducting for copes and cuts.

c. The weight (mass) of welds is to be included in the computed weight (mass), assuming the weights (mass) of fillet welds to be used as in Table 2408.04-1:

Table 2408.04-1: Weight (Mass) of Welds

Size of Weld in. (mm)	Wt. per Linear Ft., lb. (Mass per Meter), (kg)	Size of Weld in. (mm)	Wt. Per Linear Ft., lb. (Mass per Meter), (kg)
1/4 (6) 5/16(8) 3/8 (10)	0.16 (0.21) 0.25 (0.38) 0.36 (0.59)	1/2 (13) 5/8 (16) 3/4 (19)	0.64 (0.99) 1.00 (1.51) 1.44 (2.13)

d. The weight (mass) of heads, nuts, single washers, and threaded stick through all high strength shop bolts is to be included in the computed weight (mass) on the basis of the weights (mass) shown in Table 2408.04-2:

Table 2408.04-2: Weight (Mass) of Bolts

Dia. Of Bolt in. (mm)	Wt. per 100 Bolts, lb. (Mass per 100 Bolts), (kg)	Dia. Of Bolt in. (mm)	Wt. Per 100 Bolts, lb. (Mass per 100 Bolts), (kg)
12 (12.7)	19.7 (8.9)	1 1/8 (28.6)	165.1 (74.9)
5/8 (15.9)	31.7 (14.4)	1 1/4 (31.8)	212.0 (96.2)
3/4 (19.0)	52.4 (23.8)	1 3/8 (34.9)	280.0 (127.0)
7/8 (22.2)	80.4 (36.5)	1 1/2 (38.1)	340.2 (154.3)
1 (25.4)	116.7 (52.9)		

e. The computed weight (mass) includes the total weight (mass) of field bolts as specified in Article 2408.02, C, and the total weight (mass) of shims required to be furnished for incorporation into the structure.

f. The weight (mass) of castings will be computed from the dimensions shown in the contract documents with an addition of 5% for fillets and overrun.

D. Surface Preparation and Painting Structural Steel.
Surface preparation and painting structural steel will not be measured.

2408.05 BASIS OF PAYMENT.

Payment for various items of Structural Concrete, Steel Reinforcement, Structural Steel, and Incidental Metal Parts will be as follows:

A. Structural Concrete.
Article 2403.05 applies.

B. Steel Reinforcement.
Article 2404.05 applies.

C. Structural Steel and Incidental Parts.

1. Contract unit price per pound (kilogram) or lump sum for metal railing and structural steel.

2. Payment is full compensation for:

- Furnishing all materials.
- Preparation, including fabrication, nondestructive testing and inspection required by the contract documents, transportation, and erection.
- Furnishing all labor.
- Equipment.
- Incidentals to complete the structure including the surface preparation and painting of the completed structure.
- Repair and cleaning of the paint at the shop and after erection.

D. Surface Preparation and Painting Structural Steel.
Incidental to the structure.

Section 2409. Timber Structures

2409.01 DESCRIPTION.

Construct structures composed wholly of timber or of timber combined with structural steel or concrete.

2409.02 MATERIALS.

Use materials for timber construction that meet requirements of Division 41 for the respective material as follows:

A. Timber and Lumber.
Use untreated structural parts to be painted that are furnished surfaced on four sides. Use stringers that are surfaced on two edges, top and bottom. Use timber that is furnished rough for all other sawed timber, unless specified otherwise.

1. Untreated Structural and Common Timber.
Apply Section 4162.

2. Treated Timber.
Apply Section 4163.

3. Piling.
Apply Section 4165.

B. Steel.
Apply Section 4152 to steel rods for tension members or tie rods for wingwalls, all plates and structural shapes, and all drift pins and dowels. Apply Section 4151 to concrete reinforcement.

C. Hardware and Nails.
Apply Article 4153.07.

D. Paint.
Use the paint specified in the contract documents.

E. Wood Preservative.
Apply Article 4160.01.

F. Waterproofing Materials.
Use the waterproofing materials specified in the contract documents.

G. Timber Connectors.

1. Use connectors for resisting shearing stresses between tension members and for spreading the stress over the entire member that are of a design the Engineer approves. Fabricate connectors from metal and make them rugged enough to withstand handling and installing without damage.

2. When the contract documents specify tie rods to be coated with waterproofing, first clean the rods according to Article 2508.01, A, and then paint according to the manufacturer's recommendations.

3. For fastening and bracing other members to piles, use bolts in a variety of lengths which will conform to the diameter, shape, and position of the piles so that extra washers or shims will not be required to take up the extra length of bolt.

H. Concrete.
Use concrete in connection with timber structures that meets requirements of Section 2403.

2409.03 CONSTRUCTION.

A. General.

1. Apply the provisions of Sections 2401, 2402, 2403, 2404, 2405, 2408, and 2501 to various phases of the construction. Build timber portions of the structure to comply with the contract documents and requirements of this section.

2. Ensure all framing is true and exact. Drive nails and spikes with no more force than what is required to set the heads flush with the wood surface. Deep hammer marks in wood surfaces will be considered as evidence of poor work quality. Use washers under all bolt heads and nuts which would otherwise be in contact with wood.

3. Carefully handle treated timbers without sudden dropping, breaking of outer fibers, bruising, or penetrating the treated surface with tools, such as cant hooks, peaveys, timber tongs, or pike poles.

B. Storage of Materials.

1. Store lumber and timber delivered to the work site in neat piles. Clear the ground underneath and in the vicinity of material piles of all weeds and rubbish. Arrange lumber piles to shed water and prevent warping. If stored over a long period, further protect wood piles with a suitable covering.

2. Open stack untreated lumber on suitable skids at least 12 inches (0.3 m) above ground and above possible high water.

3. Close stack and pile treated timber and treated piling. When stored for long periods, cover the tops of stacks and ends of pieces to protect the material from the direct sunlight.

4. Store miscellaneous material and hardware so as to prevent loss or damage.

C. Holes for Bolts, Dowels, Rods, and Screws.

1. Bore the holes for drift bolts and dowels 1/16 inch (2 mm) smaller than the nominal diameter of the bolt or dowel used. Bore the holes for lag screws with a bit no larger than the body of the screw at the base of the thread.

2. Bore the holes for rods and bolts, other than drifts and dowels, to diameters as follows:
- **a.** In timber that is to be treated, bore the holes 1/8 inch (3 mm) larger than the nominal diameter of the bolt or rod used.
- **b.** In timber that has already been treated or that is not to be treated, bore the holes to be the same as the nominal diameter of the bolt or rod used.
- **c.** Countersink the heads of bolts or lag screws that would interfere with traffic or with other structural parts.

D. Treatment of Treated Pile Heads.
Treat all surfaces of treated pile heads cut after treatment with material specified in Section 4161.

E. Framing.

1. Accurately cut all lumber and timber and frame to a close fit in such manner that joints will have even bearing over the entire contact surfaces.

2. Bore the holes in all stringers, rails, posts, post blocks, and scupper blocks before the timber is treated. Complete all cutting, framing, and boring of treated timbers before treatment, whenever practical. Whenever boring or framing must be performed after preservative treatment, treat newly exposed surfaces as follows:
- **a.** Apply two coats of copper naphthanate to all daps, cuts, chamfers, and all abrasions, after carefully trimming these features.
- **b.** Apply two coats of copper naphthanate to all countersunk holes before the bolt is placed.

3. Ensure grooves and daps for timber connectors make a tight fit with that part which is embedded in wood. For types of connectors which permit, draw adjacent wood surfaces into tight contact with each other. For types which will not permit this surface contact, fill the opening left by the connector with plastic cement troweled upon the surface before the joint is finally assembled. After assembly, strike off flush excess plastic cement that is squeezed out, and point fill any opening in the joint.

F. Pile Bents.

1. Drive pile bents as accurately as possible in the correct location and to vertical or batter lines indicated on the plans. If a pile is driven out of line, straighten it without damage before cutting it off or bracing it. Remove and replace piles driven below grade or damaged in driving or

straightening if so directed by the Engineer. Do not shim the tops of piles.

2. Carefully select, as to size, piles for any one bent to avoid undue bending or distortion of sway bracing.

3. Accurately cut off piles to ensure satisfactory bearing between the cap and all piles of a bent. Trim edges of piles outside the cap to a slope approximately 45 degrees with horizontal.

G. Framed Bents.

1. Construct framed bents as shown in the contract documents. In general, they will be supported by piles cut off approximately 3 feet (1 m) above ground level.

2. Remove soil from contact with sills to allow free circulation of air.

3. Fasten sills to the piles. Fasten posts to sills using dowels no smaller than 3/4 inch (19 mm) in diameter, projecting into both pile and sill no less than 6 inches (150 mm).

H. Caps.

1. Place timber caps to secure an even, uniform bearing on the top of supporting piles or posts. Fasten them to the piles using drift pins no less than 3/4 inch (19 mm) in diameter, extending at least 9 inches (225 mm) into the piles.

2. Place drift pins approximately in the center of the pile or cap. When steel channel caps are used, accurately shape the tops of all piles to provide a snug fit in the caps.

I. Bracing.

1. Bolt the ends of bracing through the pile, post, or cap with bolts no less than 5/8 inch (16 mm) in diameter. Fasten intermediate intersections with bolts and spikes as shown in the contract documents. Use spikes in addition to bolts in all cases.

2. Avoid notching the piles or shimming under the bracing whenever possible.

J. Stringers.

1. Size stringers at bearings and place in position so that knots near the edges are in top portions of the stringers. Outside stringers may have butt joints. Lap the interior stringers to take full bearing on caps. Fasten stringers to caps as shown in the contract documents.

2. Use bridging that is of the size and type shown in the contract documents. With untreated stringers and floors, place bridging so that

an air space of at least 1 inch (25 mm) is left beneath the floor. With treated stringers and floors, place bridging flush with the top of the stringers.

K. Painting.

1. Wood surfaces of the structure which are to be painted will be designated in the contract documents. Clean all surfaces to be painted according to Article 2508.01, A, 1 and 2. Paint with a paint system specified in the contract documents. Paint according to the paint manufacturer's recommendations.

2. Paint all metal work, except galvanized hardware, as provided in Article 2408.02, Q.

L. Decks.
Construct decks for timber structures of the type specified in the contract documents. Construct decks according to the provisions of Sections 2410, 2411, and 2412.

2409.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the quantity of timber and lumber in thousands of board feet (cubic meters) from the nominal width and thickness, and the length measured to the nearest foot (0.1 m) for the material used in the finished work.

B. The weight (mass) of structural steel measured includes net weights (the mass) of rolled shapes or plates, of rods used as tension members, and of all bolts and rivets used to fasten steel parts together.

C. The weight (mass) of drift bolts, dowels, washers, bolts, and other hardware used to fasten wood parts together or to steel members will not be included in the weight (mass) of structural steel. The weight (mass) of these items is included in the weight (mass) of miscellaneous hardware. The Engineer will compute the weight (mass).

D. Spikes and nails are incidental to timber construction and will not be measured separately for payment.

2409.05 BASIS OF PAYMENT.

A. Payment for the quantities involved in timber structures will be according to the following:
- Excavation for Structures: Section 2402.
- Structural Concrete: Section 2403.
- Steel Reinforcement: Section 2404.
- Structural Steel: Section 2408.

B. Payment for miscellaneous hardware will be the contract unit price per pound (kilogram).

C. Payment for treated and untreated timber and lumber will be the contract unit price per thousand board feet (cubic meter), which includes the cost of spikes and nails.

D. Payment is full compensation for:
- Furnishing all materials, equipment, and labor, and
- Performance of all incidental work necessary to complete the structure in conformance with the contract documents.

Section 2410. Plank Decks

2410.01 DESCRIPTION.
Furnish and install either treated or untreated single or double plank decks according to the contract documents.

2410.02 MATERIALS.
Use materials meeting the requirements of the contract documents.

A. Lumber.
Use treated or untreated lumber as specified. Apply Section 4163 to treated lumber, and Section 4162 to untreated lumber.

B. Hardware.
Apply Article 4153.07.

2410.03 CONSTRUCTION.

A. General.

1. Lay rough planks with no more than 1/4 inch (5 mm) opening between the planks. Do not allow adjacent planks to vary more than 1/4 inch (5 mm) in thickness. Tightly fit surfaced planks together to present a smooth, uniform surface without variation due to difference in thickness or surfacing of the planks.

2. When the design requires wood stringers or nailing strips on steel beams, securely spike each plank to each nailing strip, or joist with no less than two wire spikes. Use spikes 3 inches (75 mm) longer than the nominal thickness of the plank.

3. Securely fasten all shims and scupper blocks to the plank deck. Cut ends of the plank to a true line parallel to the center line of the roadway.

4. Unless alternate hardware is provided, attach the deck to steel stringers or joists by steel clips, or by pins driven through the flange, using a process subject to approval of the Engineer. Ensure clips are securely held between the planks by double pointed nails or by hooks or fins on the clips which engage both adjacent planks. When double pointed nails are used, use 20d for 3 inch planks and 40d for 4 inch planks (5.72 mm diameter by 100 mm long for 75 mm planks and 6.65 mm diameter by 125 mm long for 100 mm planks). Position clips so that they will hold the

plank in close contact with the top flanges of beams to prevent the planks from working loose due to relative movement between the planks and flanges.

5. If methods the Contractor uses for driving adjacent planks onto double pointed nails indicate damage to the plank or unsatisfactory joints, the Engineer may require the Contractor to jack the plank into position hydraulically with no less than three jacking points per plank. Sledges and blocks may be used to facilitate jacking.

6. Ensure timber for subfloors for asphalt wearing surface or for double plank decks are given full pressure preservative treatment as specified in Section 4161, unless specified otherwise in the contract documents.

B. Single Plank Decks.
Construct single plank decks to consist of a single layer of wood planks of the size and type specified. When the plank deck is to be covered with asphalt wearing surface, use deck planks surfaced on at least one face and one edge.

C. Double Plank Decks.
Construct double plank decks to consist of two layers of planks supported by stringers or joists. Lay the lower course of planks parallel to bridge abutments. Lay the top course parallel to the roadway center line. Fasten each top course plank to the lower course by spikes placed in pairs at intervals of no more than 4 feet (1.2 m). Use spikes 3 inches (75 mm) longer than the nominal thickness of the plank. At bridge ends, bevel planks in a manner to provide a smooth riding surface.

2410.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the quantity of Plank Deck Lumber used in plank decks in thousands of board feet (cubic meters) as provided in Article 2409.04.

B. Nails, clips, and other hardware are incidental to plank deck construction and will not be measured separately for payment.

2410.05 BASIS OF PAYMENT.

A. Payment for Plank Deck Lumber will be the contract unit price per thousand board feet (cubic meters) for the types and grades of lumber specified in the contract.

B. Payment is full compensation for:
- Furnishing all lumber, nails, miscellaneous hardware, and other materials, and
- Performance of all incidental work necessary to complete the structure according to the contract documents.

Section 2411. Laminated Wood Decks

2411.01 DESCRIPTION.

Furnish and install treated laminated decks according to the contract documents and the following provisions.

2411.02 MATERIALS.

A. Lumber.
Install deck strips of the nominal dimensions shown on the plans. Use deck strips that are:

- Of common class timber, either Douglas Fir or Southern Pine, meeting requirements of Article 4162.05,
- Surfaced on four sides, and
- Treated with preservative according to Section 4161.

B. Hardware.
Apply Article 4153.07.

2411.03 CONSTRUCTION.

A. Place deck strips on edge and securely nail to preceding strips with at least one nail in each space between stringers or joists. Use nails that are no less than 2.5 times longer than the nominal thickness of the strips. For decks with wood stringers or with nailing strips on steel beams, nail each deck strip to each stringer or nailing strip with 20d (5.72 mm diameter by 100 mm long) nails.

B. When instructed in the contract documents, attach laminated decks directly to steel beams by means of clips. Securely nail each clip to deck strips with no less than two 20d (5.72 mm diameter by 100 mm long) nails. Position clips so they will hold the plank in close contact with top flanges of beams to prevent the plank from working loose due to relative movement between the plank and flanges.

C. Place and fasten successive strips to bear firmly on all supports and to be in close contact with the preceding strip. Do not allow the space between any two adjacent strips to exceed 1/8 inch (3 mm). Ensure the surface of the completed deck shows no variation in elevation greater than 1/8 inch (3 mm) between adjacent strips.

D. Cut the ends of the strips in lines parallel to the center line of the roadway.

E. Crown the roadway surface to provide deck drainage, when specified in the contract documents.

2411.04 METHOD OF MEASUREMENT.

A. The Engineer will compute the quantity of lumber used in Laminated Wood Decks in thousands of board feet (cubic meters) from the nominal widths and thicknesses of the strips and overall dimensions of the floor parallel to the length of the strips.

B. Nails, clips, and other hardware will be considered incidental and will not be measured separately for payment.

2411.05 BASIS OF PAYMENT.

A. Payment for Laminated Wood Deck will be at the contract unit price per thousand board feet (cubic meters) for common class lumber as defined in Section 4162.

B. Payment is full compensation for:
- Furnishing all lumber, hardware, and other material, and
- Performance of all incidental work necessary to complete the structure in accordance with the contract documents.

Section 2412. Concrete Bridge Decks

2412.01 DESCRIPTION.
Construct concrete decks on timber stringers, concrete beams, or steel girders. Apply Sections 2403 and 2404.

2412.02 MATERIALS.

A. Use materials for concrete decks meeting the requirements for the respective materials in Division 41.

B. Use concrete that meets the requirements for C-4WR and C-V47B concrete mixtures, as specified in Materials I.M. 529. Use Gradation No. 3 or 5 of the Aggregate Gradation Table in Section 4109. Meet the requirements of Section 4108 for fly ash and GGBFS. Refer to Table 2412.02-1 for the maximum allowable substitution rates:

Table 2412.02-1: Maximum Allowable Substitution Rates.

Cement Type	Maximum Allowable Substitution[(a)]	Time Period
Type I, Type II	35% GGBFS 20% Fly Ash	March 16 through October 15
Type IS, IP	0% GGBFS 20% Fly Ash	March 16 through October 15
Type I, II, IS, IP	0% GGBFS 0% Fly Ash	October 16 through March 15
[(a)] Maximum total mineral admixture substitution is 50%.		

C. Either the contract documents or the Engineer may require a retarding admixture. Use a water reducing/retarding admixture meeting the requirements of Materials I.M. 403, Appendix B, according to Section 2403. When placements require extended working times, increase the dosage rate for the appropriate working time and temperature. For placements requiring

normal working times, set the dosage rate according to Section 4103. The Engineer may approve other admixtures.

D. Use retarding admixtures compatible with the air entraining agent used. Previous experience, satisfactory to the Engineer, will be required to indicate the approximate adjustments in proportions made necessary by the addition of the admixture and compatibility with other materials used. Agitate the retarding admixture prior to and during its use.

E. Use a single source of cement during an individual placement. Drain all aggregate for at least 24 hours after washing and before batching.

2412.03 CONSTRUCTION.

When a two course construction with a second course of bridge deck surfacing or other wearing course is specified, use the requirements of Section 2413 or in the contract documents for the second course. When an overlay for an existing deck in conjunction with repair is specified, use the requirements of Section 2413 or in the contract documents for the overlay and repair.

A. Swinging the Span and Support of Forms.

1. Before concrete is placed in the floor of a steel span, strike the centering of the span and swing the span free on its permanent supports. Support the forms for concrete decks and curbs entirely by the beams which are to support the concrete, unless specified otherwise in the contract documents.

2. Unless the Engineer approves, do not use temporary welds to attach hangers to steel beams to support deck form joists according to Article 2408.03, B. Galvanized hangers may remain exposed in the finished structure.

3. Do not weld on structural steel in the field, unless allowed in the contract documents or approved by the Engineer.

B. Placing Reinforcement.

1. Accurately place all reinforcement in the positions shown in the contract documents. Do not weld reinforcing steel unless allowed in the contract documents or approved by the Engineer.

2. In lieu of tying requirements in Article 2404.03, D, tie reinforcement rigidly using wire at alternate intersections so 50% of the intersections are tied. For steel fabric reinforcement, use electrically welded rectangular mesh in flat sheets.

3. Support horizontal reinforcement using an adequate number of supports as specified in Article 2404.03, E. Hold the upper horizontal reinforcement securely in place with tiedowns a maximum of 4 feet (1.2 m) apart to ensure the reinforcement will not rise during concrete placement.

4. Allow the Engineer to inspect and approve reinforcement placing and fastening. The Engineer's approval is required before concrete can be placed in a deck. Make adjustments when checks indicate anticipated concrete cover over reinforcement different than specified in the contract documents. If the lack of concrete cover over reinforcement is due to over camber of the beams or improper elevation of beam splice points, adjust the beam haunch to provide proper cover, while maintaining a smooth profile for the length of the deck.

5. When the self propelled finishing machine described in Article 2412.03, D, is required, check the elevation of upper reinforcement using this machine (properly adjusted for finishing) with a suitable attached template adjusted to detect any reinforcement too close to the surface. Set the template to a tolerance of minus 1/4 inch (6 mm) to allow clearance of wire ties.

C. Placing Concrete.

1. Place concrete deck sections according to the sequence shown in the contract documents or as modified by the Engineer.

2. When cold weather protection is necessary, do not place concrete without the Engineer's written permission.

3. Do not place concrete if the temperature of the plastic concrete, at the time of placing exceeds 90°F (32°C). The Contractor may (at their own expense) cool the plastic concrete below 90°F (32°C) by a method the Engineer approves.

4. Do not place concrete if the theoretical rate of evaporation for that day exceeds 0.2 lbs. per square foot per hour (1 kg/m^2 per hour). Use the Theoretical Rate of Evaporation Chart located within the appendix to calculate the theoretical rate of evaporation. For this chart, use:

- The National Weather Service's maximum air temperature, relative humidity, and maximum steady wind velocity without gusts for the date and the location of the concrete deck placement, and
- The temperature of plastic concrete at time of placement.

D. Surface Finish.

1. After placing and vibrating the concrete as provided in Articles 2403.03, C and D, promptly strike it off with a template to provide a smooth surface with the proper crown. Ensure supports for the strike off template are parallel to the center line of the structure, firmly fastened in place, and set to the correct elevation. Include proper allowance for deflection caused by the concrete. Ensure screed supports extend sufficiently beyond each end of the bridge to accommodate the strike off template or finishing machine. Ensure they provide support for bridges when operating a longitudinal float. If required, provide any or all of the items specified in Article 2301.03, A, 3, which may be adapted to the work.

2. In lieu of the above requirements, apply the following to all bridges longer than 60 feet (20 m):
- **a.** After depositing and vibrating the concrete as provided in Articles 2403.03, C and D, promptly strike it off to the proper elevation using an approved self propelled and mechanically operated finishing machine.
- **b.** Ensure the finishing machine operates on adequately supported rails adjusted to conform to the grade specified. Include allowance for anticipated dead load deflection shown in the contract documents.
- **c.** Ensure supporting rails extend beyond each end of the bridge a sufficient distance to accommodate the finishing machine.
- **d.** Ensure the finishing machine will not cause undue deflection of the bridge members or falsework.
- **e.** The screeds of the finishing machine may be of metal or metal shod wood.
- **f.** Make a sufficient number of passes with the finishing machine to obtain a void free surface struck off to the elevation specified.
- **g.** Finishing machines other than as described above will be considered for approval.

3. After the final pass of the finishing machine or after the floating operation (if used), smooth the surface to meet the requirements of Article 2301.03, H. Check with 10 foot (3 m) straightedges. Correct surface irregularities.

4. After smoothing and checking for smoothness, promptly give the surface a final finish while the concrete is still plastic. When the contract documents show a second course of bridge floor surfacing or other wearing course, finish the surface of the first course with a burlap drag. Smooth and check the final surface for smoothness without additional finishing for one course bridge decks on Interstate and Primary projects.

- **a. Interstate and Primary Projects.**
  - **1)** Transverse grooving or tining in plastic concrete of bridge decks (and bridge approaches when included in the bridge project) will not be allowed unless otherwise stated in the contract documents.
  - **2)** Cut longitudinal grooves into hardened concrete surfaces using a mechanical cutting device. Perform longitudinal grooving after surface correction grinding.
  - **3)** Ensure longitudinal grooves are:
    - **a)** 1/8 inch ± 1/64 inch (3 mm ± 0.4 mm) wide,
    - **b)** 1/8 inch +1/32 inch or -1/16 inch (3 mm +0.8 mm or -1.6 mm) deep, and
    - **c)** Uniformly spaced at 3/4 inch (19 mm) intervals measured center to center of groove.
  - **4)** Terminate longitudinal grooving approximately 6 inches (150 mm) from bridge joints.
  - **5)** Ensure longitudinal grooving on the bridge deck and double reinforced bridge approach sections is not placed within the area approximately 1.5 feet (0.5 m) adjacent to the curbs. To accommodate varying widths of grooving equipment, the width

of the ungrooved area adjacent to curbs may be up to 3.0 feet (0.9 m).

6) Ensure longitudinal grooving of single reinforced and non-reinforced bridge approach sections is not placed within 6 inches (150 mm) of the edge of outside lane lines.

7) For staged bridge and bridge approach construction:

a) The Contractor may cut longitudinal grooves in the hardened concrete at the end of each stage of construction or wait until all stages have been completed. If the Contractor elects to delay cutting of the longitudinal grooves until completion of all stages, apply an interim course broom finish on the concrete deck and bridge approach during placement for all stages opened to traffic.

b) Within 30 calendar days following completion of the last stage of the project, establish temporary lane closures to accomplish longitudinal grooving for all stages.

c) The interim coarse broom finish will not be allowed as a surface texture when opened to traffic over a winter season. If the interim coarse broom texture is present and the Contractor is not in a position to finish all stages of the project, cut longitudinal grooving into the hardened concrete in order to establish an acceptable driving surface texture for the winter season.

b. Other Projects.

When the surface being placed is the wearing course, apply a suitable grooving by hand methods to the entire surface, except the area within approximately 2 feet (0.6 m) of the curbs. Apply grooving similar to that described in Article 2301.03, H, 3, with the following exceptions:

- Transverse to the centerline of the roadway.
- Randomly spaced from 3/4 inch to 1 5/8 inches (20 mm to 40 mm) with no more than 50% of the spacings exceeding 1 1/4 inches (30 mm) with a minimum of four different spacings in a 2 foot (0.6 m) width.

5. When the surface being placed is the final surface of a bridge sidewalk, give the surface of the sidewalk a transverse coarse broom texture.

6. Apply Section 2428 to smoothness of the completed deck surface for Primary projects and when specifically required for other projects.

E. Curing Concrete Decks.

Use burlap prewetted with sufficient water, prior to placement, to prevent absorption of moisture from the concrete surface. Keep the burlap wet.

1. Place the first layer of prewetted burlap in the following manner:

a. Interstate and Primary Projects.

Place on the concrete within 10 minutes after final finishing.

b. Other Projects.

Immediately after final finishing and grooving, cover the area finished with white pigmented curing compound meeting

requirements of Article 4105.05 applied at a maximum rate of 135 square feet per gallon (3.3 square meters per liter). Place the first layer of prewetted burlap on the concrete within 30 minutes after the concrete has been finished and grooved.

2. As soon as practical, but no later than 2 hours after placing the first layer, place a second layer of burlap on the deck.

3. Apply water to the burlap covering for a period of 4 calendar days. Use a pressure sprinkling system that is effective in keeping the burlap wet during the moist curing period. The system may be interrupted only to replenish the water supply, during periods of natural moisture, or during construction contiguous to the concrete being cured. The Engineer may approve interruptions for periods longer than 4 hours on the basis of the method for keeping the concrete moist.

4. Maintain continuous contact, except as noted above, between all parts of the concrete deck and the burlap during the 4 calendar day moist curing period.

5. On concrete decks placed after October 1 and prior to April 1, after 20 hours of the application of water, the Contractor may substitute the application of a moisture proof plastic film no less than 3.4 mils (86 µm) thick over the wet burlap in lieu of applying water. Maintain intimate contact between the surface of the concrete, the burlap, and the plastic film.

F. Curbs.
Place curbs and barrier railing separately from the deck slab. Place them in the manner shown in the contract documents.

G. Expansion Joints.
Locate and construct expansion joints as shown in the contract documents. If steel expansion plates are required, the Contractor for the superstructure shall furnish and install all such plates including those required at the end of the bridge.

H. Filling and Sealing Joints.
After removing dummy filler strips, allow the concrete to harden during the remainder of the cure period. Clean and complete the joint after it has dried. Use filler and sealer meeting the requirements of Section 4136. When the type is not specifically designated, furnish resilient filler.

1. When using premolded filler, shape it to the proper cross section. Place it in a manner that leaves at least a 1/2 inch (15 mm) deep space in the joint from surface to filler. Seal the space above the filler. Joint edge priming may be required if the sealer manufacturer recommends. Carefully fill the space completely without smearing adjacent concrete. After the sealer has set, the surface may be lightly covered with Portland cement to prevent tracking from traffic.

2. When contract documents require an elastomeric compression type preformed seal, use material of the nominal dimensions shown. Use a heavy duty type for bridge floor application with a rated capacity which will accommodate the joint movement. Submit, for prior approval, the manufacturer's name and a description of the specific seal to be used. Ensure steel armor fabrication shop details comply with the manufacturer's recommended setting depth. Install the elastomeric compression seal according to the contract documents, the manufacturer's recommendations, and the follow provisions:

a. Install the seal using suitable hand or machine tools. Thoroughly secure in place with lubricant adhesive covering both sides of the seal over the full area in contact with the sides of the joint. Adhesive may be applied to the concrete or steel joints or to the seals or in combination. Install seals in a substantially fully compressed condition. Unless the contract documents or manufacturer's recommendations specify otherwise, install at least 1/4 inch (5 mm) and no more than 1/2 inch (15 mm) below the surface at all points.

b. For transverse joints across roadways, use a one piece seal for the full width of the transverse joint. For longitudinal joints, provide the seal in lengths as long as is practical. Seal all joints between lengths of seals with additional adhesive.

c. Seals may be installed in concrete joints immediately after the curing period using the lubricant-adhesive. Observe the manufacturer's temperature limitations for the adhesive. Ensure joints are clean, dry, and free of all foreign material immediately prior to seal installation. Repair spalled surfaces in concrete joints to the Engineer's satisfaction.

2412.04 METHOD OF MEASUREMENT.

A. Measurement for structural concrete, reinforcement, and structural steel will be according to Articles 2403.04, 2404.04, and 2408.04, respectively.

B. Longitudinal Grooving in Concrete, in square yards (square meters), will be the plan quantity shown in the contract documents.

2412.05 BASIS OF PAYMENT.

A. Payment for structural concrete, reinforcement, and structural steel will be according to Articles 2403.05, 2404.05, and 2408.05, respectively.

B. Payment is full compensation for furnishing all materials, equipment, and labor and for performing all work necessary to complete the structure in conformance with the contract documents.

C. When Section 2428 applies, payment may be modified as specified therein.

D. Deductions will not be made for the volume of concrete displaced by deck drains, expansion joints, shear lugs, beam flanges, and joint material. The cost of joint material and metal strips for sealing joints is included in the

contract unit price per cubic yard (cubic meter) for structural concrete. The weight (mass) in pounds (kilograms) of structural steel paid for includes all:

- Steel expansion plates,
- Castings of steel or iron,
- Welded shapes for deck drains,
- Bearing plates,
- Anchor bolts and other steel parts, except steel reinforcement for concrete and the associated metal fastenings.

E. The cost of any additional concrete required to meet the requirements of Article 2412.03, B, is incidental to the cost of the structural concrete.

F. Payment for Longitudinal Grooving in Concrete will be the contract unit price for per square yard (square meter).

Section 2413. Bridge Deck Surfacing, Repair, and Overlay

2413.01 DESCRIPTION.

A. Deck Surfacing.
Place a wearing course on the prepared surface of a new bridge deck. Perform other necessary work shown in the contract documents.

B. Deck Repair.

1. Class A Deck Repair.
Remove deck concrete below the level described for Deck Overlay, but less than full depth. Replace the excavated volume with concrete to a level bounding the Deck Overlay classification.

2. Class B Deck Repair.
Remove deck concrete below the level described for Deck Overlay for the full depth of the floor. Replace the excavated volume with concrete to a level bounding the Deck Overlay classification.

C. Deck Overlay.
Remove deck concrete to a depth 1/4 inch (5 mm) below the existing finished surface, and overlay with a concrete course of a depth designated. Unless specified otherwise in the contract documents, overlay is to accomplish a raise of the existing roadway surface and cover the entire concrete deck surface, including those areas to be repaired.

2413.02 MATERIALS.

A. Use materials meeting the requirements for the respective items in Division 41. When structural repairs are included in the project, Class C concrete may be mixed using equipment meeting requirements of Article 2413.03, A, 3. The concrete mixture used for the overlay may be used for the repair. Use the water and consistency specified in Article 2403.02, B, 2.

B. Use a single source of cement during an individual placement.

C. Apply Sections 4110 and 4115 to the aggregates. Use only those coarse aggregates specifically allowed by Article 4115.05 for this work.

D. Use one of the following mixes:

1. Class O Portland Cement Concrete.

a. Use Class O PCC meeting the requirements of Materials I.M. 529 and the following requirements:

1) The slump, measured according to Materials I.M. 317, shall be 3/4 inch (20 mm) with a maximum of 1 inch (25 mm) and no minimum requirement. Commence testing for concrete slump from a continuous mixer within 2 to 4 minutes after the concrete is discharged.

2) The intended air entrainment of the finished concrete is 6%. Ensure the air content of fresh, unvibrated concrete at the time of placement, as determined by Materials I.M. 318 is 6.5%, with a maximum variation of plus 2.0% and minus 1.0%.

b. Fly ash substitution is not permitted for Class O PCC.

2. Class HPC-O High Performance Concrete.

Meet the requirements of Materials I.M. 529 and the following:

a. A slump of 1 inch (25 mm) to 3 inches (75 mm), measured according to Materials I.M. 317, with a maximum of 4 inches (100 mm). Commence testing for concrete slump from a continuous mixer within 2 to 4 minutes after the concrete is discharged. Before placing ready mix concrete, test the slump.

b. Use a mid-range water reducing admixture meeting the requirements of Materials I.M. 403, Appendix C. The intent of the mid-range water reducer is to achieve a workable, dense, and low w/c ratio concrete. The Engineer may approve other admixtures or combinations of admixtures and dosages to achieve a workable low w/c ratio mix.

c. Air content is to be the same as required for Class O PCC.

d. Use Type IS or Type IP cement. If Type I/II is used, 25% replacement with GGBFS is required.

e. Limit fly ash substitution to 15% replacement by weight.

E. To bond new concrete to previously placed concrete, use a grout consisting of a mixture of about 5 to 6 gallons of water to each 94 pound bag (0.45 to 0.50 L/kg) of cement. Mix to a consistency such that the slurry can be applied with a stiff brush or broom to the previously placed concrete in a thin, even coating that will not run or puddle in low spots. An equivalent grout of Portland cement and water, applied by pressure spray may be substituted with approval of the Engineer. For sealing vertical joints between adjacent lanes and at the curbs, thin this grout to paint consistency.

2413.03 CONSTRUCTION.

A. Equipment.

Use equipment approved by the Engineer and complying with the following:

1. General.

a. Ensure the overall combination of labor and equipment for proportioning, mixing, placing, and finishing the new surface is of such minimum capability as to meet the requirements of Table 2413.03-1, except when noted otherwise in the contract documents.

Table 2413.03-1: Minimum Capacity and Labor Requirements

Total Surface Area per Bridge, sq. yd. (m^2)	Minimum Requirement, cu. yd. per hour (m^3 per hour)
0-328 (0-274)	1.0 (0.8)
329-492 (274.1-410)	1.5 (1.2)
493-656 (410.1-550)	2.0 (1.6)
over 656 (over 550.1)	2.5 (2.0)

b. Use a finishing machine designed so the elapsed time between depositing the mixture on the floor and final screeding does not exceed 10 minutes when the mixture is being mixed and placed at the specified minimum rate under normal operating conditions.

2. Preparation Equipment.

Use the following types of preparation equipment:

a. Sawing Equipment.
Use sawing equipment capable of sawing concrete to the specified depth.

b. Sandblasting or Shot Blasting Equipment.
Use sandblasting or shot blasting equipment capable of removing rust, oil, and concrete laitance from the existing surface of the bridge deck and exposed uncoated reinforcing bars.

c. Power Driven Hand Tools.
Power driven hand tools will be permitted with the following restrictions:

1. Do not use jack hammers heavier than nominal 30 pound class (14 kg)

2. Do not operate jack hammers or mechanical chipping tools at an angle exceeding 45 degrees measured from the surface of the deck.

3. Do not use chipping hammers heavier than a nominal 15 pound (7 kg) class.

d. Hand Tools.
Provide hand tools, such as hammers and chisels, for removal of final particles of unsound concrete or to achieve the required depth.

e. High Pressure Water Blasting Equipment.
Use high pressure water blasting equipment capable of removing rust, oil, concrete laitance, and unsound concrete from the existing surface of the bridge floor and exposed uncoated reinforcing bars.

3. Proportioning and Mixing Equipment.

a. Use proportioning and mixing equipment for Class O PCC or Class HPC-O that meets requirements of Articles 2001.20, E, and

2001.21, D. Use equipment capable of proportioning water accurately to within 1.0%. Use a rotating paddle type concrete mixer (construction or stationary). A continuous mixer used in conjunction with volumetric proportioning, described above, is acceptable.

b. Provide sufficient mixing capacity so the intended quantity can be placed without interruption.

c. The cement, fly ash, and GGBFS for Class HPC-O shall be pre-blended by the producer or by using equipment capable of thoroughly mixing the materials to the tolerances in ASTM C 685 when concrete is produced using a volumetric mixer.

d. For Class HPC-O, ready mixed concrete equipment meeting the requirements of Articles 2001.20 and 2001.21 is acceptable. For ready mixed concrete, the cement, fly ash, and GGBFS are not required to be pre-blended.

4. Placing and Finishing Equipment for Deck Surfacing and Deck Overlay.

a. Include adequate hand tools for placing the mixture and working it down to approximately the correct level for striking off with the screed. A self propelled finishing machine is required for all surfacing and overlays. Use a machine that operates on supporting rails which:

- Are adequately secured to the previously placed surface and are adjustable to the correct profile without shimming,
- Do not deflect under the load of the machine, and
- May be removed without damage to the edge of the new surface that remains in place.

b. When placing the mixture in a lane abutting a previously completed lane, equip the side of the finishing machine adjacent to the completed lane to travel on the completed lane. The Engineer will inspect the finishing machine. The Engineer's approval of the finishing machine is required before starting work on each project.

c. Use a finishing machine meeting the requirements of Article 2412.03, D. This machine shall be self propelled, capable of forward and reverse movement under positive control, and provide for raising all screeds to clear the screeded surface for traveling in reverse. The machine shall meet the following additional requirements for the type of mixture to be placed.

1) Class O Portland Cement Concrete.

The machine shall:

a) Have a mechanical strike off to provide a uniform thickness of mixture in front of the screed designed to consolidate the mixture by vibration, as specified.

b) Have a front screed designed to consolidate the mixture to be placed to 100% of the rodded density.

c) Have the bottom face for each screed at least 5 inches (125 mm) wide with a turned up or rounded leading edge to minimize tearing of the surface of the plastic concrete.

d) Have an effective weight (mass) for each screed at least 75 pounds for each square foot (365 kg/m^2) of bottom face area.

e) Have positive control of the vertical position, the angle of tilt, and the shape of the crown for each screed provided.

f) Be designed so that, together with appurtenant equipment, obtains positive machine screeding of the plastic concrete within 1 inch (25 mm) of the face of the existing curbs.

g) Have a screed long enough to:

- Extend at least 6 inches (150 mm) beyond the line where a saw cut is intended to form the edge of a subsequent placement section, and
- Overlap the sawed edge of a previously placed course at least 6 inches (150 mm).

2) Class HPC-O High Performance Concrete.
The machine shall:

a) Be capable of finishing the surface to within 1 foot (0.3 m) of the edges of the area being placed.

b) Have positive control of the vertical position of the screeds.

d. For Class O PCC, internal vibration equipment is required for consolidation at the edges of the placement.

B. Preparation of Surface for Deck Surfacing and Deck Overlays.

1. Remove material for test wells (for Class O PCC density testing) and all loose, disintegrated, or unsound concrete from the bridge deck, as designated by the Engineer. Test wells for nuclear density checks shall have nominal dimensions of 1 1/2 inches x 10 inches x 10 inches (40 mm x 250 mm x 250 mm). On bridge deck overlays, Class A bridge deck repair removal areas may be used as test wells provided they meet the nominal dimensions and are located in the testing frequency areas. Nuclear density testing of Class O PCC will be according to Materials I.M. 358.

2. For bridge deck overlays, uniformly scarify or prepare the entire existing concrete floor area to a depth of 1/4 inch (5 mm), except over areas of Class A and Class B repair where the 1/4 inch (5 mm) removal may be coincidental with operations for repair removal. Removal to a greater depth will be required at drains and elsewhere as noted in the contract documents. Measure the thickness of the concrete overlay from a level 1/4 inch (5 mm) below the original surface to a final raised surface as shown. Use a minimum thickness of abutting overlay of 3/4 inch (20 mm) and taper to the full designated thickness where removal to a level lower than 1/4 inch (5 mm) below the original surface is necessary because of surface fixtures.

3. Place all new concrete above the prepared surface for bridge deck surfacing at the thickness specified in the contract documents. The thickness of concrete above the prepared surface (for bridge deck surfacing) and above the prepared surface or reinforcing steel (for bridge deck overlay) is to be at least 1 3/4 inches (45 mm), and greater if specified in the contract documents. Check the thickness and clearance in the following manner before concrete is placed:

a. To the bottom of the screed, attach a filler block having a thickness 1/4 inch (5 mm) less than the overlay thickness. With screed guides in place, pass the screed over the area to be concreted. An alternate to passing the finishing machine is passing an approved template, supported by the screed guides, over the area to be concreted. Where the intended clearance does not allow use of this method, use a string line or other means as approved by the Engineer. If the filler block or other method used to check does not clear the area to be concreted, adjust the profile of the new surface to the Engineer's satisfaction.

b. Prepare the surface for placement of new concrete by sandblasting or shot blasting, followed by an air blast. Ensure this cleaning removes all dirt, oil, and other foreign material. Ensure it removes all unsound concrete, laitance, or loose material from the surface and edges against which the surface mixture is to be placed. The cleaning should roughen the surface in order to provide satisfactory bond with the surfacing mixture. Protect metal floor drains and areas of the curb or railing above the proposed surface from the cleaning.

c. Keep areas from which concrete has been removed free of slurry produced by wet sawing of concrete joints. Remove all slurry from prepared areas before placing new concrete.

d. Use hand tools to remove final particles of concrete or to achieve the required depth. Sandblast or shot blast the entire surface against which new concrete is to be placed, including curbs and exposed reinforcement. Remove all dirt, oil, and other foreign material, as well as any unsound concrete. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Clean the surface with an air blast immediately before applying grout in preparation for placement of concrete.

e. Do not presaturate existing concrete prepared for repair, surfacing, or overlay with water before placing grout and new concrete. Allow the prepared surface to dry to allow some absorption of the grout.

f. At the time of placement of either Class O PCC or Class HPC-O, ensure the area is clean and all exposed reinforcement free of rust. Rust forming overnight because of dew on clean reinforcement will not be considered objectionable, but reinforcement with a greater amount of rust must be recleaned before the concrete is placed. Clean the area by air blast before the concrete is placed.

C. Preparation of Surface for Deck Repair.

Remove concrete from each area (either designated in the contract documents or by the Engineer) to a depth and in a manner consistent with the classification for that area. Areas as shown in the contract documents are based on the best information available. The Engineer will determine actual areas.

1. General.

a. Keep areas from which concrete has been removed free of slurry produced by wet sawing concrete joints. Remove all slurry from prepared areas before concrete is placed.

b. Use hand tools to remove final particles of concrete or to achieve the required depth. Sandblast or shot blast all surfaces against which new concrete is to be placed, including curbs and exposed reinforcement. Remove all dirt, oil, and other foreign material, as well as any unsound concrete. Clean the surface with an air blast immediately before applying grout in preparation for placement of new concrete.

c. Thoroughly clean all reinforcing bars and newly exposed concrete by sandblasting or shot blasting. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Where bond between existing concrete and reinforcing steel has been destroyed, remove the concrete adjacent to the bar to a depth that will permit new concrete to bond to the entire periphery of the exposed bar. A minimum of 3/4 inch (20 mm) clearance is required around the bar. Exercise care to prevent cutting, stretching, or damaging any exposed reinforcing steel. The Engineer may require enlarging a designated area should inspection indicate deterioration of concrete or corrosion of reinforcing beyond the limits previously designated.

d. Do not presaturate existing concrete prepared for surfacing before grout and new concrete is placed. Allow the prepared surface to dry to allow some absorption of the grout.

e. At the time of placement of either Class O PCC or Class HPC-O, ensure the area is clean and the reinforcement free of rust. Rust forming overnight because of dew on clean reinforcement will not be considered objectionable; however, reinforcement with a greater amount of rust shall be recleaned before placing the concrete. Clean the area with an air blast before the concrete is placed.

2. Class A Deck Repair.

a. Class A repair removal is considered to start 1/4 inch (5 mm) below the existing surface. This does not preclude removal coincidental with preparation for overlay. Removal for Class A repair extends at least to the level of the top reinforcing bars, and deeper, as determined by the Engineer, to remove unsound concrete.

b. Concrete may be removed by chipping, shot blasting, hydro blasting, or by a combination of these. Complete the final cleanup using hand tools.

c. For Class A repair and in preparation for bridge deck overlay, the deck surface may also be prepared or partially prepared using a high pressure water system, at the Contractor's option. Use the equipment manufacturer’s recommended procedures, subject to the Engineer’s approval, and within such limitations as may be imposed.

d. Additional removal may be required to provide for test wells.

3. Class B Deck Repair.

a. Class B repair removal is considered to start 1/4 inch (5 mm) below the existing surface. This does not preclude removal coincidental with preparation for overlay. Remove all concrete within all areas designated for Class B repair, and in all areas designated for Class

A repair in which the depth of the remaining sound concrete is less than 50% of the original depth of the bridge deck.

b. Designated Class A repair areas will be measured as Class B Deck Repair when full depth removal is required. At the Engineer's direction, limited areas of removal greater than 50% of the floor thickness (such as beneath reinforcing) may be allowed. These limited areas of excess depth will be measured as Class A Deck Repair.

c. Remove concrete using a jack hammer or chipping hammer, or by using a combination of a scarifyier and chipping hammer. Accomplish the final removal at the periphery of Class B repair using a 15 pound (7 kg) jack hammer, chipping hammer, or hand tools.

d. Provide forms to enable placement of new concrete in the full depth opening. Use forms that, preferably, are suspended from existing reinforcing bars by wire ties. In the case of large area openings, forms may be supported by blocking from the beam flanges. Support all forms by elements of the existing superstructure unless specifically noted or shown otherwise in the contract documents.

D. Proportioning and Mixing.

1. General.

a. Proportion and mix Class O PCC at the project site. Ready mixed concrete will not be approved.

b. For Class HPC-O, ready mixed concrete or portioned and mixed concrete at the project site will be allowed.

c. Mix the water reducing admixture for improved workability of Class O PCC or HPC-O into the concrete according to the manufacturer's recommendations and the Engineer's instructions.

2. Stationary Mixer.

When a construction or stationary mixer is used, proportion and mix according to applicable provisions of Article 2403.02, D.

3. Continuous Mixing Equipment.

When continuous mixing equipment is used, apply the following:

a. Use mobile continuous mixers that accurately proportion all materials for the specified mixture.

b. Calibrate the proportioning equipment for each material in the presence of the inspector. The Engineer may accept a previous calibration and require satisfactory verification checks only, at the settings indicated by the previous calibration.

c. Operate the proportioning equipment at the speed recommended by the manufacturer during calibration, checks, or normal operation.

d. Recharge continuous mixers at the site.

e. The Contractor may make yield checks or other checks and the inspector will cooperate in such checking.

f. Mix the materials in an approved mixer within 1 mile (2 km) of the site of placement. Mix the materials according to the specified requirements for the equipment used. Ensure the mixture, as discharged from the mixer, is uniform in composition and consistency.

E. Placing and Finishing.

1. Repairs.

Apply the following to repair work:

a. Although repair classes are considered to begin 1/4 inch (5 mm) below the original concrete surface, place repair concrete monolithically with the overlay course, except as described for larger areas of Class B repair. Internally vibrate fresh concrete 3 inches (75 mm) or more in thickness.

b. For Class B repair areas 2 square yards (2 m^2) or greater:

1) Use floor forms supported by beams or stringers.

2) Bring the individual concrete replacement to the lower boundary for the superimposed overlay.

3) Use Class C structural concrete meeting the requirements of Sections 2403 and 2412 for Class B repair.

4) Leave the surfaces of individual placements rough.

5) Complete placements for each construction stage before starting the overlay course.

6) If a full depth repair is staged, provide a beveled keyway not less than 1 1/2 inch by 3 inches (35 mm by 75 mm) at the vertical joint.

7) Ensure concrete placement and reinforcing support comply with applicable portions of these specifications except as modified by the contract documents.

8) After the cure, surface dry, sandblast or shot blast, and clean individual placements before applying overlay course or grout.

c. For Class A repair areas:

1) Use Class O or Class HPC-O concrete when repair concrete is placed monolithically with the overlay.

2) Deck repair concrete, described in Article 2413.02, or Class C structural concrete, meeting requirements of Sections 2403 and 2412, may be used when individual placements are placed to the lower boundary for the superimposed overlay.

3) Allow the partial placement to cure for 72 hours.

4) After the cure, surface dry, sandblast or shot blast and clean individual placements before applying the overlay course or grout.

2. Deck Surfacing and Deck Overlay.

a. Use an approved finishing machine as specified in Article 2413.03, A, 4.

b. Place the support rails upon which the finishing machine travels outside the area to be surfaced. Make provisions for anchorage of supporting rails that provide for horizontal and vertical stability. The Engineer may require positive anchorage. Do not use a hold down device shot into concrete unless the concrete shall be subsequently surfaced. Hold down devices of other types leaving holes in exposed areas will be approved provided the holes remaining are grouted full. Submit support rail anchoring plans and the mixture placing procedure to the Engineer for approval.

c. The locations of longitudinal joints may be shown in the contract documents. If not shown, locate longitudinal joints as approved by

the Engineer. The approval will be based on avoiding joints in the wheel paths as much as practical.

d. In order to assure a junction with properly consolidated concrete, saw the surface course previously placed to a straight and vertical edge at longitudinal and transverse joints and remove before adjacent concrete is placed. The Engineer will determine the extent of such removal.

e. Take every reasonable precaution to secure a smooth riding bridge deck. Prior to placement operations, review the equipment, procedures, personnel, and previous results with the Engineer. The Engineer will review inspection procedures to assure coordination. Include the following precautions:

1) Assurance that concrete can be produced and placed within the specified limits, continuously and with uniformity.

2) After finishing, check the surface with a 10 foot (3 m) straightedge. Eliminate causes for irregularities exceeding 1/8 inch (3 mm) and make corrections, if practical.

3) The Engineer will check each placement according to Section 2428 the day following placement or before another section is placed.

f. After cleaning the surface and immediately before placing Class O PCC or Class HPC-O, scrub a thin coating of bonding grout into the dry, prepared surface. At the Contractor's option, the grout may be sprayed onto the surface in a manner subject the Engineer’s approval. Exercise care to assure that all parts receive a thorough even coating, and that no excess grout is permitted to collect in pockets. Limit the rate of progress for applying grout so that the grout does not become dry before it is covered with new concrete. If the grout becomes dry, remove it by sandblasting and apply new grout.

g. Place concrete in a continuous operation. For Class O PCC, manipulate the new concrete and mechanically strike it off slightly above final grade. Then mechanically consolidate it to 100% of the rodded density, with a minus tolerance of 2%. Screed the new concrete to final grade. The Engineer will determine rodded density according to Materials I.M. 358.

h. The rodded density measurement is not required for Class HPC-O.

i. For Class O PCC, use internal vibration for consolidation at the curb side, and along the longitudinal construction joint adjacent to a previously constructed lane.

j. Ensure concrete temperature and theoretical evaporation rate comply with Article 2412.03, C.

k. Apply Section 2428 to smoothness of the completed bridge deck surfacing and bridge deck overlay for Interstate and Primary projects and when specifically required for other projects.

3. Placement of Grooving.

a. Interstate and Primary Projects.

1) Transverse grooving or tining in plastic concrete of bridge deck surfacing or bridge deck overlay (and bridge approach overlay

when included in a bridge deck overlay project) will not be allowed.

2) Perform longitudinal grooving according to Article 2412.03, D.

b. Other Projects.

1) After achieving a tight, uniform surface, apply a suitable grooving, by hand methods, similar to that described in Article 2301.03, H, 3, with the following exceptions:

- Grooving is to be transverse to the centerline of roadway.
- Transverse grooving is to be randomly spaced from 3/4 inch to 1 5/8 inches (20 mm by 40 mm) with no more than 50% of the spacings exceeding 1 1/4 inches (30 mm) with a minimum of four different spacings in a 2 foot (0.6 m) width.

2) Perform this operation at a time and in a manner to achieve the desired texture while minimizing displacement of the larger aggregate particles. The texture should not extend into the areas within approximately 2 feet (0.5 m) of curbs. As soon as finishing has been completed, seal all vertical joints with adjacent concrete by painting with thinned grout.

F. Curing.

1. Place the first layer of prewetted burlap on the concrete as follows:

a. Interstate and Primary Projects.
Place within 10 minutes after finishing. If Class O PCC is revibrated because of failure to meet density requirements with initial vibration, place the prewetted burlap within 10 minutes after finishing of the revibrated area.

b. Other Projects.
Immediately after final finishing, cover the area finished with white pigmented curing compound meeting the requirements of Article 4105.05, applied at a rate of no more than 135 square feet per gallon (3.3 square meters per liter). Place the first layer of prewetted burlap on the concrete within 30 minutes after the concrete has been deposited on the deck. If Class O PCC is revibrated because of failure to meet density requirements with initial vibration, this time limit will be extended by 15 minutes.

2. Cure the concrete as follows:

a. For Class O PCC or Class HPC-O:

1) Allow the surface to cure for at least 72 hours.

2) For the first 24 hours, keep the burlap continuously wet by means of an automatic sprinkling or wetting system. After 24 hours, the Contractor may cover the wet burlap with a layer of 4 mil (100 µm) polyethylene film for a minimum of 48 hours in lieu of using the sprinkling or wetting system.

3) Failure to apply wet burlap within the required time is cause for rejecting the affected work. Remove the surface concrete in the rejected area and replace at no additional cost to the Contracting Authority.

b. Prewet the burlap with sufficient water, prior to placement, to prevent absorption of moisture from the concrete surface.

c. At the Contractor's option, partial depth concrete for Class B repair may be cured with white pigmented curing compound only. When this curing is completed, sandblast the surface and allow to dry. Sandblast the existing concrete in vicinity of Class B repair prior to placement of the overlay course.

G. Sealing for Deck Overlay.
Seal the tops and traffic sides of curbs, retrofit barrier rails, and concrete barrier rails according to Article 2403.03, P, 3. In addition, for Class O PCC overlay or Class HPC-O overlay, apply the sealer along each gutter line, extending 1 foot (0.3 m) onto the roadway. The Engineer or the contract documents may designate other areas requiring concrete sealer.

H. Limitations of Operations.

1. Do not commence work on the surface until the lower course meets the requirements of Article 2403.03, N, 2.

2. If traffic shall be maintained during the construction period of this contract, it will be noted in the contract documents. Provide traffic controls required by the contract documents.

3. Night work will be permitted. Furnish adequate lights for nighttime work at the direction of the Engineer at no additional cost to the Contracting Authority. Provide the Engineer with advanced notice.

4. If there is a major delay in the placement operation, place a construction dam or bulkhead. During minor delays of 1 hour or less, the end of the placement may be protected from drying with several layers of wet burlap.

5. Protect freshly placed concrete from sudden or unexpected rain. The Engineer may order removal of concrete damaged by rainfall.

6. Screed rails may be removed at any time after the concrete has taken initial set. Protect the edge of the new surface from damage during screed removal.

7. Do not place concrete adjacent to a surface course less than 36 hours old (this restriction does not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip).

8. If concrete placement is stopped or delayed for a period of 90 minutes or more, discontinue further placement. Resume only after a period of no less than 12 hours. This restriction does not prohibit continuation of placement provided a gap is left in the lane or strip. Ensure the gap is sufficiently long for the finishing machine to clear previously placed concrete.

9. Preparation work will not be allowed in a lane or strip until the lane is closed to traffic. In areas where there is no traffic, preparation of the area may be started in a lane or strip adjacent to newly placed surface

the day following its placement. If this work is started before the end of the 72 hour curing period, the work will be restricted as follows:

a. Limit the interference sawing, or other operations, has on curing to the minimum time practical, and to the immediate area only. Resume curing promptly.

b. Do not use chipping hammers heavier than a nominal 15 pound (with a mass greater than 7 kg) class.

c. Operate air compressors on the deck only directly over the piers.

d. Do not allow loads, other than construction equipment, on any portion of the bridge deck that has undergone preparation in advance of new concrete placement and curing.

10. Do not allow traffic on a finished surface course until 72 hours after placement. At temperatures below 55°F (13°C), the Engineer may require a longer waiting time.

11. Do not place PCC when the air or floor temperature is below 40°F (4°C).

12. Do not place concrete mixture after October 1 and before April 1 without the Engineer's written approval.

2413.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Deck Surfacing (Class O PCC), Deck Surfacing (Class HPC-O), Class A Deck Repair, Class B Deck Repair, Deck Overlay (Class O PCC), and Deck Overlay (Class HPC-O): square yards (square meters) computed from measurements of the areas surfaced, repaired, or overlaid. For deck surfacing, the Engineer may require concrete removal for Class O PCC test wells. This removal will not be measured for payment.

B. Sealing (as required in Article 2413.03, G): not measured separately for payment.

C. Longitudinal Grooving in Concrete: according to Article 2412.04.

2413.05 BASIS OF PAYMENT.

Payment will be as described below. The profile may be improved by raising the finished overlay surfaces up to 1/2 inch (15 mm) above that shown in the contract documents, with no additional compensation to the Contractor. Locations where the raise exceeds 1/2 inch (15 mm), payment will be made as extra work for the materials which represent the volume in excess of the 1/2 inch (15 mm) raise.

A. Deck Surfacing (Class O PCC) or Deck Surfacing (Class HPC-O):

1. Contract unit price per square yard (square meter).

2. Payment is full compensation for furnishing all material, equipment, forms, and labor necessary to complete this work according to the contract documents.

B. Class A Deck Repair, Class B Deck Repair, Deck Overlay (Class O PCC), and Deck Overlay (Class HPC-O):

1. Contract unit price per square yard (square meters).

2. Payment is full compensation for removal of excess concrete from the project and it becoming the property of the Contractor, for furnishing all material, equipment, forms, and labor necessary to complete the work according to the contract documents.

3. When there is no item for Class B Deck Repair, but such work is required, payment for each square yard for 5 square yards (square meter for 4 m^2) or less will be at three times the contract unit price per square yard (square meter) for Class A Deck Repair. Should the quantity exceed 5 square yards (4 m^2), payment will be made as extra work.

C. Sealing as required in Article 2413.03, G: included in the contract unit price for Deck Overlay (Class O PCC) or Deck Overlay (Class HPC-O).

D. Longitudinal Grooving in Concrete: according to Article 2412.05.

E. When Section 2428 applies, payment may be modified as specified therein.

Section 2414. Railings

2414.01 DESCRIPTION.
Furnish and construct railings of the type, dimensions, and materials shown in the contract documents.

2414.02 MATERIALS.
Apply Section 2403.

A. Concrete Railings.

1. Concrete Barrier Railing.
Apply Section 2406 and Article 2513.02.

2. Concrete Open Railing.
Apply Section 2406.

3. Retrofit Concrete Barrier Railing.
Apply Section 2406 and Article 2513.02.

B. Pipe and Structural Steel Pedestrian Hand Railings.

1. Use pipe that meets the requirements of Section 4153. Use structural steel that meets the requirements of Section 4152.

2. On all Primary projects and when specified on Secondary projects, use pipe and structural steel railings galvanized according to Article 4100.07.

C. Wood Railings.
Unless provided otherwise in the contract documents, apply Section 4162.

D. Formed Steel Beam Guardrail.

1. Meet the requirements of Section 4155.

2. On Primary projects and when specified for Secondary projects, use steel galvanized according to Article 4100.07 for posts which are placed on concrete by means of anchor bolts.

E. Aluminum Pedestrian Hand Railings.

1. Aluminum Parts.
Apply Section 4190.

2. Anchor Bolts, Nuts, and Washers.
Apply Article 4153.06 unless shown otherwise in the contract documents.

2414.03 CONSTRUCTION.
Apply Section 2403.

A. Concrete Railings.

1. Concrete Barrier Railing.
Construct to the dimensions and length shown in the contract documents and according to Sections 2406 and 2513.

2. Concrete Open Railing.
Construct to the dimensions and length shown in the contract documents. Apply the requirements of Section 2406.

3. Retrofit Concrete Barrier Railing.
Construct to the dimensions and length shown in the contract documents. Apply the requirements of Sections 2406 and 2513.

B. Pipe and Structural Steel Pedestrian Hand Railings.

1. Construct pipe hand railings, structural steel hand railings, and posts as indicated in the contract documents. Install posts as provided in Article 2414.03, E, 2.

2. The Contractor for the substructure shall furnish and install protection railings on abutments.

3. Paint ungalvanized metal railings according to Section 2508. The Contractor for the superstructure shall furnish and apply field coats of paint.

C. Wood Railings.
Unless provided otherwise in the contract documents, construct wood railings of common class lumber as defined in Section 4162. Ensure details of the construction comply with Section 2409. Paint wood railings as provided in Article 2409.03, K.

D. Formed Steel Beam Guardrail.
Furnish and install formed steel beam guardrail for bridge structures or approaches according to the contract documents and Section 2505. Use structural steel posts furnished and installed as part of the bridge structure for rails on new bridge structures.

E. Aluminum Pedestrian Hand Railings.
Construct aluminum hand railings with aluminum posts supporting rails of aluminum tubing according to the contract documents and the following:

1. Handling and Storage.
- **a.** Carefully handle and store aluminum posts and rails at the work site. Do not store aluminum parts in contact with the ground or where they may be attacked by acid or alkali.
- **b.** Replace members which are marred or damaged to the extent that their usefulness or appearance is impaired at no additional cost to the Contracting Authority.

2. Installation.
- **a.** Set anchor bolts in the concrete curb at the correct location and elevation. Hold them firmly in place using suitable templates that will insure their correct position during placing and hardening of the concrete.
- **b.** Assemble and align the rails. If necessary, shim the rails to bring them to the correct elevation. Tighten anchor nuts to hold the rails firmly in place. After aligning the rails, position them to accommodate the anticipated expansion. Tighten the setscrews to hold the rails firmly in place. Cap the ends of tubular rails.
- **c.** After erection, carefully remove all dirt and grease from the rails, posts, and concrete around the post base using a cleaning method the Engineer approves.

2414.04 METHOD OF MEASUREMENT.

Measurement for the various items involved in the construction of railings will be as follows:

A. Concrete Railings.

1. Concrete Barrier Railing.
Linear feet (meters) shown in the contract documents. Measurement for the weight (mass) of reinforcement steel installed in the barrier will be according to Article 2404.04.

2. **Concrete Open Railing.**
Linear feet (meters) shown in the contract documents. Measurement for the weight (mass) of reinforcement steel installed in the barrier will be according to Article 2404.04.

3. **Retrofit Concrete Barrier Railing.**
Linear feet (meters) shown in the contract documents. Reinforcement steel in Retrofit Concrete Barrier Railing will not be measured for payment.

4. **Electrical Circuits.**
   a. When electrical conduit and junction boxes are installed as part of Section 2525, Article 2525.04 applies; otherwise, electrical conduit and junction boxes will not be measured.

B. Steel Pipe Pedestrian Hand Railing and Structural Steel Pedestrian Hand Railing.
Linear feet (meters) shown in the contract documents, from end to end of the railing.

C. Wood Railings.
Article 2409.04 applies.

D. Formed Steel Beam Guardrail.

1. Article 2505.04 applies.

2. Section 2408 applies for steel posts.

E. Aluminum Pedestrian Hand Railings.
Aluminum railing will be the quantity shown in linear feet (meters) in the contract documents for Aluminum Pedestrian Hand Railing.

2414.05 BASIS OF PAYMENT.
Payment for the quantities of various items of construction, measured as specified in Article 2414.04, will be the contract unit price as described below. Payment is full compensation for furnishing all materials, equipment, and labor necessary to construct the rail as shown in the contract documents.

A. Concrete Railings.

1. Concrete Barrier Railing, Concrete Open Railing, or Retrofit Concrete Barrier Railing: per linear foot (meter).

2. Reinforcement measured for payment: Article 2404.05 applies. The reinforcement quantities may be included in the quantities for the superstructure or abutments. Reinforcement Steel in Retrofit Concrete Barrier Railing will not be paid for separately, but will be included in the price bid for Retrofit Concrete Barrier Railing.

3. Electrical Circuits:

When electrical conduit and junction boxes are installed as part of Section 2525, payment will be according to Article 2525.05; otherwise, electrical conduit and junction boxes will be incidental to the concrete railing.

B. Steel Pipe Pedestrian Hand Railing and Structural Steel Pedestrian Hand Railing.
Contract unit price for structural steel when measured by weight (mass), and contract unit price per linear foot (meter) when measured in linear feet (meters).

C. Wood Railings.
Article 2409.05 for lumber and hardware.

D. Formed Steel Beam Guardrail.

1. Apply Article 2505.05.

2. Article 2408.05 applies for steel posts.

E. Aluminum Pedestrian Hand Railings.
Per linear foot (meter).

Section 2415. Concrete Box, Arch, and Circular Culverts

2415.01 DESCRIPTION.

A. Cast-in-place.
Construct a cast-in-place concrete box, arch, or circular culvert.

B. Precast.

1. Precast box culverts may be accepted when shown in the contract documents.

2. Use culvert sections that meet the requirements of ASTM C 1433.

3. The contract documents will designate the span, rise, and either the design earth cover, or the design loading, both defined in ASTM C 1433.

4. Apply Section 2407 to the aggregates used in the concrete.

5. Apply the appropriate requirements of Section 2407 to manufacturing process inspection.

6. Concrete strength will be based on cylinder tests.

2415.02 MATERIALS.
Use Class C structural concrete meeting the requirements of Section 2403, unless specified otherwise.

2415.03 CONSTRUCTION.

Apply the requirements of Sections 2401, 2402, 2403, 2404, and 2414.

A. Footings.

1. Construct footings to the elevations shown in the contract documents, unless directed otherwise by the Engineer.

2. Footing depths may be increased when necessary to prevent undermining or scour or to secure adequate bearing. In general, decrease footing depth only when solid rock is encountered at elevations above those shown.

3. Use suitable wood or metal forms according to Section 2403 to enclose all footing concrete.

B. Placing Concrete.

1. **Footings.**
   - **a.** Do not allow dirt, mud, or other foreign material to become mixed with concrete which is being placed in the footing.
   - **b.** Monolithically construct footings, pavements, and curtain walls between construction joints if practical.
   - **c.** Provide a key notch of the form shown in the contract documents between the walls and footings to insure proper anchorage.
   - **d.** Remove all dirt, dust, shavings, or other foreign material from the key notch and wall forms before placing concrete.

2. **Barrels of Culverts.**
   - **a.** The sidewalls and top slab may be constructed as a monolith between construction joints, or the concrete in sidewalls may be placed and allowed to harden before the top slab is placed, at the discretion of the Contractor.
   - **b.** If the sidewalls and top slab are constructed as a monolith, all necessary construction joints are to be vertical and at right angles to the axis of the culvert. If the sidewalls are placed and allowed to harden before the top slab is placed, leave appropriate keys in the sidewalls for anchoring the cover slab.
   - **c.** Place forming and reinforcement for the entire barrel section between construction joints before concrete is placed in the sidewalls or headwalls.

3. **Headwalls.**
   - **a.** In general, construct headwalls monolithically. However, when construction joints are unavoidable, place them in a horizontal or vertical position and locate them so no joint is visible above the roadbed.
   - **b.** Place triangular fillet strips in the forms to avoid sharp edges and corners.

4. Placing Concrete in Arch Culverts.
Place concrete in arch culverts as provided in Section 2403.

C. Surface Finish.
Surface all exposed parts of the wingwalls, headwalls, and railings according to Article 2403.03, P.

D. Placing Backfill Material.
Place backfill material according to Article 2402.03, H.

E. Protection Railings.

1. Furnish and install protection railings shown in the contract documents.

2. Paint protection railings, other than aluminum or galvanized railings, as provided in Section 2508.

2415.04 METHOD OF MEASUREMENT.

A. Excavation for structures, structural concrete, steel reinforcement, and other items in the contract documents will be the quantity shown in the contract documents.

B. Protection railing (when specified in the contract documents) will be the quantity shown in the contract documents.

2415.05 BASIS OF PAYMENT.

A. Payment for all concrete box, arch, or circular culverts will be the contract unit price for excavation for structures, structural concrete, steel reinforcement, and other items included in the contract documents.

B. Payment for protection railings will be the contract unit price for the railing material.

C. Payments are full compensation for furnishing all materials, equipment, and labor and for performance of all work necessary to complete the structures in conformance with the contract documents or as ordered by the Engineer.

Section 2416. Rigid Pipe Culverts

2416.01 DESCRIPTION.
Furnish and install concrete pipe for roadway and entrance culverts.

A. Roadway culverts are defined as culverts placed on a public way, whether Primary Road, Secondary Road, city street, or other way maintained for public traffic.

B. Entrance culverts are defined as culverts for private drives such as entrances to farms, city lots, and so on, which are not maintained for public traffic.

2416.02 MATERIALS.

Meet the requirements of Section 4145 for the type and class of pipe specified in the contract documents.

2416.03 CONSTRUCTION.

A. Class 1500D (75D) pipe may be used for entrance culverts only. Use class 2000D, 3000D, or 3750D (100D, 150D, or 175D) pipes for roadway culverts, or if conditions require, for entrance culverts. Table 2416.03-1 provides minimum and maximum allowable pipe sizes.

Table 2416.03-1: Minimum and Maximum Allowable Pipe Sizes

Culvert Use	Minimum Pipe Size in. (mm)	Maximum Pipe Size in. (mm)
Roadway Culvert	18 (450)	108 (2700)
Entrance Culvert	15 (375)	108 (2700)

B. For 24 inch (600 mm) or larger diameter pipes, the number of 4 foot (1.2 m) sections is to be the minimum necessary to produce the length of culvert required.

C. Where a new fill is being constructed, place roadway pipe in a trench only when the total fill over the pipe is 5 feet (1.5 m) or less. Place embankment within the restrictions of Article 1105.14.

D. Except as indicated otherwise in the contract documents, install pipe culverts according to the following requirements:

1. Trench Width.
Ensure the trench is wide enough to permit tamping of bedding material under and around the pipes. The Contractor has the option to cut a trench wide enough to accommodate a tamping type roller on each side of the pipe.

2. Base Preparation.

a. Bring the surface upon which the pipe sections are to rest to a suitable elevation to fit the desired grade and camber. Prepare the base as shown in the contract documents. Use Class B bedding when specified. Use Class C if not specified.

1) Class B Bedding.
Class B bedding consists of a 2 inch (50 mm) cushion of sand shaped with a template to a concave saddle in compacted or natural earth to such a depth that 15% of the height of the pipe rests on the sand cushion below the adjacent ground line.

2) Class C Bedding.
Class C bedding consists of a concave saddle shaped with a template, or shaped by other means and checked with a template, in compacted or natural earth to such a depth that 10% of the height of the pipe rests below the adjacent ground line.

b. Where bedrock, shale, or very hard clay is encountered, excavate the trench below the bottom of the pipe for a depth of at least 1 foot (0.3 m). Place earth backfill material and thoroughly tamp.

c. If the bottom of the footing is of an unstable nature, the Engineer may direct that the foundation be treated by first excavating below the required elevation and then placing backfill materials consisting of one of the granular surfacing materials listed in Section 4120 or other suitable material approved by the Engineer. Place backfill material according to Article 2402.03, H, or as directed by the Engineer.

d. Unless bedding is specifically designated in the contract documents, Class C bedding will not be required for entrance pipe 24 inches (600 mm) or less in diameter. Instead, the pipe may be bedded carefully in suitable material and the backfill material compacted with a mechanical tamper to mid-height elevation of the pipe. Complete remaining backfill material placement according to 2416.03, D, 4.

3. Placing Pipe Sections.

a. Provide proper facilities for lowering sections into place without damage to the pipe.

b. Carefully lay pipe with hub, bell, or groove ends upstream.

c. Carefully bed and place each section in close contact with adjacent sections, with lifting holes (if provided) at the top.

d. Place pipe section to alignment and grade established or approved by the Engineer.

e. Fill lifting holes (if provided) with concrete or precast concrete plugs prior to placing backfill material.

4. Placing Backfill Material around Pipe Culverts.

a. Thoroughly tamp under and around the pipe in layers not to exceed 8 inches (200 mm) for the full length and width of the pipe.

b. Fill and thoroughly tamp earth around and over the culvert for its full length, according to Articles 2402.03, G and 2402.03, H. Ensure that adjacent to the pipe on each side is an embankment of thoroughly tamped or undisturbed earth.

c. Extend the embankment on both sides of the culvert from the original ground line to at least 1 foot (0.3 m) above the top of the pipe with a slope as shown in the contract documents. Ensure the width of this fill at its top is no less than the outside diameter of the culvert and extends one-half its width on each side of the culvert center line. Increase the height of fill, if necessary to accommodate construction traffic, to the nominal diameter of the pipe or 3 feet (1 m), whichever is greater.

d. When pipes are laid wholly or partly in a trench, granular backfill material may be required for backfill material as provided in Article 2402.03, H. Use compacted earth for the remainder of the fill, to at least 1 foot (0.3 m) above the top of the pipe, with slopes as outlined above.

e. If the trench is cut wide enough to permit the use of a roller, first bed the pipe and then thoroughly tamp the backfill material under and alongside the pipe to the mid-height elevation of the pipe.

Place and compact the remainder of the backfill material according to Section 2107.

f. If a roadway pipe culvert is being placed after construction of an embankment and moisture control is not required, place the pipe using methods that will produce results equivalent to those required for construction of the embankment. For this situation, moisture determinations will be waived for backfill material placement completed within 48 hours after excavation.

g. When ordered by the Engineer, build approach fills to provide a roadway 10 feet (3 m) in width over the culvert with grades not steeper than 10%.

5. Concrete Pipe Joints.

a. When required by the contract documents, wrap concrete pipe joints with Engineering Fabric of the type specified.

b. Ensure joint openings on the outside or inside of the bottom half of the pipe do not exceed 1/4 inch (6 mm) for pipe with an internal diameter of 24 inches (600 mm) or less.

c. For pipe with an internal diameter of more than 24 inches (600 mm), ensure joint openings on the outside or inside of the bottom half of the pipe do not exceed 1/8 inch per foot (1 mm per 0.1 m) of internal diameter, with a maximum allowable joint opening of 5/8 inch (15 mm).

d. Fully encase larger joint openings, unless they are required for pipe camber, with a Type C-1 concrete collar. Use Class C structural concrete as specified in Section 2401. Point the collar and inner surface of the joint full and flush using sand cement mortar for the lower 75% of the pipe perimeter.

2416.04 METHOD OF MEASUREMENT.

Measurement for the items associated with rigid pipe culverts will be as follows:

A. Pipe culvert: measured length, in feet (meters), of culvert installed, excluding aprons, to the nearest foot (0.1 m) with no deductions for elbows, tees, and other fittings. Quantity will be determined along the axis. Measurement for pipe laterals terminating at a tee will be from the point of inlet to a point 6 inches (150 mm) from the outside of the main, less the length of the apron, if any.

B. Aprons: quantity shown in the contract documents.

C. Appurtenances (elbows, tees, and other fittings): not measured for payment, but quantity will be shown on the contract documents.

D. Type C adaptors required by the contract documents or installed to correct faulty work will not be measured for payment.

E. Excavation for culverts:

1. Roadway culverts: Article 2402.04, C applies.

2. Entrance culverts: not measured for payment.

3. Sand required for Type B bedding: not measured for payment.

F. Granular Backfill (when required and furnished): Article 2402.04, E, applies.

G. Foundation treatment material (when placed at the direction of the Engineer): Article 2402.04, F, applies.

2416.05 BASIS OF PAYMENT.
Payment for the items associated with rigid pipe culverts will be the contract unit price as follows:

A. Pipe culvert: per linear foot (meter) for type and size specified.

B. Wrapping pipe joints, Type C adapters, and appurtenances: included in the contract unit price per linear foot (meter) for the pipe culvert.

C. Aprons: per unit for the size specified.

D. Payment for Type C adaptors not shown in the contract documents, but required because of changes in alignment will be as extra work according to Article 1109.03, B.

E. Excavation for culverts:

1. Roadway culverts and the quantity of extra excavation for embankments: per cubic yard (cubic meter).

2. Entrance culverts: incidental to the contract unit price for rigid pipe culvert.

3. Sand required for Class B bedding: incidental to the contract unit price for pipe culvert.

F. Granular Backfill (when required and furnished): Article 2402.05, G, applies.

G. Foundation treatment material (furnished and placed): Article 2402.05, F, applies.

Section 2417. Corrugated Culverts

2417.01 DESCRIPTION.

A. Furnish and install corrugated culverts.

B. Roadway and entrance culverts are defined in Article 2416.01.

2417.02 MATERIALS.

A. Use corrugated culverts that meet the requirements of Section 4141, or Section 4146 when polyethylene culvert pipe is designated.

B. Use round culvert pipe, unless specified otherwise. When required, elongate round pipe. When specified, use arch type pipe.

C. When placing under roadway, use corrugated steel culverts coated according to Article 4141.02.

D. A paved invert may be required according to the contract documents.

2417.03 CONSTRUCTION.

A. Maximum and Minimum Sizes.

1. Table 2417.03-1 provides minimum allowable pipe sizes.

Table 2417.03-1: Minimum Allowable Pipe Sizes

Culvert Use	Minimum Pipe Size in. (mm)
Roadway Culvert	18 (450)
Entrance Culvert	15 (375)

2. Table 2503.03-2 provides maximum allowable pipe sizes.

Table 2417.03-2: Maximum Allowable Pipe Sizes

Corrugation Depth in. (mm)	Maximum Pipe Size in. (mm)
1/2 (13)	84 (2100)
1 (25)	120 (3000)

3. When culverts of sizes outside the limitations in Tables 2417.03-1 and 2417.03-2 are specified, they will be covered by the contract documents.

B. Minimum Depth of Fill.

1. Place a minimum of 1 foot (0.3 m) of fill over entrance culverts.

2. Place a minimum of 2 feet (0.6 m) of fill over roadway culverts.

3. If necessary to accommodate construction traffic, increase depth of fill over roadway culverts to the nominal diameter of the pipe or 3 feet (1 m), whichever is greater.

C. Installation.

Use Class A bedding when installing corrugated metal pipe or polyethylene pipe for roadway culverts.

1. Class A Bedding.
Use a uniform uncompacted cushion of sand as detailed in the contract documents and meeting the gradation requirements of Gradation No. 1 or 32 of the Aggregate Gradation Table in Section 4109.

2. Deflection Testing for Polyethylene Pipes.

a. General.

1) No sooner than 30 calendar days following pipe installation compaction and placing backfill material, or before paving, perform deflection testing on at least 10% of the pipe locations along their entire length at locations determined by the Engineer.

2) The internal diameter of a pipe is not to be reduced by more than 5.0% of its nominal inside diameter.

3) If any pipe fails post installation testing, the Engineer may require the Contractor to perform post installation testing on any additional pipes or all of the remaining pipes.

4) Pipes failing post installation testing will be considered unacceptable. Replace with new pipe or reinstall undamaged pipe. Test for deflection.

b. Pipe Diameter of 30 Inches (750 mm) or Less.
Perform deflection testing using a properly sized nine-point mandrel test.

c. Pipe Diameter Greater than 30 Inches (750 mm).
Ensure the internal diameter of the entire length of the pipe is not reduced by more than 5.0% of it nominal inside diameter.

2417.04 METHOD OF MEASUREMENT.
Measurement for the items associated with corrugated pipe culverts will be as follows:

A. Pipe culvert: measured length, in feet (meters), of culvert installed, excluding aprons, to the nearest foot (0.1 m). Quantity of pipe will be determined along the axis. Measurement for pipe laterals terminating at a tee will be from the point of inlet to a point 6 inches (150 mm) from the outside of the main, less the length of the apron, if any.

B. Aprons: quantity shown in the contract documents.

C. Appurtenances (elbows, tees, and other fittings): not measured for payment, but quantity will be shown on the contract documents.

D. Excavation for culverts:

1. Roadway culverts: Article 2402.04, E, applies.

2. Entrance culverts: not measured for payment.

E. Granular Backfill (when required and furnished): Article 2402.04, E, applies.

F. Foundation treatment material (when placed at the direction of the Engineer): Article 2402.04, F, applies.

2417.05 BASIS OF PAYMENT.
Payment for the items associated with corrugated pipe culvert will be at the contract unit price as follows:

A. Pipe culvert: per linear foot (meter) for type and size specified.

B. Aprons: per unit for the size specified

C. Appurtenances: included in the contract unit price per linear foot (meter) for the pipe culvert.

D. Excavation for culverts:

1. Roadway culverts and the quantity of extra excavation for embankments: per cubic yard (cubic meter).

2. Entrance culverts: incidental to the contract unit price for corrugated pipe culvert.

E. Granular Backfill (when required and furnished): Article 2402.05, G, applies.

F. Foundation treatment material (furnished and placed): Article 2402.05, F, applies.

G. Deflection testing required according to the contract documents: incidental to the contract unit price for polyethylene pipe.

Section 2420. Structural Plate Pipes, Pipe Arches, and Arches

2420.01 DESCRIPTION.
Furnish and construct structural plate pipes, pipe arches, or arches meeting requirements of these specifications and of the sizes and dimensions shown in the contract documents.

2420.02 MATERIALS.

A. Use materials for structural plate pipe, pipe arches, and arches that meet the requirements of Section 4144.

B. Unless specified otherwise, furnish a galvanized corrugated steel structure.

2420.03 CONSTRUCTION.

A. Quality of Work.

1. In addition to compliance with the details of construction, the completed structure must demonstrate high quality work. Plates on which the galvanizing has been damaged or broken, either in the shop or in shipping, or which show defective work will be rejected. The requirement applies not only to the individual plates but to the shipment for any contract as a whole.

2. Among others, the following defects are specified as constituting poor quality work. The presence of any or all of them in any individual culvert plate, in any shipment, or, in general, in the completed culvert, will constitute sufficient cause for rejection:
   - **a.** Uneven laps.
   - **b.** Elliptical shaping (unless specified), or otherwise excessive distortion.
   - **c.** Variations from a straight center line.
   - **d.** Ragged edges.
   - **e.** Loose, unevenly lined or spaced bolts.
   - **f.** Illegible brand.
   - **g.** Damaged, scaled, or broken galvanizing.
   - **h.** Dents or bends in the metal itself.

B. Bedding.

1. When a pipe structure is to be erected in a trench, construct the trench to be wide enough to permit thorough tamping of the earth backfill material against every plate except the bottom one.

2. Bed the pipe in an earth foundation of uniform density. Carefully shape the foundation with a template, or use other means and check with a template. Support the pipe at the desired grade. Ensure pipe has the required camber to fit the lower plate of the pipe.

3. When rock in either ledge or boulder formation is encountered, remove it below grade. Replace the rock with suitable materials in a manner to provide a minimum 8 inch (200 mm) thick compacted earth cushion having a thickness under the pipe no less than 1/2 inch per foot (40 mm/m) of fill over the pipe.

4. When firm foundation is not encountered at the grade established, due to soft, spongy, or other unsuitable soil, remove all unsuitable soil for a maximum distance of one diameter under and on each side of the pipe. Replace with suitable earth or granular material properly compacted to provide adequate support of the pipe. Use other special construction methods if specified. Excavate unsuitable soil below grade and place backfill material only at the at the Engineer's direction. This will be paid for as extra work unless provided otherwise in the contract documents.

5. Prepare the base according to Article 2416.03, D, 2. Ensure the bedding provides camber to allow for settlement after placing the fill. Vary the amount of camber to suit the height of fill and nature of supporting soil. Provide a minimum camber of 1% of the length of the pipe.

C. Multiple Structures.

When multiple structures of pipe or pipe arches are used, space them so that the adjacent sides of pipe are from 50% of the diameter to a maximum of 4 feet (1 m) apart to permit tamping of backfill material. Ensure the distance between plates at skewback of multiple arch spans is no less than 10% of the longer adjoining span.

D. Field Erection, Structural Plate Pipe, and Pipe Arches.

1. Beginning at the downstream end, place full sized bottom plates along the center line of the structure, lapping each plate one corrugation with the previous plate. Use fasteners to connect plates at longitudinal and circumferential seams. Stagger joints so that no more than three plates come together at one point.

2. After all plates have been placed, tighten all bolts to a minimum torque value of 100 foot pounds (135 N·m) and a maximum of 300 foot pounds (400 N·m).

3. When end treatment requires a rigid headwall, anchor the plates to the headwall with anchor bolts no smaller than 3/4 inch (19 mm) and spaced at no more than 19 inch (480 mm) on center.

4. Assemble pipe arch plates so they form cross sections made up of four circular arcs that are tangent to each other at their junctions and are symmetrical about the vertical axis.

E. Skewed Arch Spans.

Ensure the end skew of arches does not exceed 45 degrees. When the skew is more than 15 degrees, adjust the length of the structure so that no portion of the live load will be carried by the cut portion of the end. Where right-of-way or other conditions do not permit the required length, support the cut end with rigid headwalls designed to meet the conditions. Anchor the plates to the headwall with 3/4 inch (19 mm) bolts spaced at no more than 19 inch (480 mm) on center.

F. Arch Anchorage.

Anchor each side of the arch to the foundation by means of a formed channel or a structural angle bolted to the bottom row of plates. Ensure the arch plates bear directly on the channel or angle. Use channels or angles made of the same material as the plates. Anchor them to the foundation at intervals of no more than 24 inches (0.6 m).

G. Field Erection, Arches.

1. Begin erection of arch plates at the downstream end by bolting the side plates, at intervals no greater than 24 inches (0.6 m), to the angle or channel attached to the foundation.

2. Set plates inside the vertical leg of the angle or the longer leg of the channel. Ensure they bear directly on the horizontal leg of the angle or the web of the channel.

3. Assemble succeeding plates so that joints at right angles to the center line of the arch are staggered and not continuous for more than the width of one plate.

4. Support the upper edge of each plate of the first ring in its proper place until the full number of plates for the ring is in position.

5. Tighten bolts in each section as required in Article 2420.03, D.

H. Shop Forming.

1. When specified, shop form structural plate pipes to increase the vertical diameter approximately 5% out of round before placement of the fill.

2. A tolerance of ± 2.5% of the nominal pipe diameter or 5 inches (125 mm), whichever is less, will be permitted.

I. Placing Backfill Material.

1. After the structure has been assembled, place backfill material according to Articles 2402.03, G; 2402.03, H; and 2402.03, I. Thoroughly tamp each layer between the structure and the sides of the trench or for a distance on each side of the structure equal to the diameter of the structure.

2. After the fill over the structure has been completed to the full height, release and remove the struts, if any.

3. Exercise care when placing backfill material to prevent excessive distortion of the shape of the structure, either in peaking action or rolling action. Deflection in any direction greater than 2.5% from the original specified shape will not be allowed during the backfill material placement operation.

4. In addition to placing backfill material as required above, when the Engineer orders, build approach fills that will provide a roadway 10 feet (3 m) wide over the culvert, with grades no steeper than 10%.

2420.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Structural pipe culvert: feet (meters) to the nearest foot (0.1 m) shown in the contract documents for each culvert. The quantity of pipe will be determined as follows:

1. Pipes and arches with either square or skewed vertical ends: end to end of metal on center line of structure.

2. Pipes or pipe arches with square ends, beveled: average end to end at top and bottom of pipe.

3. Pipes or pipe arches with skewed ends, beveled: average end to end at top and bottom of pipe parallel to center line.

4. Arches with ends other than vertical: as noted in the contract documents.

B. Excavation for structural plate pipe: as specified for culverts in Article 2402.04. When the pipe is installed without change in location, dimensions, or elevation, the quantities of Class 20 or Class 23 and Class 24 excavation, as shown in the contract documents, will be the quantities for which payment is made.

C. Excavation for structural plate arches: as specified for structures in Article 2402.04 for the respective classes of excavation performed.

D. Structural concrete: Article 2403.04 applies.

E. Steel reinforcement: Article 2404.04 applies.

2420.05 BASIS OF PAYMENT.

A. Payment for structural pipe culvert of type and size specified will be the contract unit price for per linear foot (meter).

B. Payment is full compensation for furnishing all materials, labor, and equipment necessary to complete the work.

C. Excavation for structures, structural concrete, and reinforcement will be paid for separately.

Section 2422. Unclassified Pipe Culverts

2422.01 DESCRIPTION.

A. Construct and install roadway and entrance culverts for which inside dimensions and length are specified.

B. The selection of pipe of a type permitted by this specification, or other approved types permitted in the contract documents, will be optional with the Contractor.

C. Refer to Article 2416.01 for definitions of roadway and entrance culverts.

2422.02 MATERIALS.

Select the type of pipe culvert for unclassified roadway and unclassified entrance from the following tables.

Table 2422.02-1: Unclassified Roadway Pipe Culvert

Concrete - 2000D (100D)	Section 2416
Coated Corrugated Steel	Section 2417
Polyethylene Pipe	Section 2417

Table 2422.02-2: Unclassified Entrance Pipe Culvert

Unclassified roadway pipe culverts	Any type permitted
Concrete Pipe - 1500D (75D)	Section 2416

Corrugated Steel Pipe	Section 2417

Table 2422.03-3: Unclassified Roadway Letdown Pipe Culvert

Coated Corrugated Steel	Section 2417
Polyethylene Pipe	Section 2417

2422.03 CONSTRUCTION.

A. Install according to the contract documents and in conformance with applicable requirements for the particular type of pipe used.

B. Using more than one type of pipe at one installation site will not be permitted unless by written approval of the Engineer.

C. When rigid pipe culverts are furnished, install as provided in Article 2416.03. When corrugated pipe culverts are furnished, install as provided in Articles 2417.03, B and 2417.03, C.

2422.04 METHOD OF MEASUREMENT.

Measurement for the items associated with unclassified pipe culverts will be as follows:

A. Unclassified pipe culverts: Articles 2416.04 and 2417.04 apply.

B. Excavation for culverts:

1. Roadway pipe culverts: will be measured as provided in Article 2402.04. The plan quantity of excavation will be based on an excavation, centered for the pipe, of the required depth, length, and a width of 42 inches (1 m) plus the specified diameter of the pipe. Modification will not be made in the quantity shown in the contract documents for variations in wall thickness of the various types of pipe. Modifications will be made in the quantity of excavation for changes in location or flowline as provided in Article 2402.04.

2. Entrance culverts: incidental to pipe installation and will not be measured separately for payment.

C. Granular Backfill (if required and furnished): Article 2402.04, E, applies.

D. Foundation treatment (if placed at the direction of the Engineer): Article 2402.04, F, applies.

2422.05 BASIS OF PAYMENT.

Payment for the items associated with unclassified pipe culverts will be the contract unit price as follows:

A. Unclassified pipe culverts: Articles 2416.05 and 2417.05 apply.

B. Excavation for culverts:

1. Roadway culverts and the quantity of extra excavation for embankments: per cubic yard (cubic meter).

2. Entrance culverts: incidental to the contract unit price for unclassified pipe culvert.

F. Granular Backfill (when required and furnished): Article 2402.05, G, applies.

G. Foundation treatment material (furnished and placed): Article 2402.05, F, applies.

Section 2423. Support Structures for Highway Signs, Luminaires, and Traffic Signals

2423.01 DESCRIPTION.

Fabricate, furnish, and erect support structures for highway signs, luminaires, and traffic signals. Design according to the contract documents and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

2423.02 MATERIALS.

Apply Section 4187.

2423.03 CONSTRUCTION.

A. General Requirements.

1. Before fabrication, submit shop drawings according to Article 1105.03.

2. Provide the Engineer ample notice:
- Prior to the start of shop fabrication so that required inspection can be performed, and
- Prior to shipment so that final shop inspections can be performed.

3. Fabricate support structures according to the contract documents. Present proposed design or material changes to the Engineer in written form, plan form, or both. Do not make changes without the Engineer's written approval. The Engineer will not approve substitution of material or design detail changes which constitute a reduction in quality or strength of the structure.

4. The Contractor is to defend and save the Contracting Authority harmless from any and all patent infringement suits resulting from the use of any design, device, material, process, portion, or phase thereof, employed in the manufacture or use of overhead sign support structures according to the contract documents and Article 1107.04.

B. Fabrication and Assembly.
Fabricate structural steel supports according the Structural Welding Code – Steel, AWS D1.1, current edition, or the Structural Welding Code – Aluminum, AWS D1.2, current edition, with the following exceptions:

1. Apply AWS D1.1, Section 6, Part D to non-destructive tests of welds for steel structures, and include tests of column-to-base plate full penetration welds. Apply AWS D1.2, Section 5, to non-destructive tests of welds for aluminum structures and limit tests to the flange connections of the overhead section and the end supports.

2. Apply Article 2408.03, B, relative to qualifications of welders, welding operators, and tackers and the effective period of their qualifications.

3. The provisions of AWS D1.2, Paragraph 9.1.2 do not apply. Structures are Class II structures.

4. Clean weld splatter, black smoke, and residue from fabrication before shipping completed structure to the job site. The fabricator is required to warrant that each complete structure is free from misfits or structural deficiencies prior to shipment.

C. Packing.
Pack prefabricated structural units in a manner to prevent damage or defacement during transportation.

D. Acceptance and Rejection.
Failure of the structure to meet requirements of this specification may be cause for rejection.

2423.04 METHOD OF MEASUREMENT.
Measurement for items for construction of support structures for highway signs, luminaires, and traffic signs will be as follows:

A. Superstructure.
Each overhead sign support structure will be counted by the span and type specified and shown in the contract documents.

B. Substructures.

1. Excavation: as specified in Article 2402.04 for the class shown in the contract documents.

2. Concrete: as specified in Article 2403.04.

3. Reinforcement: as specified in Article 2404.04.

2423.05 BASIS OF PAYMENT.
Payment for acceptable portions of the following items of work will be at the contract unit price as follows:

A. Superstructure.

1. For overhead sign support structures, payment will be for each span and type specified.

2. Payment is full compensation for the following:
- **a.** Furnishing prefabricated structural units, supports, necessary fastenings for assembly of the structure, anchor bolts, and fittings for bolting the upright supports to the concrete bases.
- **b.** Erection of the structure as designated by the contract documents or by the Engineer.

B. Substructures.

1. Excavation:
- **a.** As specified in Article 2402.05 for the class shown in the contract documents.
- **b.** Payment is full compensation for excavation, placing backfill material, compaction of backfill material, replacement and compaction of special shoulder construction materials at the same depth and elevation encountered in the excavation, and depositing of unused excavated materials in a manner satisfactory to the Engineer.

2. Concrete:
- **a.** As specified in Article 2403.05.
- **b.** Payment is full compensation for furnishing, placing, and finishing according to the provisions of Section 2405.

3. Reinforcement: As specified in Article 2404.05.

Section 2424. Shotcrete

2424.01 DESCRIPTION.

A. Remove unsound concrete, prepare concrete surfaces, and apply and cure shotcrete where indicated in the contract documents and where directed by the Engineer.

B. Shotcrete is mortar or concrete conveyed through a hose and pneumatically projected at high velocity onto a surface. Apply Shotcrete using the Dry Mix Process. This is a process in which the dry cement aggregate mixture is carried by compressed air to the nozzle where water is interjected and the resulting mixture is jetted from the nozzle onto the surface to be shotcreted.

1. Shotcrete Mortar.
Shotcrete mortar is a top or surface layer in which the aggregate is limited to sand with a maximum nominal particle size of 1/4 inch (6.3 mm).

2. Shotcrete Concrete.
Shotcrete concrete contains fine aggregate and coarse aggregate with particle sizes in excess of 1/4 inch (6.3 mm). Procedures and quality of work are, in general, to comply with provisions of the current edition of ACI Standard 506, "Recommended Practice for Shotcreting," subject to approval of the Engineer.

2424.02 MATERIALS.

Use materials for shotcreting that meet the following requirements:

A. Portland Cement.
Meet the requirements of Section 4101, Type I.

B. Water.
Apply Section 4102.

C. Fine Aggregate.
Use natural sand meeting the requirements of Section 4110 or 4111.

D. Coarse Aggregate for Concrete.
Meet requirements of Section 4115 and the gradation requirements of Table 2424.02-1:

Table 2424.02-1: Gradation

Sieve No.	Percent Passing
3/4" (19 mm)	100
1/2" (12.5 mm)	97-100
3/8" (9.5 mm)	40-90
No. 4 (4.75 mm)	0-30
No. 200 (75 µm)	0-1.5
The maximum percent passing the No. 200 (75 µm) sieve may be increased to 2.5%, provided the agreed documented production limit is maintained at 1.0% or less, and any increase up to 2.5% is due to degradation of the parent material and not to contamination by other material.	

E. Wire Mesh.
Apply Article 4151.04. Use mesh that is 3 inches by 3 inches or 4 inches by 4 inches (75 mm by 75 mm or 100 mm by 100 mm) with nominal area of wire between 0.014 and 0.030 square inches (9 mm^2 and 19 mm^2), inclusive. Use mesh that is galvanized with a coating (minimum of 0.15 ounces per square foot (45 g/m^2)) recognized in the industry as a "regular" coating.

F. Concrete Anchors.
Furnish concrete anchors designed for use with 1/4 inch (6.4 mm) anchor bolts. Furnish 1/4 inch (6.4 mm) diameter, galvanized, hooked anchor bolts in lengths suitable for anchoring wire mesh to existing concrete.

G. Burlap.

For curing concrete use burlap that meets the requirements of Section 4104.

2424.03 CONSTRUCTION.

A. Equipment.

1. Power Driven Hand Tools.

Power driven hand tools are allowed, with the following restrictions:

a. Jack Hammers.

1) Do not use jack hammers heavier than a nominal 30 pound (14 kg) class.

2) Do not operate jack hammers or mechanical chipping tools at an angle in excess of 45 degrees measured from the surface of the concrete.

b. Chipping Hammers.

Do not use chipping hammers heavier than a nominal 15 pound (7 kg) class.

2. Hand Tools.

Provide hand tools, such as hammers and chisels, to remove final unsound concrete particles or to achieve the required depth.

3. Sand Blasting Equipment.

Use sand blasting equipment capable of removing rust, oil, and concrete laitance from the existing surface.

4. Proportioning and Mixing Equipment.

Use proportioning and mixing equipment that meets requirements of Articles 2001.20 and 2001.21, C. Use mixing equipment capable of thoroughly mixing the materials in sufficient quantity to maintain placing continuity.

5. Air Supply.

Use a compressor of adequate capacity to maintain a sufficient, constant nozzle velocity for all parts of the work while simultaneously operating a blow pipe for cleaning away rebound. Equip the air hose with a filter to prevent any oil or grease from entering the air stream.

6. Delivery Equipment.

Use delivery equipment capable of delivering a continuous, smooth supply of uniformly mixed material. Equip the nozzle with a water ring and valve to permit adjustment of the water. Maintain the water pressure at the nozzle at least 15 psi (100 kPa) greater than the air pressure. Use a nozzle capable of delivering a conical discharge stream.

B. Qualification of Operators.

1. Certification of Training and Experience.

Provide the Engineer a certified statement of training and experience in shotcreting for each of the individuals proposed to occupy the position of supervisor, shotcrete nozzle operator, and shotcrete gun operator.

2. Qualification Test.

a. Each nozzle operator, working with a certified gun operator, must pass a qualification test prior to undertaking the shotcrete application in the project work. This test serves to qualify the shotcrete operator and is to be performed prior to beginning work. The test measures the percent by weight (mass) of rebound. If the rebound is over the allowable percentage, the operator will be disqualified. Replace with an operator who can pass this test.

b. The Engineer may require additional qualification tests during the progress of the work if the quality of the shotcrete operation declines.

c. The test is as follows:

1) Erect 30 inch by 30 inch (750 mm by 750 mm) plywood board test panels horizontally, vertically, overhead, or any combination of positions depending on the anticipated corresponding shooting positions.

2) Arrange drop cloths around and over the test panel to collect the rebound.

3) The shotcrete operator is to fill the middle 18 inch by 18 inch (450 mm by 450 mm) area of the test panel with shotcrete mortar to a minimum depth of 4 inches (100 mm).

4) Determine the quantities of rebound and applied shotcrete. Compute the percent of rebound by dividing the weight (mass) of rebound by the combined weight (mass) of rebound plus the weight (mass) of the applied shotcrete.

5) The allowable percentage of rebound depends on the position of the surface and is specified in the Table 2424.03-1:

Table 2424.03-1: Maximum Rebound

Position of Surface	Maximum Allowable Percentage of Rebound by Weight (Mass)
Horizontal	15
Vertical	30
Overhead	50

d. Furnish the drop cloths, plywood, and all other material necessary for these tests.

C. Preparation of Surface for Shotcrete Repair.

1. Removals.

a. Remove concrete from each area the Engineer designates. Areas as shown in the contract documents are based on the best information available. The Engineer will determine actual areas.

b. Concrete may be removed with power or hand tools. Use only hand tools for final cleanup.

c. Extend removal at least to the level of reinforcing bars and deeper, as necessary, to remove all unsound concrete. Ensure removal allows for a minimum replacement depth of 2 inches (50 mm). Cut

boundaries of removal areas to a 45 degree bevel, with no feather edges or square corners.

2. Cleaning Existing Reinforcement.

a. Use hand methods to remove pack rust.

b. Sandblast to sound metal.

c. Do not damage the reinforcement with tools. To ensure concrete will bond around the periphery of a reinforcing bar, excavate the existing concrete 3/4 inch (20 mm) clear around the bar when:

- More than one-half of an existing reinforcing bar circumference is exposed, or
- A reinforcing bar is loose and unbonded.

3. Anchorage.

The principal anchorage of shotcrete to the existing structure is to be the bond of the shotcrete to the old concrete and to exposed existing reinforcement. Provide supplemental anchorage as follows:

a. Where reinforcement has been exposed and clearance around the periphery of the bar is provided, do not add supplemental reinforcement unless existing reinforcement density and pattern are such that individual open spaces between bars are of 1.5 square foot (0.14 m^2) area or larger. For this situation, install 1/4 inch (6.4 mm) diameter hooked anchor bolts at the rate of one anchor bolt per each 1.5 square feet (0.14 m^2) of area within each open space.

b. Where existing reinforcement is not exposed to provide clearance around the bar periphery, install 1/4 inch (6.4 mm) diameter hooked anchor bolts on an approximate 1 foot by 1 foot (300 mm by 300 mm) grid spacing. For individual areas of 1 square foot (0.1 m^2) or less, install at least one anchor, although mesh will not be required.

4. Reinforcement.

For areas described in Article 2424.03, C, 3 above:

a. Ensure wire mesh is clean and free from coatings which will prevent adequate bond.

b. Fasten mesh to each anchor or to any existing exposed reinforcement, or both. Ensure wire mesh has a minimum of 3/4 inch (20 mm) clearance from the prepared surface.

c. Lap adjacent sheets of mesh at least 1.5 times the spacing of the mesh. Align laps so that parallel wires are staggered, not placed adjacent to each other.

d. Tie sheets together at 1 foot (300 mm) intervals.

e. Bend mesh extending around outside corners or re-entrant corners to template before securing to the anchorage.

f. Position all wire mesh, hook bolts, and existing reinforcement so that they will be covered by the application of at least 3/4 inch (20 mm) of shotcrete.

5. Final Preparation.

Give repair areas a final cleaning by sandblasting followed by air cleaning.

D. Proportioning and Mixing.

1. Storage and Handling.

Store and handle cement and aggregates and measure materials according to Article 2403.02, D.

2. Mix Proportions.

Determine the exact proportions of ingredients on the basis of design mix proportions and a trial application of the design mix. Once the Engineer approves, use the field determined mix in the actual application of shotcrete. Do not vary the mix without the Engineer's written approval.

3. Field Test of Design Mixes.

a. Field test design mixes by shooting one or more test panels. Shoot the first panel in the vertical position. If the first panel is satisfactory, shoot a second panel in the overhead position, if such position is applicable to the work.

b. Conduct a test for percentage of rebound with each test panel. The Engineer will:

1) Observe production of the test panel.

2) Approve or reject the mix based on observation of the placement characteristics and appearance of the completed panels.

3) Direct the testing of a new trial mix if one is necessary.

c. Use 30 inch by 30 inch (750 mm by 750 mm) plain plywood boards for test panels. Install one No. 5 (No. 15) reinforcing bar 1 inch (25 mm) from the surface of the backing board. Place this bar parallel to and 6 inches (150 mm) from one side of the panel.

d. Cover the middle 18 inch by 18 inch (450 mm by 450 mm) area with shotcrete to a minimum depth of 4 inches (100 mm), and finish.

e. Cure the test panels according to Article 2424.03, F.

f. The operator qualification tests specified in Article 2424.03, B may be conducted coincidentally with the field determination of mix for shotcrete.

4. Proportions for Shotcrete Concrete.

Set the design mix proportions for shotcrete concrete at 1 part cement to 3.5 parts aggregate. Proportion the aggregate fraction to be 40% coarse and 60% fine by volume.

5. Proportions for Shotcrete Mortar.

Set the design mix proportions for shotcrete mortar at 1 part cement to 3.5 parts fine aggregate.

6. Proportioning.

a. Proportion dry materials by weight (mass).

b. Ensure the moisture content of fine aggregates is in the range of 3% to 6% by weight (mass) and does not vary more than ± 0.5% during a day's production.

7. Mixing.

a. Do not reuse rebound materials.

b. Mix each batch for at least 1.5 minutes.

c. Clean the mixer as needed to remove all adherent material from the mixing vanes and from the drum.

d. Do not use batches in which the ingredients have been in contact with each other for 45 minutes or more.

8. Admixtures.

a. Admixtures will not be specified.

b. The Contractor may propose specific admixtures for either reducing rebound or improving the workability during finishing.

c. The Engineer may approve such admixtures provided they are incorporated in the field determination of mix.

d. Do not use admixtures containing calcium chloride or polyvinyl acetate.

E. Placing and Finishing.

1. Prewetting.

Saturate the placement area at least 1 hour before the placement of shotcrete, and keep the area damp. However, do not place shotcrete in standing water.

2. Concrete Placement.

a. Apply shotcrete concrete in one or more layers to the total thickness required to restore the repair areas to original lines and section, or to construct a modified section as shown in the contract documents. Ensure each layer is 1 1/2 to 2 inches (40 mm to 50 mm) in thickness.

b. Use ground lines or other suitable devices as necessary to establish true lines and section.

c. Apply a wood float or broom finish to the final surface, subject to the Engineer's approval.

d. The Contractor may use the following procedure in place of surface finishing shotcrete concrete as described above:

1) Follow the procedure described in 1 and 2 above, except stop the concrete filling and strike off the new concrete at about 1/2 inch (15 mm) below the final surface.

2) Change to shotcrete mortar and complete the repair, finishing the surface as described above.

3. Application Sequence.

When shotcreting a vertical face, apply all layers from bottom to top with adequate attention to preventing incorporation of rebound.

F. Curing.

1. Use wet burlap or other approved curing blankets to cover repair areas restored with shotcrete. Apply this cover immediately following finishing and leave in place for at least 7 calendar days. Maintain curing covers in a moist condition throughout this period.

2. The Contractor may submit, for the Engineer's approval, an alternate procedure to provide a wet cure through the minimum period stipulated above. Submit this procedure, together with the schedule for application, to the Engineer for approval before beginning the work.

G. Limitations of Operations.

1. Temperature.
- **a.** Apply shotcrete only when the ambient temperature is at least 40°F (4°C).
- **b.** Do not apply shotcrete to any frozen or frosted surface.
- **c.** Protect shotcrete in place from freezing throughout the curing period.

2. Rain.
- **a.** Do not apply shotcrete during periods of rain without shielding the work, the materials, and the batching and mixing facilities from the weather.
- **b.** Shield shotcrete in place from rain until the curing blankets are in place.

3. Wind.
- **a.** Provide sufficient screening or protection from wind to prevent the cement or fines from being blown out of the jet.
- **b.** Protect fresh shotcrete in place from rapid cooling or drying out by shielding from the wind or application of fog mist, or both, until curing blankets are in place.

4. Containment.
Screen the work area to:
- **a.** Contain dust and rebound materials.
- **b.** Protect nearby structures and vegetation.

5. Protection of Traffic.
Place screening between the work area and nearby traffic, as directed by the Engineer.

2424.04 METHOD OF MEASUREMENT.

Measurement of areas will be based on final surface dimensions to the nearest 0.1 foot (0.1 m). The Engineer will calculate the quantity to the nearest square foot (0.1 m^2) for each area.

2424.05 BASIS OF PAYMENT.

A. Payment for Shotcrete will be the contract unit price per square foot (square meter) for the number of square feet (square meters) placed in a satisfactory manner.

B. Payment is full compensation for:
- Preparing the surface,
- Installing anchors and reinforcement,

- Testing,
- Placing the concrete and mortar,
- Curing and protection, and
- Furnishing all materials, equipment, tools, labor, and incidentals necessary to complete the repair of the areas.

Section 2425. Precast Prestressed Concrete Deck Panels

2425.01 DESCRIPTION.

This specification describes precast prestressed concrete deck panels to be used in the construction of bridge decks. When authorized in the contract documents, these panels may be used in construction of the deck, at the option of the Contractor, in place of the usual removable deck forms. These panels are to remain in place because they are designed to function as part of the deck in the completed structure. When the option is authorized, the contract documents will include details of the panels and their use.

2425.02 MATERIALS.

Produce the panels according to the requirements in the contract documents and Section 2407. Consolidate the concrete for the panels by vibration. Air entrainment will be required. Apply Article 2407.03, B.

2425.03 CONSTRUCTION.

A. Fabricate the panels according to the details shown in the contract documents and the approved shop drawings. Submit shop drawings according to Article 1105.03. On skewed decks, the Contractor may form and cast the skewed portion of the deck, or use individually precast skewed end deck panels. A minimum 2 foot (600 mm) bearing length is required along the edge of the panels.

B. Set the panels in place over strips of preformed joint filler. Place the reinforcement as shown in the contract documents. Place, consolidate, finish, and cure the concrete of the deck. Prior to placement of the concrete, clean the top surface of each panel and beam as designated in the contract documents. Ensure the panel surface is dry and dust free when cast-in-place concrete is placed on the panel.

2425.04 METHOD OF MEASUREMENT.

If the Contractor chooses to use precast prestressed concrete deck panels in the operations, measurement for construction of the deck will be based on the plan quantities for the various items involved.

2425.05 BASIS OF PAYMENT.

If the Contractor chooses to use precast prestressed concrete deck panels in the operations, payment for construction of the deck will be based on the plan quantities and the associated contract prices for the various items involved. No adjustment will be made for using this option.

Section 2426. Structural Concrete Repair

2426.01 DESCRIPTION.

A. Repair spalled or deteriorated structural concrete as specified in the contract documents. This work may include the installation of concrete anchors, reinforcing bars, or wire mesh.

1. Shallow Repair.

a. Repair that:

- Is 3/4 inch to 1 1/2 inch (20 mm to 40 mm) in depth,
- Is placed against sound concrete, and
- Requires a bonding grout, but does not use forms to support the patching material.

b. Forms may be needed in areas of shallow repair where the patching material can not support itself. In these areas bonding grout will not be required.

2. Regular Repair.

a. Repair that:

- Is a minimum depth of 1 1/2 inch (20 mm), or 3/4 inch (40 mm) behind an unbonded reinforcing bar, and
- Is placed against sound concrete.

b. Forms are used, but bonding grout is not required.

B. The Engineer will outline the areas to be repaired.

2426.02 MATERIALS.

A. Use materials meeting the appropriate requirements of Division 41.

B. Mix proportions are as follows:

1. Bonding Grout.

Use equal parts by weight (mass) of Type I cement and sand with enough water to form a slurry with a consistency such that it can be applied with a stiff brush in a thin even coating that will not run or puddle.

2. Concrete.

a. Shallow Repair.

Table 2426.02-1: Proportions

Materials	by weight (mass)
Type I Portland cement	4 parts
Concrete sand (Section 4110)	5 parts
Coarse aggregate (Article 4115.05)	5 parts

Add enough water to the mixture to form a consistency that will permit placement and consolidation by hand compaction without slumping.

b. Regular Repair.
Furnish Class O concrete. Use 3 inches (75 mm) as the target slump, with a variation not to exceed ± 1 inch (25 mm).

2426.03 CONSTRUCTION.

A. Equipment.
Use equipment that meets the requirements of Article 2413.03, A, 2, to prepare the repair area.

B. Surface Preparation.

1. Remove all loose, disintegrated, and unsound concrete from the repair areas. Outline all repairs with a 3/4 inch (20 mm) deep saw cut. Concrete anchors and wire mesh may be required, as shown in the contract documents. Overhead repairs may require special procedures, as proposed by the Contractor and approved by the Engineer.

2. After removal of loose, unsound concrete, sandblast the repair area and follow with an air blast with oil free air so the substratum is sound, clean and free of all contaminants. Exercise extreme care in concrete removal so that prestressed strands are not damaged. The substrate must be dry prior to concrete placement or bonding grout application, if required.

3. Sandblast exposed reinforcement to remove all rust. Remove and replace damaged or badly corroded reinforcing bars, as directed by the Engineer.

C. Placement Procedure.

1. Shallow Repair.
a. Bonding Grout.
Apply bonding grout to the properly cleaned, dry surface of the old concrete with a stiff bristle brush. Do not prewet the concrete surface before placing grout.
b. Repair Concrete.
Place and compact repair concrete before the grout dries. If the grout dries prior to concrete placement, remove the grout by sandblasting and reapply. Strike off and finish the repair concrete to the correct lines.

2. Regular Repair.
a. Place concrete according to Article 2403.03, C.
b. When repairing a vertical face, place the patch in heights not to exceed 4 feet (1.2 m). Provide access ports at 4 foot (1.2 m) intervals in the forms for placement and vibration. Remove forms according to Article 2403.03, M.

D. Curing.
Apply white pigmented curing compound to the concrete immediately following concrete finishing or immediately after removing forms, if used. Apply curing compound according to Article 2403.03, E, except use an application rate of 100 square feet per gallon (2.5 m^2/L).

2426.04 METHOD OF MEASUREMENT.
The Engineer will determine the square feet (square meters) of Concrete Repair by measuring the surface dimensions of the area repaired to the nearest 0.1 foot (0.1 m). Distinction will not be made between shallow repair and regular repair.

2426.05 BASIS OF PAYMENT.

A. Payment for the number of square feet (square meters) of Concrete Repair completed, measured as provided above, will be the contract unit price per square foot (square meter).

B. Payment is full compensation for:
- Removal of excess concrete from the project,
- Furnishing all materials and equipment, including concrete anchors, wire mesh, and reinforcing bars, if required.
- Sandblasting exposed reinforcement,
- Removing and replacing damaged reinforcing bars,
- Forms, and
- Labor necessary to complete the work according to the contract documents.

Section 2427. Bridge Cleaning

2427.01 DESCRIPTION.

A. Remove all accumulated foreign material from the entire bridge, including the bridge deck, sidewalk, curbs, pier tops, trusses, interior of truss members, and lower flanges of beams or girders.

B. Clean expansion joints, wind links, and drains.

2427.02 MATERIALS.
None.

2427.03 EQUIPMENT, CLEANING, AND TRAFFIC CONTROL.

A. Equipment.

1. Furnish cleaning equipment consisting of hand tools, power brooms, air compressors, water tanks, and water pumps with associated delivery hardware necessary to properly flush, clean, and remove all foreign material from the bridge structure.

2. Other types of cleaning equipment may be used with the Engineer's approval.

3. Ensure air and/or water pressure are sufficient to remove the accumulated material without damaging paint coverage of the structural steel.

4. Equip each self propelled unit used in the cleaning operation with an amber revolving light that:
   - Is visible from all directions, and
   - Flashes at least 60 times per minute, but not more than 120 times per minute.

5. Other equipment such as high-reach trucks, and under bridge access trucks or movable scaffolds may be necessary to gain access to areas designated for cleaning. It will be the Contractor's responsibility to determine and use whatever method and equipment is best suited for the operation to successfully clean the structure.

B. Cleaning.

1. Ensure areas that have been cleaned are free of all accumulations of sand, gravel, dirt, bird nests and excreta, and other foreign materials.

2. Obtain a source of fresh water free of sediments and salt contaminants, at no cost to the Contracting Authority.

3. Prior to cleaning with water pressure, remove all accumulated foreign material from bridge sidewalks, bridge decks, curb tops, beam flanges, gusset plates, abutment bridge seats, pier tops, truss joints, deck drain systems, and other locations specified and as directed by the Engineer. Remove the accumulated foreign material with hand brooms, hand shovels, scrapers, vacuum cleaners or other methods acceptable to the Engineer. Collect this removed material and dispose of at an approved waste area according to Federal, State, and Local regulations. Do not at any time allow this removed material to fall or be disposed of in the water or on the land below the bridge.

4. Use sufficient water under pressure to remove salt contaminants, dirt, and other detrimental foreign matter without damaging or removing paint from any structural steel. To clean the bridge, use a minimum water flow rate of 5 gallons (20 L) per minute. The maximum water pressure is to be 1000 psi (6900 kPa), but not so high that any paint is removed.

5. Stop the cleaning operation if foreign material has not been removed or if removal of or damage to existing paint coverage occurs. In this situation, adjust the water pressure to remove foreign material without damaging or removing existing paint coverage.

6. Flush all deck drains and scuppers at drains with water under pressure after the accumulated foreign material in them has been properly

removed. Drain systems may have to be taken apart to remove large blockages of accumulated foreign material. Should this be necessary, return them to their original configuration immediately after cleaning. Ensure drain systems drain properly after cleaning.

7. Flush out the interior of all truss members with water under pressure. Continue to do so until such time each truss member is draining out clear water.

8. Thoroughly wash down the exterior of all truss members, miscellaneous structural steel connecting truss members, and floor beam ends projecting outwardly from the row of exterior stringers using water under pressure.

9. At the direction of the Engineer, repair or replace all roadway appurtenances damaged during the cleaning operations at no additional cost to the Contracting Authority.

10. Do not soil or damage private or public property during cleaning operations.

C. Traffic Control.

1. Apply Traffic Control according to the traffic control plan.

2. Private vehicles will not be allowed to park on the structure at any time.

3. Furnish, erect, maintain, and remove all signs and traffic control devices made necessary for the work.

2427.04 METHOD OF MEASUREMENT.
Bridge Cleaning will not be measured separately for payment but will be considered as a lump sum.

2427.05 BASIS OF PAYMENT.

A. Payment for Bridge Cleaning will be the lump sum contract price.

B. Payment is full compensation for:
- Furnishing all material, labor, and equipment, and
- Performing of all work necessary to flush, wash, and clean and remove all foreign material and debris, and dispose of according to the contract documents.

Section 2428. Smoothness of Bridge Decks and Bridge Deck Overlays

2428.01 DESCRIPTION.
Test and evaluate smoothness of bridge decks and bridge deck overlays. Perform surface correction if required.

2428.02 TESTING AND EVALUATION.

A. General.

1. Except when specifically excluded in the contract documents, evaluate smoothness for all:
- **a.** Interstate and Primary bridge decks, new approaches and bridge deck overlays, and overlaid approaches.
- **b.** Non-Primary bridge decks, new approaches and bridge deck overlays, and overlaid approaches for projects where the Department is the Contracting Authority.

2. If this specification is required by contract documents on non-Primary projects let by the Department, it will be added in its entirety. Selected portions of the specification will not be deleted.

B. Measurement.

Provide and operate an Ames type or California type profilograph to produce a profilogram (profile trace) of the surface tested according to Materials I.M. 341. Other types of profilographs or profilers that produce compatible results and meet the requirements of Materials I.M. 341 may be used.

C. Profilograph Testing.

1. Remove all objects and foreign material from the deck surface, including protective covers, if used, prior to testing by the Engineer. If appropriate, properly replace protective covers after testing.

2. A profilogram will be made by a test in each wheel path of each traffic lane. The profilogram will include a minimum of 16 feet (5 m) beyond the bridge section when there is adjoining pavement. Bridge decks and bridge deck overlays will be treated as one section. The profilogram will include a minimum of 100 feet (30 m) beyond the approach section when there is adjoining pavement.

3. For bridge lengths of 778 feet (240 m) or less, each traffic lane is a segment. For bridges longer than 778 feet (240 m), a segment shall be 0.1 miles (160 m) of the traffic lane. If the remaining segment is 250 feet (80 m) or less in length, it is included in the adjacent bridge segment. If the remaining segment is more than 250 feet (80 m) in length, it is evaluated on its own. When bridge deck overlay expansion joints are not new or replaced, segments begin and end at the expansion joints.

4. Each bridge approach lane is a separate segment.

5. Perform quality control testing and furnish the profilogram results to the Engineer. Ensure:
- Testing and evaluation are done by a trained and certified person, and
- The evaluation is certified according to Materials I.M. 341.

D. Profile Index.

1. Calculate an average profile index for each segment from the two wheel path profilograms, according to Materials I.M. 341, except for:
- **a.** Bridge decks or bridge deck overlays less than 100 feet (30 m) in length.
- **b.** New bridge approach sections or bridge approach overlays less than 100 feet (30 m) in length.
- **c.** Bridge decks for new concrete slab bridges.
- **d.** The 16 feet (5 m) at the ends of the section.
- **e.** The 16 feet (5 m) on each side of the expansion joints that are not new or replaced.

2. Limits for average profile index per 0.1 mile (160 m) are as follows:

New Bridge Deck	less than 22.1 inches/mile (351 mm/km)
Bridge Deck Overlay	less than 15.1 inches/mile (241 mm/km)
Bridge Approach (New or Overlaid)	less than 22.1 inches/mile (351 mm/km)

3. The Engineer will perform verification testing to validate the Contractor's certified quality control testing. If the Engineer's verification test results validate the Contractor's test results, The Contractor's results will be used for acceptance. Disputes between the Contractor's and the Engineer's test results will be resolved according to Materials I.M. 341. The Engineer may test the entire project length if it is determined the Contractor's certified test results are inaccurate. The Contractor will be charged for this work at a rate of $500 per bridge deck. In addition, providing inaccurate test results may result in decertification.

4. On deck placements less than 100 feet (30 m), test and evaluate each lane of placements. Provide the Engineer with the final trace and index and the final evaluation within 14 calendar days of deck completion.

5. On deck placements of 100 feet (30 m) or more, provide the Engineer with the initial profile trace and index for each lane by noon of the fifth working day following each of the first row placements. On subsequent placements, provide the Engineer with the trace and index following every third placement until the deck is completed. On single-pour bridges, provide the Engineer with the final profile trace and index and the final evaluation within 2 weeks of deck completion.

2428.03 SURFACE CORRECTION.

A. Perform surface correction for the full segment width of the paved surface.

B. Obtain the Engineer's approval for all correction work. After all required correction work is completed, determine the final profile index.

C. Accomplish surface correction by grinding or by other methods the Engineer approves. Perform the work as identified in Section 2532. Use a cutting head that is a minimum of 24 inches (600 mm) wide.

D. Perform surface correction parallel to lane lines or edge lines as directed by the Engineer. Make each pass parallel to the previous passes. Grind the surface to a uniform texture.

E. Do not overlap adjacent passes more than 1 inch (25 mm) or have a vertical difference of more than 1/8 inch (3 mm) as measured from bottom of groove to bottom of groove.

F. Begin and end smoothness correction at lines normal to the lane lines or edge lines within any one corrected area. Proceed from the center line or lane line toward the edge to maintain cross slope.

G. Maintain cross slope throughout the corrected area.

H. Perform corrective grinding prior to longitudinal grooving.

2428.04 BUMPS AND DIPS.

Bumps and dips, including those at headers, on all surfaces for which smoothness is designated will be evaluated. Correction work will be required according to the criteria in Paragraphs B and C below. For areas excluded from profilograph testing, correct deviations exceeding 1/8 inch in 10 feet (3 mm in 3 m).

A. Bumps.

1. Correct all bumps exceeding 0.5 inch (12.7 mm) within a 25 foot (7.6 m) span, as indicated on the profilogram, except as stated in Article 2428.04, F.

2. Corrected bumps will be considered satisfactory when profilograph measurement shows that the bumps were 0.3 inch (7.6 mm) or less in a 25 foot (7.6 m) span.

B. Dips.

1. Correct all dips exceeding 0.5 inch (12.7 mm) in a 25 foot (7.6 m) span, as indicated on the profilogram, only when the Engineer requires, except as stated in Article 2428.04, F. The Contractor will be assessed a price adjustment of $900 for each dip exceeding 0.5 inch (12.7 mm) that is not corrected, except as stated in Article 2428.04, C.

2. A dip in both wheel paths at a lane location will be considered a single dip when assessing a price adjustment.

3. Corrected dips will be considered satisfactory when the profilogram shows the dips are less than 0.3 inch (7.6 mm) in a 25 foot (7.6 m) span.

C. Exceptions.

When the Contractor is not responsible for the adjoining surface, the Engineer will evaluate bumps and dips exceeding 0.5 inches (12.7 mm) located within 16 feet (5 m) either side of the end of a section. The Contractor will not receive a price adjustment for bumps and dips in this

area. When the Engineer instructs, the Contractor will be paid to repair these bumps and dips according to Article 1109.03, B.

2428.05 SCHEDULE OF PAYMENT.

The cost of certified profilograph testing and associated traffic control is incidental to the contract unit price for the item for which the testing is required.

A. Incentives.

1. New bridge decks or bridge deck overlays which are designated for smoothness will be evaluated for incentives using the initial profile index and the number of segments on the bridge.

2. For each segment of a bridge to be qualified for an incentive payment, the profilogram for that segment before correction must meet the specification requirement so there is no price reduction.

3. For each segment of the bridge deck or bridge deck overlay, the incentive index is 12.0 inches per mile (190 mm/km) for new bridge decks, and 4.0 inches per mile (65 mm/km) for bridge deck overlays. The incentive payment will be according to Table 2428.05-1:

Table 2428.05-1: Incentives

New Bridge Decks		Bridge Deck Overlays	
Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment	Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment
0 - 6.0 (0 - 95)	6000	0 - 2.0 (0 - 32)	2000
6.1 - 12.0 (96 - 190)	3000	2.1 - 4.0 (33 - 65)	1000
12.1 - 22.0 (191 - 350)	Unit Price	4.1 - 15.0 (66 - 240)	Unit Price

B. Price Reduction.

1. New bridge decks or bridge overlays which are designated for smoothness will be evaluated for price reduction assessment using the final profile index and the number of segments.

2. The Contractor may grind the surface of the bridge deck to a final index of 22.0 inches per mile (350 mm/km) or less, or the surface of a bridge deck overlay to a final index of 15.0 inches per mile (240 mm/km) in lieu of a price reduction.

3. Each segment of bridge deck with a final index of 22.1 inches per mile (351 mm/km) or greater or bridge deck overlay with a final index of 15.1 inches per mile (241 mm/km) or greater will be assessed a price reduction according to Table 2428.05-2:

Table 2428.05-2: Price Reduction

New Bridge Decks		Bridge Deck Overlays	
Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment	Initial Profile Index Inches Per Mile (mm/km) Per Segment	Dollars Per Segment
22.1 - 30.0 (351 - 470)	2000	15.1 - 20.0 (241 - 315)	1000
30.1 - 35.0 (471 - 550)	4000	20.1 - 25.0 (316 - 390)	2000
35.1 - 40.0 (551-630)	6000	25.1 - 30.0 (391 - 470)	3000
over 40.0 (over 630)	[a]	over 30.0 (over 470)	[a]
[a] Correction is required to an index of 15.0 inches per mile (240 mm/km) for overlays and to an index of 22.0 inches per mile (350 mm/km) for new decks.			

C. Bridge Approach Sections and Overlay of Bridge Approach Sections. Correct bridge approach sections and overlays of bridge approach sections for smoothness as specified in Article 2428.03 in lieu of a price reduction.

Section 2429. Pre-Engineered Steel Truss Recreational Trail Bridge

2429.01 DESCRIPTION.

A. These specifications are for an engineered truss bridge of welded steel construction and are minimum standards for design and construction.

B. Install an engineered truss bridge of welded steel construction manufactured by a company on the approved manufacturer's list in Materials I.M. 557, Appendix D.

2429.02 DESIGN AND MATERIALS.

A. Design.

1. Designer Qualifications.

a. No less than 5 years experience in design and fabrication of engineered bridge trusses. In addition, provide information regarding similar projects that were previously completed, including references.

b. Professional Engineer licensed in the State of Iowa.

2. Design Loads and Related Requirements.

a. Allowable Design Stresses according to the "Standard Specifications for Highway Bridges" adopted by AASHTO.

b. Vertical Loads:

- Live load: 85 pounds per square foot (4 kPa) applied to the complete width of the deck area shown in the contract documents.

- Concentrated load: located at mid-span and equal to 10,000 pounds (4.5 Mg) plus 30% for impact loading.
- Vehicle loads: 20,000 cycles or less.
- Buoyancy due to submergence.

c. Horizontal Loads:
- Minimum horizontal wind load: 30 pounds per square foot (1.4 kPa) applied to the entire truss as if fully enclosed.
- Seismic and loads combinations: applied according to the AASHTO Specifications for Highway Bridges noted in this specification.

d. Bridge camber at center of bridge span of 1% of the total bridge span. Camber to offset full dead load deflections.

e. Bridge designed to accommodate a temperature differential of 100ºF (56ºC).

f. Teflon or other approved slip pads placed between the bearing and setting plates provided by the bridge manufacturer. At least 1 inch (25 mm) clearance provided between the bridges and the abutments.

g. Welded Tubular Connection Design: according to the Structural Welding Code from ANSI/AWS D1.1, Chapter 10 Tubular Structures.

h. Shop Drawings (Manufacturer's standard schematic drawings and diagrams):

1. Unique drawings prepared to illustrate the specific portion of the project.

2. All relative design information such as member sizes, bridge reactions, and general notes clearly specified.

3. Accurately prepared to be complete in every respect. Include cross referenced details and sheet numbers. Signed and sealed by a Professional Engineer licensed in the State of Iowa.

4. Submit shop drawings according to Article 1105.03.

i. Maximum deflection due to live load plus impact not to exceed that specified in the contract documents.

j. If intermediate piers are required for the bridge over a railroad, a minimum 25 foot (7.62 m) horizontal and vertical clearance, or a distance as specified elsewhere in the contract documents, from the track is required.

3. Geometry.

a. Low profile (pony truss) half through truss design.

b. Provide one diagonal per panel. Chords, diagonals, verticals, and bracing shall be tube steel.

c. A minimum of 72 inches (1.8 m) from top of bottom chord to top of railing.

4. Railings and Accessories.

a. All railings:
- Located on the inside surface of the trusses.
- Smooth inside surface with no protrusions or depressions.

b. Top railings: a minimum of 54 inches (1.4 m) above the floor for bicycle applications, according to AASHTO.
c. Safety railings: a maximum opening of 4 inches (100 mm). All ends of angles and tubes welded and ground smooth.

B. Materials.

1. Structural Thickness.
- Structural tubing: minimum material thickness of 1/4 inch (6 mm).
- All other structural members: minimum material thickness of at least 5/16 inch (8 mm).

2. Unpainted Bridges.
- Unpainted and fabricated from high strength weathering steel.
- All fabrications produced from high strength, low alloy, atmospheric corrosion resistant ASTM A 606 or ASTM A 242 plate and structural shapes.
- Minimum yield (F_y) greater than 50,000 psi (345 MPa).

3. Field Splices.
- Bolted with high strength bolts according to ASTM A 325.
- Type 3 bolts are required for Weathering Steel bridges, according to ASTM A 325 or A 490.
- Field connection bolts tightened by the “turn-of-nut method” to obtain proper torque. See Article 2408.03, S, 5, b.

4. Welding.
- Materials: according to AWS.
- Welders: certified according to AWS D1.1.

5. Railings and Accessories.
- Railings (except rub rail): fabricated from steel.
- Rub rail: fabricated from 2 inch by 8 inch (50 mm by 200 mm) treated wood.

6. Toe Plates.
Toe plates are required. Use 6 inch x 5/16 inch (150 mm x 8 mm) plate located 2 inches (50 mm) above the floor decks.

7. Anchor Bolts.
Provided by the manufacturer.

2429.03 CONSTRUCTION.

A. Fabrication.
Ensure quality, fabrication, and shop connections comply with AASHTO Specifications for Highway Bridges noted in this specification.

B. Welding.

1. Welding.

- Comply with Article 2408.13.
- Use E70 or E80 series electrodes that have the same weathering characteristics as corrosion-resistance steel, or the gas metal arc welding process (Short Circuiting Transfer) with Carbon Dioxide/Argon shielding gas with ER80-D2 filler material conforming to AWS A5.28.

2. Welding Operators.
Properly accredited experienced operators, each of whom must:
- Submit satisfactory evidence of experience and skill in welding structural steel with the kind of welding to be used in the project, and
- Have demonstrated the ability to make uniform good welds meeting the size and type of weld required.

C. Quality Assurance.
The Manufacturer pays all costs associated with the following inspection requirements for fabrication and finishes:

1. Welded tubular connections qualified per AWS D1.1-94 using short circuited gas metal arc process.

2. All welds to be visually inspected.

3. Base material certifications to be supplied by the material suppliers.

D. Weld Testing.
Have nondestructive weld testing performed by an independent agency. The Manufacturer pays for nondestructive weld testing.

1. Ten percent of all welds are to be magnetic particle tested.

2. Ultrasonic testing is to be performed on all top and bottom chord, full penetration welds.

E. Finishes.
Sandblast unpainted weathering steel bridges according to SSPC Surface Preparation Specification No. 6.

F. Delivery and Erection.

1. Manufacturer's Responsibilities.
- Deliver the bridge by truck to a location nearest to the site accessible by roadways.
- Notify the Contractor in advance of the expected arrival time.
- Provide the Contractor information regarding delays after the truck departs the plant, such as inclement weather, delays in permits, rerouting by public agencies, or other circumstances, as soon as possible.

- Advise the Contractor of the actual lifting weights, attachment points, and all other pertinent information needed to install the bridge.

2. Contractor's Responsibilities.
- Provide proper lifting equipment.
- Unload the bridge from the truck at the time of arrival.
- Splice and bolt the components.

2429.04 METHOD OF MEASUREMENT.
Measurement will be by count for each Pre-engineered Steel Truss Recreational Trail Bridge installed.

2429.05 BASIS OF PAYMENT.

A. Payment for each Pre-engineered Steel Truss Recreational Trail Bridge furnished and erected will be the contract unit price.

B. Payment is full compensation for:
- Designing, manufacturing, delivering, erecting, and assembling the unit complete as shown in the contract documents, and
- All foundations, footings, abutments, piers, pier caps, bearing plates, pads, bolts, anchor bolts, grouting, decking, railing, and any other materials, labor, and equipment necessary to complete the bridge in place.

Section 2430. Modular Block Retaining Wall

2430.01 DESCRIPTION.
Furnish and install modular block retaining wall units, wall fill, and granular backfill material to the lines and grades shown in the contract documents. Modular block retaining walls are defined as systems that usually do not require mesh or strips in the backfill material behind the wall facing to limit backfill material stresses by reinforcing the soil structure.

2430.02 DESIGN AND MATERIALS.

A. Design.

1. Wall Design Engineer.
The Wall Design Engineer is required to be a Professional Engineer licensed in the State of Iowa.

2. Submittals.
Prior to the beginning of the wall construction, submit for approval, according to Article 1105.03, detailed design calculations including soil bearing pressure, construction drawings, and shop drawings prepared and sealed by the Wall Design Engineer. If required, submit a detailed explanation of the design properties and quality control test limits for the geogrid reinforcement with the design.

B. Materials.
Furnish a wall manufactured by a company on the approved manufacturer's list in Materials I.M. 445.04.

1. Concrete Units.
- **a.** Exterior dimensions may vary. Each unit is required to have a minimum of 0.5 square feet (0.046 m^2) of face area and an 8 inch (200 mm) maximum vertical dimension.
- **b.** Block faces are to be straight, with split face texture.
- **c.** Angled sides are to be capable of attaining concave and convex alignment curves of minimum radius of 5.0 feet (1.5 m).
- **d.** Units are to be interlocked:
  - Either with: 1) connector pins of the type, size, and design recommended by the supplier/manufacturer for the type of masonry unit and backfill reinforcement material used in the wall; or 2) by integrally cast shear lugs.
  - To provide minimum of 1/4 inch (6 mm) of setback for each course of wall height.

2. Leveling Pad.
Use supplier/manufacturer recommended leveling pad materials. If granular material is recommended for the leveling pad, use backfill material meeting the requirements of Section 4132. If unreinforced concrete is recommended for the leveling pad, use Class C concrete meeting the requirements of the Materials I.M. 529 and Section 2403.

3. Unit Fill.
Unit fill is the granular material that is within the concrete facing units. Use porous backfill material meeting the requirements of Section 4131.

4. Backfill Material.
When required, use granular backfill material meeting the requirements of Section 4133.

5. Tieback Reinforcement.
When required, use the type, size, and design the supplier/manufacturer recommends.

2430.03 CONSTRUCTION.

A. Excavation.

1. Excavate according to Section 2102. This includes benching of the existing roadway foreslopes and the excavation area under the pad line. Do not disturb existing embankment materials beyond what is needed to construct the wall.

2. At locations where the wall is to be constructed adjacent to a fill section, construct and compact the fill to 95% Standard Proctor Density prior to beginning wall construction. After the fill has been constructed, make the cut to permit a minimum of 12 inches (300 mm) beyond the wall to

be filled with granular backfill materials meeting the requirements of Section 4131. Place and compact the granular backfill material on a course by course basis.

B. Foundation Soil Preparation.

1. Prepare foundation soil as required for the leveling pad.

2. The Engineer will examine the foundation soil to assure that the actual foundation soil strength meets or exceeds the assumed design bearing strength. Remove soils not meeting required strength and replace with soil meeting the design criteria.

3. Ensure the earth foundation has a density equal to or greater than 90% Standard Proctor Density. Step the earth foundation at the required intervals to keep it a minimum 1 foot (300 mm) below the finished grade.

4. Place granular backfill material as replacement material for over excavation in the foundation soil. Compact the replacement material according to Article 2107.03, H.

C. Leveling Pad.

1. Minimum of 6 inches (150 mm) thick.

2. Construct the leveling pad to ensure complete contact of the retaining wall unit with the leveling pad. Gaps will not be allowed between the retaining wall unit and the leveling pad.

D. Unit Installation.

1. Ensure units are in full contact with the leveling pad.

2. Place units side by side for the full length of wall alignment. Alignment may be done by means of a string line or offset from the base line.

3. Install connecting pins and fill units, and tamp the fill.

4. Sweep all excess material from top of units and install the next course. Ensure each course is completely filled prior to proceeding to the next course.

5. Place each course so that pins protrude into adjoining courses a minimum of 1 inch (25 mm) or to tolerances recommended by the supplier/manufacturer. Two pins are required per unit. Repeat the above procedure for each course to the top of wall height.

6. At the end of each course where the wall changes elevation, turn the units into the backfill material. Place units to create the minimum radius possible. Install a minimum of 3 units into the grade. Ensure only the front face of the units is visible from the side of the wall.

E. Backfill Material Placement.

1. Place each course of granular backfill material for the reinforcing following the erection of each lift of wall. At each level for reinforcing, roughly level the backfill material before placing and connecting the reinforcement. Place reinforcing normal to the face of the wall. Place the lifts to closely follow panel erection. Decrease this lift thickness, if necessary, to obtain the specified density.

2. At the end of each day's operations, shape the last level of backfill material to permit runoff of rainwater away from the wall face.

3. Compact granular backfill material according to Article 2107.03, H. Ensure the moisture limits are from 3% under optimum moisture to no more than the optimum moisture content.

4. Place and compact backfill material without disturbing or distorting the tieback reinforcement or the wall. Do not use tamping type rollers or other rollers that may damage the reinforcing. Use light mechanical tampers to achieve the required compaction in a strip 3 feet (1 m) wide adjacent to the backside of the wall; however, compaction within this strip will not be subjected to density testing.

F. Tieback Reinforcement Installation For Retaining Walls, Where Specified.

1. Place the tieback reinforcement horizontally on compacted backfill material, connect it to the concrete wall units, and embed it a minimum of 12 inches (300 mm). Hook reinforcement over pins, pull taut, and anchor before backfill material is placed on the tieback reinforcement.

2. Remove slack in the tieback reinforcement at the wall unit connections.

3. Place tieback reinforcement at the proper elevation and orient it as recommended by the supplier/manufacturer.

4. Correct orientation (roll direction) of the tieback reinforcement, if applicable, as recommended by the supplier/manufacturer.

5. Tieback reinforcement may be secured in place with staples, pins, sand bags, or backfill material depending on the fill properties, fill placement procedures, and weather conditions.

6. Overlaps:
- **a.** Overlapping uniaxial tieback reinforcement in the across-the roll direction is not required, except to contain the fill at the slope face when wrap around facing is used. Overlap uniaxial tieback reinforcement a minimum of 48 inches (1.2 m) in the roll direction.
- **b.** Spread a layer of compacted backfill material, a minimum of 4 inches (100 mm) in thickness, between uniaxial tieback reinforcement layers in the area to be overlapped.

2430.04 METHOD OF MEASUREMENT.
Measurement for Modular Block Retaining Wall will be in square feet (square meters), determined from the area of the front face of the wall in place. The height will be measured from the top of the leveling pad to the top of the wall, including cap block.

2430.05 BASIS OF PAYMENT.

A. Payment for Modular Block Retaining Wall constructed will be the contract unit price per square foot (square meter).

B. Payment is full compensation for furnishing and erecting the modular block retaining wall according to the contract documents, including:
- Design,
- Excavation,
- Foundation soil preparation,
- Leveling pads,
- Concrete units,
- Connector pins,
- Unit fill for inside the blocks,
- Granular backfill material, and
- Tieback reinforcement if required.

Section 2431. Segmental Retaining Wall

2431.01 DESCRIPTION.
Furnish and install segmental retaining wall (SRW) units, wall fill, and granular backfill material to the lines and grades shown in the contract documents. Segmental retaining walls are defined as systems which usually require mesh or strips in the backfill material behind the wall facing to limit backfill material stresses by reinforcing the soil structure.

2431.02 DESIGN.

A. Design

1. Wall Design Engineer.
The Wall Design Engineer is required to be Professional Engineer licensed in the State of Iowa.

2. Minimum Design Requirements.
The SRW is required to be designed according to ASTM C 90 and recommendations of the National Concrete Masonry Association (NCMA) Design Manual for Segmental Retaining Walls. The following table summarizes the minimum design criteria and is based upon the structure being critical:

External Stability	Minimum Factor of Safety
Sliding, Fs_{sl}	1.5
Overturning, Fs_{ot}	2.0
Bearing Capacity, Fs_{bc}	2.0

Internal Stability	Minimum Factor of Safety
Tensile Overstress, Fs_{to}	1.2
Pullout, Fs_{po}	1.5

Local Stability	Minimum Factor of Safety
Fs_{sl} (Maximum Unreinforced Height)	1.5
Fs_{ot} (Maximum Unreinforced Height)	2.0
Shear Facing Units, Fs_{sc}	1.5
Facing Connection Strength, Fs_{cs}	1.5
Global Stability	1.5

3. Submittals.

Prior to beginning SRW construction, submit the following for review according to Article 1105.03:

- Detailed design calculations (including soil bearing pressure), construction drawings, and shop drawings, all prepared and sealed by the Wall Design Engineer.
- A detailed explanation of the design properties for the geogrid reinforcement with the design.
- The quality control test limits for the geogrid meeting those design requirements.

B. Materials.

Furnish a wall manufactured by a company on the approved manufacturer's list in Materials I.M. 445.04. Ensure both the supplier of all substantial material components and the Wall Design Engineer have demonstrated experience in reinforced soil-reinforced SRWs for previous projects.

1. Concrete Units.

a. Ensure the following:

- Concrete segmental units and cap blocks comply with the requirements of ASTM C 1372, except with a minimum 28 day compressive strength of 5500 psi (40 MPa) for any one individual unit, and 6000 psi (41 MPa) for the average of three units.
- The 24 hour water absorption rate does not exceed 5%.
- The top surface of cap blocks are sloped 10:1 from front to back or from a crown at the center.

b. Ensure block sampling and testing comply with ASTM C 140, except replace Section 6.2.4 with:

> The specimens shall be coupons cut from a face shell of each unit and sawn to remove any face shell projections. The coupon size shall have a height to thickness ratio of 2 to 1 before capping and a length to thickness ratio of 4 to 1. The coupon shall be cut from the unit such that the coupon height dimension is in the same direction as the unit height dimension. Compressive testing of full size units shall not be permitted. The compressive strength of the coupon shall be assumed to represent the net area compressive strength of the whole unit.

c. Freeze-thaw durability testing will be required as described in ASTM C 1372 Sections 4.2, 4.2.1, and 7.3. Ensure testing is done according to ASTM C 1262.

d. Ensure specimens meet weight (mass) loss limits for testing in water as required in ASTM C 1372 Section 4.2.1.

e. Ensure specimens are also tested in a 3% saline solution and comply with either of the following:
- The weight (mass) loss of each of five test specimens at the conclusion of 40 cycles does not exceed 1% of its initial weight (mass); or
- The weight (mass) loss of four out of five specimens at the conclusion of 50 cycles does not exceed 1.5% of its initial weight (mass).

f. Ensure testing is continued until one of the following occurs:
- The weight (mass) loss each of five test specimens exceeds 2% of its initial weight (mass), or
- The weight (mass) loss of one of the five test specimens exceeds 2.5% of its initial weight (mass), or
- The specimens have been tested for at least 100 cycles.

g. Submit complete durability test reports for water and saline conditions, including the cycle number at which failure occurred, to the Engineer.

h. Ensure all units are sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the construction.

i. Ensure SRW units dimensions do not differ by more than ±1/16 inch (±1.5 mm).

2. Leveling Pad.
Use supplier/manufacturer recommended leveling pad materials. If granular material is recommended for the leveling pad, use backfill material meeting the requirements of Section 4132. If unreinforced concrete is recommended for the leveling pad, use Class C concrete meeting the requirements of the Materials I.M. 529 and Section 2403.

3. Unit Fill.
If fill is required by the construction drawings for in-place concrete segmental units, place porous backfill material meeting the requirements of Section 4131.

4. Subdrains.

a. Ensure the subdrains are a minimum of 4 inches (100 mm) in diameter and meet the requirements of Article 4143.01, B.

b. Provide Standard Road Plan RF-19F Type A outlets and fit with Standard Road Plan RF-19E rodent guards.

5. Backfill Material.
Use granular backfill meeting the requirements of Section 4133 for fill soil material in the entire reinforced earth zone.

6. Geogrid Reinforcement.
Comply with the following:

- Type, strength, and placement location determined by the Wall Design Engineer.
- Design properties of the reinforcement determined according to the procedures outlined in NCMA Section 3.5.
- Detailed test data (including strength, creep, site damage, and pullout testing) submitted to the Engineer for approval at least 30 days prior to construction.
- Of a type recommended by the block supplier to be compatible with the facing units, with a minimum long term design strength of 1500 pounds per foot (1000 kg/m).
- Regular grid structure having an aperture geometry and rib and junction cross-sections sufficient to permit significant mechanical interlock with the granular backfill material.
- High continuity of tensile strength through all ribs and junctions of the grid structure.
- High resistance to deformation under sustained long term design load while in service, and resistant to: 1) ultraviolet degradation; 2) damage under normal construction practices; and 3) all forms of biological or chemical degradation normally encountered in the granular backfill material.

7. Certifications.

a. Submit a notarized manufacturer's certification to the Engineer at least 14 days prior to the preconstruction conference, stating that the SRW units meet the requirements of this specification.

b. Submit a notarized manufacturer's certification signed and sealed by an officer of the manufacturer, prior to start of work, stating that the geogrid reinforcement meets the requirements of the SRW unit manufacturer and this specification.

2431.03 CONSTRUCTION.

A. Construction Supervision.

1. SRW units and geogrid reinforcement material suppliers shall provide, at no additional cost to the Contracting Authority, a qualified and experienced representative on site at the beginning of wall construction for up to 3 working days.

2. The Contractor is to provide an experienced and qualified field construction supervisor to direct all work at the site.

B. Excavation.

Excavate to the lines and grades shown on the construction drawings as being the reinforced earth zone. Take precautions to minimize over excavation. If required, design a system for excavation support at no additional cost to the Contracting Authority.

C. Foundation Soil Preparation.

1. Excavate foundation soil as required for base course leveling pad dimensions and limits of reinforced earth zone as shown in the contract documents.

2. The Engineer will examine foundation soil to assure that the actual foundation soil strength meets or exceeds the assumed design bearing strength. Remove soils not meeting the required strength and replace with soil meeting the design criteria.

3. Ensure the earth foundation has a density equal to or greater than 90% Standard Proctor Density. Step the earth foundation at the required intervals to keep it a minimum 2 feet (600 mm) below the finished grade.

D. Leveling Pad.

1. Place the leveling pad a minimum of 6 inches (150 mm) in thickness.

2. Construct the leveling pad to ensure complete contact of the retaining wall unit with the leveling pad. Ensure no gaps exist between the retaining wall unit and the leveling pad.

E. Unit Installation.
Install materials at the proper elevation and orientation shown in the contract documents. Install the concrete segmental units and geogrid reinforcement according to the approved submittals in Article 2431.02, A, 2. The plans govern in all conflicts between the two requirements.

F. Subdrains.

1. Install subdrains as shown in the contract documents to maintain gravity flow of water to outside of the reinforced earth zone. Outlet subdrains into a storm sewer access or along a slope at an elevation lower than the lowest point of the pipe within the SRW reinforced earth zone.

2. Place porous backfill material meeting the requirements of Article 2431.02, B, 3, around the subdrain to a minimum cover of 3 inches (75 mm).

G. Backfill Material Placement.

1. Compact the granular backfill material according to Article 2107.03, H. Place the granular backfill material as shown in the contract documents in maximum 8 inch (200 mm) lifts, compacted to a minimum 95% of standard Proctor density (ASTM D 698). Ensure moisture limits are between 3% under optimum moisture to no more than the optimum moisture content. Place the backfill material, spread, and compact in such a manner that eliminates the development of wrinkles and/or movement of the geogrid reinforcement.

2. Only hand-operated compaction equipment will be allowed within 3 feet (1 m) of the front of the wall face.

3. Do not operate tracked construction equipment directly on the geogrid reinforcement. A minimum backfill material thickness of 6 inches (150 mm) is required prior to operation of tracked vehicles over the geogrid reinforcement. Minimize turning of tracked vehicles to prevent tracks from displacing the fill and damaging the geogrid reinforcement.

4. Rubber-tired equipment may pass over the geogrid reinforcement, if done according to the manufacturer's recommendations. Avoid sudden braking and sharp turning.

H. Geogrid Installation.

1. Overlapping the geogrid in the design strength direction will not be permitted. The design strength direction is that length of geogrid reinforcement perpendicular to the wall face. Use one continuous piece of material. Butt adjacent sections of geogrid in a manner to ensure 100% coverage after placement.

2. Install the geogrid reinforcement under tension. Apply a nominal tension to the reinforcement and maintain it by staples, stakes, or hand tensioning. The tension applied may be released after the geogrid reinforcement has been covered and held in place with soil fill.

2431.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Segmental Retaining Wall.
Square feet (square meters) from measurements of the front face of the wall in place. The height will be measured from the top of the leveling pad to the top of the wall, including coping or cap block.

B. Granular Backfill Material.
Tons (megagrams) or cubic yards (cubic meters) as stipulated in the contract documents.

C. Excavation.
Classed and measured according to Section 2102.

2431.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Segmental Retaining Wall.

1. Per square foot (square meter).

2. Payment is full compensation for furnishing all materials, tools, and labor for the performance of all work necessary to construct the wall, according to the contract documents, including the design, foundation

preparation, leveling pad, geogrid fabric, porous backfill material, and subdrains.

B. Granular Backfill Material.
Per ton (megagram) or cubic yard (cubic meter) as stipulated in contract documents for material furnished, hauled, placed, and compacted.

C. Excavation.
Article 2102.05, A, 1, applies for each class of excavation for preparing the reinforced earth zone for construction of the wall. This will normally be included for payment with other excavation required by the contract documents.

Section 2432. Mechanically Stabilized Earth (MSE) Retaining Wall

2432.01 DESCRIPTION.

Construct mechanically stabilized earth (MSE) retaining walls according to this specification and in reasonably close conformity with the lines, grades, design, and dimensions shown in the contract documents or established by the Engineer. MSE walls are defined as large panel retaining wall systems which use mesh or strips in the soil backfill material behind a concrete wall facing to limit backfill material stresses by reinforcing the soil structure.

2432.02 DESIGN AND MATERIALS.

A. Design

1. Wall Design Engineer.
The Wall Design Engineer shall be a Professional Engineer licensed in the State of Iowa.

2. Design Requirements.

a. Consideration is to be given to the internal stability of the wall mass. The wall is to be designed per Section 5, 'Retaining Walls', of the AASHTO Standard Specifications for Highway Bridges.

b. Design calculations are to include a summary of all design parameters used, including material types, strength values and assumed allowable soil bearing pressure, assumed load and loading combinations, and factor of safety parameters.

c. Earth reinforcing, and their connections to concrete panels, are to be designed for corrosion over the design life using the following electrochemical criteria:

Requirement	Test Method
Resistivity > 2,000 ohm-cm	AASHTO T 288
Chlorides < 200 ppm	AASHTO T 291
Sulfates < 300 ppm	AASHTO T 290

d. All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown in the contract documents are to be accounted for in the stability design of the wall.

e. Unless noted otherwise in the contract documents, a minimum cover of 4 feet (1.2 m) is to be provided from the top of the leveling pad to finish grade.

f. A special vertical corner element panel (to cover the joint of the panels that abut the corner and allow for independent movement of the abutting panels) is to be used where wall or wall sections intersect with an angle of 130 degrees or less on the backfill side. Corner elements are not to be formed by connecting standard facing panels that abut the acute corner.

g. The face panels are to be designed to accommodate differential settlement of 1 foot in 100 feet (0.3 m in 30 m). The spacing between adjacent panels is to be designed to be at least 3/4 inch (19 mm). Where shown in the contract documents, slip joints are to accommodate excessive differential settlement included.

3. Submittals.

a. MSE Supplier: For Interstate and Primary projects, provide the Office of Design, Soils Design Section with preliminary (non-structural) design calculations, which include estimated maximum applied (required) MSE wall bearing pressures, reinforcing strip or mesh lengths, and random backfill material requirements (if other than Class 10 backfill material), prior to preparation of their final MSE plans.

b. The Contractor: submit design computations and approved final MSE system construction drawings according to Article 1105.03. Ensure the drawings include all details, dimensions, and cross-sections necessary to construct the wall, and include (but are not limited to) the following:

1) An elevation sheet or sheets for each wall.

2) An elevation view of the wall which includes:

- The elevation at the top of the wall at all horizontal and vertical break points and at least every 15 feet (5 m) along the face of the wall,
- All steps in the leveling pads,
- The designation as to the type of panel,
- The length of soil reinforcing elements,
- The distance along the face of the wall to where changes in length of the soil reinforcing elements occur, and
- An indication of the final ground line and maximum calculated bearing pressures.

3) Details of the architectural treatment. Refer to the contract documents for details and nominal dimensions.

4) All panel details showing all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of soil reinforcing connection devices embedded in the panels.

5) The details for connections between the concrete panel and the soil reinforcements.

6) A typical cross section or cross sections showing the elevation relationship between ground conditions and proposed grades.

7) General notes pertaining to design criteria and wall construction.
8) The details for diverting soil reinforcements around obstructions such as piles, catch basins, and other utilities.
9) Clearly indicated details for construction of walls around drainage facilities.
10) General location of subdrain and outlets of the internal drainage system.

B. Materials.
Install a wall system manufactured by a company on the approved manufacturer's list in Materials I.M. 445, Appendix A.

1. Concrete Panels.

a. Concrete.

1) Type I cement meeting requirements of Section 4101.
2) Cement content per cubic yard (cubic meter) of concrete for face panels and precast coping sections no less than 600 pounds (360 kg) nor more than 700 pounds (420 kg).
3) Concrete aggregates meeting the requirements of Sections 4110 and 4115. Class 3 durability crushed stone coarse aggregate. The use of gravel requires the Engineer's approval and is based on past history of deleterious and stain-producing material found in the aggregate source.
4) Air entrainment obtained by addition of an approved air-entraining agent. The air content of fresh, unvibrated concrete, as determined by AASHTO T 152, is to be 6.5% as a target value, with a maximum variation of ± 1.0%. When specified or authorized by the Engineer, approved admixtures for the purpose of improving workability or for retardation may be used according to the Engineer's instructions.
5) Obtain the Engineer's approval for the final mix design.

b. Compressive Strength.

1) Minimum compressive strengths for concrete reinforced face panels:

Strength prior to moving	Strength at 28 days
1800 psi (12.4 MPa)	4000 psi (27.6 MPa)

2) Acceptance of the concrete face panels with respect to compressive strength will be determined on a lot basis. The lot will consist of all production units (batches of concrete or panels) produced within a consecutive 7 day production period. Production units will be randomly selected according to the production day sample sizes of Table 2432.03-1 and tested for compressive strength. Perform compression tests on the test specimens according to Materials I.M. 315.

Table 2432.03-1: Production Day Samples

Production Day Quantities	Sample Size
35 cubic yards (27 m^3) or less (50 panels or less)	1
35-70 cubic yards (27-54 m^3) (50-100 panels)	2
70-100 cubic yards (54-81 m^3) (100-150 panels)	3
Over 100 cubic yards (81 m^3) (150 panels)	5

3) Cast a minimum of four test cylinders for each production unit sampled. Cure all of the specimens according to this specification.

4) Test two specimens at 7 days and two at 28 days. A test will be the average compressive strength of 2 cylinders.

5) Acceptance of the lot will be made:

- If all acceptance tests in a lot are greater than 4000 psi (27.6 MPa), or
- Provided no individual 28 day compressive-strength test result falls below 3500 psi (24.8 MPa), and the average 28 day compressive strength of all test results of the lot equals or exceeds the acceptance limits set forth in Table 2432.03-2.

6) Apply the acceptance limits of Table 2432.03-2 to core compressive strength test results.

Table 2432.03-2: Lot Acceptance Limits

Number of Lot Acceptance Tests	Average of all Lot Acceptance Tests Must Equal or Exceed these Limits
3-7	4000 psi + 0.33R* (27.6 MPa + 0.33R*)
8-15	4000 psi + 0.44R* (27.6 MPa + 0.44R*)
16+	4000 psi+ 0.46R* (27.6 MPa + 0.46R*)

* R is the range (the difference between the highest and lowest acceptance test result).

c. Reinforcement.

Epoxy coated steel meeting the requirements of Article 4151.03.

d. Casting.

1) Prior to casting, earth reinforcement connections or ties, PVC pipe, and lifting devices are to be set in place to the required dimensions and tolerances.

2) Panels are to be cast on a flat area, the front face of the panel at the bottom, the back face at the upper part. Reinforcement connection guides are to be set on the rear face. The concrete in each unit is to be placed without interruption and consolidated by use of an approved vibrator, supplemented by such hand-tamping as may be necessary to force the concrete into the corners of the forms and to prevent the formation of stone pockets or cleavage planes. Clear form oil from the

same manufacturer is to be used throughout the casting operation.

e. Concrete Finish.

Uniform surface as designated on the formed front face. The rear face of the panel is to be roughly screeded to eliminate open pockets of aggregate and surface distortions.

f. Marking.

The date of manufacture, production lot number, and piece-mark are to be clearly scribed on the rear face of each panel.

g. Fasteners.

Bolts and nuts for fasteners, where required, are to be of type and length recommended by the Wall Design Engineer; high strength, conforming to ASTM A 325 or equivalent, and galvanized.

h. Tolerances.

All units manufactured are to be within the following tolerances:

1) Lateral position of the strips within 1 inch (25 mm).

2) All dimensions within 1/4 inch (5 mm).

3) Angular distortion with regard to the height of the panel not to exceed 1/4 inch in 5 feet (5 mm in 1.5 m).

4) Surface defects on smooth-formed surfaces not to exceed 1/8 inch in 5 feet (2.5 mm in 1.5 m). On textured surfaces, surface defects not to exceed 5/16 inch in 5 feet (8 mm in 1.5 m).

i. Curing.

1) Panels are to be covered with wet burlap as soon as practical after casting, but not later than 30 minutes, and kept wet. Within two hours of the initial covering, water is to be applied to the burlap by means of a continuous, pressure-sprinkling system that is effective in keeping the burlap wet during the initial curing period. The initial curing period is to be continued until the minimum moving strength is obtained.

2) After the initial curing period is complete, panels may be moved from the casting beds to a secondary curing area and covered with one layer of wet burlap and one layer of 2 mil (50 µm) plastic, secured to retain curing moisture. Concrete face panels are not to be uncovered more than 30 minutes during the moving process. Curing is to be continued until the specified strength is obtained.

3) Steam curing procedures may be approved by the Engineer.

j. Removal of Forms.

Forms are to be left in place until they can be removed without damage to the unit.

k. Testing and Inspection.

1) Acceptability of the precast units will be determined on the basis of compression tests and visual inspection.

2) The precast units will be considered acceptable, regardless of age, when compression test results indicate the concrete will meet the specified 28-day strength. Furnish facilities and collaborate with the Engineer so that all necessary sampling and testing is done in an expeditious and satisfactory manner, as approved by the Engineer. Panels will be considered acceptable for placement in the wall when 7-day strengths exceed 80% of 28-day requirements.

l. Rejection.
Units may be subject to rejection because of failure to meet any of the requirements specified above. In addition, any or all of the following defects may be sufficient cause for rejection:
1) Defects that indicate imperfect molding.
2) Defects indicating honeycombed or open-texture concrete.

m. Handling, Storage, and Shipping.
Handle, store, and ship all units in such a manner as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses. Store panels on firm blocking located immediately adjacent to earth reinforcing connections to avoid damage to support panels.

2. Leveling Pad.
This concrete may be any mix the supplier markets as having a nominal strength of 3500 psi (24.1 MPa).

3. Joint Materials.

a. Horizontal and Vertical Joints.
Cover horizontal and vertical joints between panels with a polyester fabric that meets requirements of Article 4196, C, and is acceptable to the MSE wall company. Obtain the Engineer's approval for adhesives used to temporarily attach the fabric to the back of the facing panels.

b. Bearing or Filter Pads.
Ensure bearing and filter pads (where required) are of the quality and dimensions recommended by the MSE wall company. Obtain the Engineer's approval.

4. Subdrains.

a. Use one of the perforated, plastic pipes described in Article 4143.01, C. If the size is not designated, use a pipe of nominal diameter no less than 4 inches (100 mm) or more than 6 inches (150 mm).

b. Provide a Standard Road Plan RF-19F Type A outlet fitted with a Standard Road Plan RF-19E rodent guard.

5. Backfill Material.

a. Unless specified otherwise in the contract documents, furnish granular backfill material for the entire reinforced earth zone. Unless specified otherwise in the contract documents, furnish granular backfill material when identified as an MSE wall design requirement in the contract documents for core-outs, other remedial/ ground improvement location, or use behind the reinforced zone. Ensure the backfill material meets the requirements of Section 4133, except that the percent passing the No. 200 (75µm) sieve is not to exceed 5.0%.

b. Use backfill material meeting the following criteria for electrochemical requirements:

Requirement	Test Method
Resistivity > 3000 ohm-cm	AASHTO T 288
pH range 5 to 10	AASHTO T 289

Chlorides < 100 ppm	AASHTO T 291
Sulfates < 200 ppm	AASHTO T 290
Organic content < 1%	AASHTO T 267

c. The Engineer will take two samples from the source of the granular backfill material to determine the electrochemical levels. Obtain the Engineer's approval for the source of backfill material prior to placing.

6. Earth Reinforcing.
Carefully inspect all reinforcement to ensure it is true to size and free from defects that may impair its strength and durability.

a. Reinforcing and Tie Strip.

1. Tie strips shall be shop-fabricated from hot-rolled steel conforming to the minimum requirements of ASTM A 570, Grade 50, or equivalent. Galvanization shall comply with the minimum requirements of ASTM A 123 or equivalent.

2. Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Physical and mechanical properties shall comply with ASTM A 572, Grade 65, or equivalent. Galvanization shall comply with ASTM A 123. Strips shall be cut to lengths and tolerances shown on the plans or recommended. Holes for bolts shall be punched in the locations shown.

b. Reinforced Mesh
Prefabricated from smooth bars meeting the requirements of ASTM A 82 and A 185. Reinforcing mesh shall be galvanized according to ASTM A 123. Mesh connectors are to be galvanized according to ASTM A 153. Mesh is to be cut to lengths and tolerances shown in the contract documents.

2432.03 CONSTRUCTION.

A. Construction Supervision.

1. MSE units and reinforcement material suppliers shall provide a qualified and experienced representative on site at beginning of wall construction for up to 3 working days at no additional cost to the Contracting Authority.

2. The Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site.

B. Excavation.
Comply with the limits and construction stages shown on the contract documents. Prior to start of MSE wall construction, complete and obtain approval for core-outs or other remedial/ground improvement procedures identified in the construction drawing. Temporary or other excavation lines shown or depicted in the contract documents are for right of way, quantity calculation, and/or other design purposes only.

C. Foundation Soil Preparation.
Grade the foundation for the structure level for a width equal to or exceeding the length of reinforcing mesh or strips, unless shown otherwise in the contract documents. Prior to wall construction, compact the foundation with a smooth-wheeled, vibratory roller.

D. Leveling Pad.
At each panel leveling pad, place an unreinforced concrete leveling pad provided as shown in the contract documents. Cure the footing for a minimum of 24 hours before wall panel placement.

E. Wall Erection.

1. Panels.
For erection, handle the panels using a lifting device set into the upper edge of the panels. Place the panels in successive horizontal lifts in the proper sequence as backfill material placement proceeds. As backfill material is placed behind a panel, maintain the panels in position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall. External bracing may also be required for the initial lift. Ensure vertical tolerances and horizontal alignment tolerance do not exceed 3/4 inch (19 mm) when measured along a 10 foot (3 m) straight edge. Limit offsets in panel joints to 3/4 inch (19 mm) or less. Ensure the overall vertical tolerance of the wall does not exceed 1/2 inch per 10 feet (12.5 mm per 3 m) of wall height.

2. Coping.
Place the coping as shown in the contract documents. Mix, cast, and cure precast coping units with the same concrete mixture and in the same manner as used for construction of the panels. Cast-in-place coping may be constructed in the same manner or Class C structural concrete may be used; however, use aggregates meeting the same quality requirements as are specified in Article 2432.02, B, 1.

F. Subdrains.

1. Install the subdrains behind the bottom course of panels in direct contact with the granular backfill material. Install a second subdrain at the base of the temporary excavation backslope, behind the reinforced earth zone, and at an elevation similar to the subdrain behind the bottom course of panels. Place vertical pipes (if required) as shown in the contract documents. Install the subdrain as shown in the contract documents to maintain gravity flow of water to outside of the reinforced earth zone. The subdrain should outlet into a storm sewer access or along a slope at an elevation lower than the lowest point of the pipe within the reinforced earth zone.

2. The contract documents may require additional subdrain at the base of the granular backfill material in a core-out, if used.

3. Place porous backfill material meeting the requirements of Section 4131 around the subdrain to a minimum cover of 3 inches (75 mm).

G. Backfill Placement.

1. Place backfill material in a manner to closely follow the erection of each lift of panels. At each level for earth reinforcing, roughly level the backfill material before placing and connecting reinforcement. Place reinforcing normal to the face of the wall. Closely follow panel erection with placement of lifts. Decrease this lift thickness, if necessary, to obtain the specified density.

2. At the end of each day's operations, shape the last level of backfill material so as to permit runoff of rainwater away from the wall face.

3. Compact backfill material according to Article 2107.03, H. Place granular backfill material in the reinforced zone and behind the reinforced zone as shown in the contract documents in maximum 8 inch (200 mm) lifts. Compact to a minimum 95% of Standard Proctor density (ASTM D 698). Ensure moisture limits are between 1% under optimum moisture to not more than 2% over optimum moisture content. Perform backfill material compaction without disturbing or distorting earth reinforcing and panels. Do not use tamping-type rollers or other rollers which damage the reinforcing. In a 3 foot (1 meter) wide strip adjacent to the backside of the wall, use light mechanical tampers to achieve compaction. Compaction within this strip will not be subjected to density testing.

4. Compact granular backfill material and/or other materials placed in a core-out or other remedial/ground improvement location to a minimum of 98% of Standard Proctor density or as otherwise defined in the contract documents.

H. Earth Reinforcing Placement.
Place tie strips or mesh in horizontal layers as detailed in the contract documents. When tie strips or mesh can not be placed as detailed in the contract documents, submit a modified placement plan as recommended by the Wall Design Engineer for approval by the Engineer.

I. Surface Water Control
The cross sections in the contract documents will show excavation for any temporary backslope behind the reinforced earth zone. Protect the backslope from surface water which will affect stability of the backslope. Provide positive control and discharge for surface water in the area behind the backslope. If a gravity outlet is available, drain the bases of core-out excavations by temporary trench outlets or subdrains until granular backfill material is installed in the core-out.

2432.04 METHOD OF MEASUREMENT.

The work involved in construction of Mechanically Stabilized Earth Retaining Walls will be measured as follows:

A. Mechanically Stabilized Earth Retaining Wall.
The Engineer will measure the area of Mechanically Stabilized Earth Retaining Wall in square feet (square meters), from measurements of the front face of the wall in place. The height will be measured from the top of the leveling pad to the top of the wall, including coping.

B. Granular Backfill Material.
The quantity of Granular Backfill Material, in tons or cubic yards (megagrams or cubic meters), that is placed in the reinforced earth zone; identified as an MSE wall design requirement in the contract documents for any core-out or other remedial/ground improvement location; or placed in the temporary excavation zone behind the reinforced earth zone as shown in the contract documents, will be measured in tons or cubic yards (megagrams or cubic meters).

C. Excavation.
Excavation for preparing the reinforced earth zone for construction of the wall and all core-outs or other remediations/ground improvement areas included in the contract documents will be classed and measured according to Section 2102.

2432.05 BASIS OF PAYMENT.
Payment for construction of Mechanically Stabilized Earth Retaining Walls, satisfactorily placed, will be as follows:

A. Mechanically Stabilized Earth Retaining Wall.
For the number of square feet (square meters) of Mechanically Stabilized Earth Retaining Wall constructed, the Contractor will be paid the contract unit price per square foot (square meter). This payment is full compensation for furnishing and erecting the MSE retaining wall including the design, foundation preparation, leveling pad, panels, coping, earth reinforcement placement, and subdrains according to the contract documents. Subdrains within core-out areas, if required in the contract documents, will be measured and paid for separately.

B. Granular Backfill Material.

1. For Contractor furnished Granular Backfill Material for the reinforced earth zone; any core-outs or other remedial/ground improvement locations; and placed in the temporary excavation zone behind the reinforced earth zone as shown in the contract documents, the Contractor will be paid for the quantity of material furnished, hauled, actually placed, and compacted for the contract unit price per ton or cubic yard (megagram or cubic meter) up to the contract quantity.

2. If the slope shown for the temporary excavation zone in the contract documents is not adequate for safety, provide written notification to the Engineer, including a copy of a slope stability analysis, and identification of the additional quantity of Granular Backfill Material that will be needed, before the work begins. The slope stability analysis is to be done by a Professional Engineer licensed in the State of Iowa (at no addition cost to the Contracting Authority). If approved by the Engineer,

the additional quantity for Granular Backfill Material will be adjusted according to Article 1109.03, A.

C. Excavation.

1. For the quantity of each class of excavation for preparing the reinforced earth zone and all core-outs or other remediation/ground improvement areas included in the contract documents for construction of the wall, the Contractor will be paid as provided in Article 2102.05, A, 1. This will normally be included for payment with other excavation required by the contract documents.

2. If the slope shown for the temporary excavation zone in the contract documents is not adequate for safety, provide written notification to the Engineer, including a copy of a slope stability analysis, and identification of the additional quantity of excavation that will be needed, before the work begins. The slope stability analysis shall be done by a Professional Engineer licensed in the State of Iowa (at no additional cost to the Contracting Authority). If approved by the Engineer, the additional quantity for excavation will be adjusted according to Article 1109.03, A.

Section 2433. Concrete Drilled Shaft

2433.01 DESCRIPTION.

A. A concrete drilled shaft foundation consists of reinforced concrete placed in a drilled shaft and rock socket as shown in the contract documents.

B. Ensure elevations, dimensions, and depth of the drilled shafts and rock sockets are as specified in the contract documents. If bearing strata are encountered at different elevations or are judged to be of a different quality, the Engineer may adjust the socket elevation.

2433.02 MATERIALS.

Submit information in electronic format.

A. Slurry.

1. Use only mineral or polymer slurries in the drilling process unless the Engineer, in writing, approves other drilling fluids. Ensure the percentage and specific gravity of the material used to make the suspension is sufficient to maintain the stability of the excavation and to allow proper concrete placement. In the event of a sudden significant loss of slurry to the excavation, stop foundation construction until the Engineer has approved either: 1) methods to stop slurry loss; or 2) an alternate construction procedure.

2. Perform all tests at a slurry temperature of 40°F (4°C) or higher.

3. Thoroughly premix mineral slurry or polymer slurry with clean, fresh water. Mix for the adequate time (as prescribed by the manufacturer)

allotted for hydration in slurry tanks. Adequate capacity slurry tanks are required for slurry circulation, storage, treatment, and disposal. No excavated slurry pits will be allowed. Prior to introduction into the shaft excavation, draw sample sets from the slurry tanks and test the samples for conformance with the specified material properties. A sample set consists of samples taken at mid-height and within 2 feet (0.6 m) of the bottom of the slurry tanks.

4. In the Engineer's presence, sample and test all slurry, unless directed otherwise. Record the date, time, persons' names sampling and testing the slurry, and the test results. Submit a copy of the recorded slurry test results to the Engineer at the completion of each shaft, and during construction of each shaft when the Engineer requests.

5. During shaft excavation, take and test sample sets of all slurry, composed of samples taken at mid-height and within 2 feet (0.6 m) of the bottom of the shaft, as necessary to verify the control of the slurry properties. As a minimum, take and test sample sets at least once every 2 hours after beginning slurry use. When the test results show consistent specified properties, take and test sample sets at least once every 4 hours of slurry use. When tests show that the sample sets do not have consistent specified properties, either recirculate the slurry or agitate it with drilling equipment.

6. When samples are found to be unacceptable, either clean, recirculate, desand, or replace the slurry in order to maintain the required slurry properties. Do not begin cleaning the bottom of the excavation and placing concrete until after tests show that the sample sets have consistent specified properties.

7. Demonstrate to the Engineer's satisfaction that stable conditions are being maintained. If the Engineer determines that stable conditions are not being maintained, immediately take action to stabilize the shaft. Submit a revised installation plan which corrects the problem and prevents future instability. Do not continue with shaft construction until receiving the Engineer's approval of the revised shaft installation plan.

a. Mineral Slurry.

Ensure mineral slurry complies with Table 2433.02-1:

Table 2433.02-1: Mineral Slurry Requirements

Property	Test Method	Requirements
Density (lb/ft^3 (kg/m^3))	Slurry Density Materials I.M. 387	64 to 75 (1030 to 1200)
Viscosity (sec/gal (sec/L))	Marsh Funnel and Cup Materials I.M. 387	104 to 201 (27.5 to 53)
pH	pH Paper	8 to 11
Sand Content (%)	Sand Content Test Materials I.M. 387	*

*	Sand content of mineral slurry prior to placing the reinforcing steel cage and immediately prior to placing concrete less than or equal to 4.0%.

b. Polymer Slurry.

1) For polymer slurry use, comply with the manufacturer's recommendations and this specification. Submit to the Engineer the name and telephone number of the manufacturer's representative. The manufacturer's representative is to provide technical assistance in the use of the polymer slurry as needed.

2) Ensure polymer slurry complies with Table 2433.02-2:

Table 2433.02-2: Polymer Slurry Requirements

Property	Test Method	Requirements
Density (lb/ft^3 (kg/m^3))	Slurry Density Materials I.M. 387	62 to 63 (995 to 1010)
Viscosity (sec/gal (sec/L))	Marsh Funnel and Cup Materials I.M. 387	136 to 227 (36 to 60) 231 to 252 (61 to 66.5) (dry sand/gravel)
pH	pH Paper	8 to 11
Sand Content (%)	Sand Content Test Materials I.M. 387	*
* The sand content of polymer slurry prior to placing the reinforcing steel cage and immediately prior to placing concrete less than 2.0%.		

3) Wait 30 minutes after the last drilling and scouring to allow contaminants to settle out before taking and testing a sample set of slurry. After the reinforcing steel cage is placed in the excavation, take and test a sample set of slurry immediately prior to concrete placement.

B. Concrete.

Comply with the following:

1. All materials, proportioning, air entraining, mixing, slump, and transporting of PCC shall be according to Section 2403, except as modified herein.

2. Water/cement ratio: not to exceed 0.45.

3. Drilled shaft construction: use Class D PCC mixture with a slump of 8 inches ±1.5 inches (200 mm ±40mm).

4. Portland cement: meet the requirements of ASTM C 150 Type I / II and Section 4101.

5. Air entrainment: apply Section 2403.

6. Mid-range water reducer is required according to Materials I.M. 403.

7. Retarder is required according to Materials I.M. 403 to maintain workable concrete.

8. Do not use GGBFS.

C. Grout.
Apply Materials I.M. 388.

2433.03 CONSTRUCTION.

Submit information in electronic format.

A. Construction Tolerances.
Drilled shaft excavations and completed shafts not constructed within the required tolerances will be considered unacceptable. Correct all unacceptable shaft excavations and completed shafts to the Engineer's satisfaction. Furnish materials and work necessary, including engineering analysis and redesign, to complete corrections for out of tolerance drilled shaft excavations (without either cost to the Contracting Authority or an extension of the completion dates of the project).

1. Ensure the drilled shaft is within 3 inches (75 mm) of plan position at the top of shaft.

2. Ensure the vertical alignment of shaft excavation does not vary from the plan alignment by more than 1/4 inch/foot (20 mm/m of depth).

3. Set full depth reinforcing steel cages at no less than 6 inches (150 mm) above the bottom of the excavated shaft prior to concrete placement.

4. Ensure that, after all the concrete is placed, the top of the reinforcing steel cage is no more than 6 inches (150 mm) above and no more than 2 3/4 inches (70 mm) below plan position.

5. Casing dimensions are subject to American Pipe Institute tolerances applicable to regular steel pipe.

6. The top elevation of the shaft may have a tolerance of plus 1 inch (25 mm) or minus 3 inches (75 mm) from the plan top of shaft elevation. Ensure sufficient reinforcement bar splice length for splices above the shaft.

7. Use excavation equipment and methods that ensure the completed shaft excavation will have a planar bottom. Ensure the excavation equipment cutting edges are normal to the equipment's vertical axis within a tolerance of 3/8 inch/foot (30 mm/m) of diameter.

B. Drilled Shaft Installation Plan.

1. Two weeks prior to the pre-construction conference, submit a list containing at least three drilled shaft projects, of similar diameter and

length to those shown on the plans, completed in the last three years. In the list of projects include names and phone numbers of owner's representatives who can verify the Contractor's participation on those projects. In addition, submit a signed statement that the Contractor has inspected the project site and all the subsurface information made available in the contract documents.

2. No later than 1 month prior to constructing drilled shafts, submit a drilled shaft installation plan for the Engineer to review. In this plan provide the following information:

- **a.** Name and experience record of firm(s) and associated personnel for the following:
  - **1)** Driller.
  - **2)** Drilled shaft superintendent.
  - **3)** Site exploration.
  - **4)** Confirmation boring.
  - **5)** Crosshole sonic logging (CSL).
  - **6)** Name of load cell testing firm, if applicable.
- **b.** List of proposed equipment to be used, including cranes, drills, augers, bailing buckets, grooving equipment, scouring equipment, final cleaning equipment, core sampling equipment, confirmation boring equipment, tremies or concrete pumps, casing, slurry equipment, airlift pumps, and so forth.
- **c.** Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
- **d.** Details of shaft excavation methods.
- **e.** Details of casing and forms, including installation and removal.
- **f.** Details of the type and methods to mix, circulate, desand, test, and dispose of slurry (if applicable). If polymer slurry is proposed, submit data on load transfer and manufacturer’s requirements for slurry control.
- **g.** Details of methods to clean the shaft excavation, including air lift methods and spin bucket methods as applicable.
- **h.** Details of reinforcement placement, including support and cage centering methods.
- **i.** Reinforcing steel cage splicing method, if proposed, including details of dimensions, installation, splice location, support and cage centering methods, and estimated time required for splicing.
- **j.** Details of concrete placement including procedures for tremie or pumping methods and method to prevent slurry intrusion at the discharge end.
- **k.** Concrete mix proposal.
- **l.** Details of methods to control cuttings, water, slurry, and so forth with adjacent traffic conditions (vehicular or railroad if applicable).
- **m.** Details of CSL testing, including location and attachment methods of the steel access pipes.
- **n.** When a load cell test is specified, include details of the test equipment used in the load cell test, and description of load cell test procedures and program according to Materials I.M. 388.
- **o.** Details of methods used to groove the sides of the drilled shaft length within the bedrock supporting stratum and methods of scouring and verification of grooving.

p. Details of final discharge of concrete at top of shaft, of removing contaminated concrete, and verifying concrete uniformity for site specific conditions.

q. When casing is required, include details on casing to be used, including:

- Specific length/depth of all casing proposed, and
- Specific evaluation and determination of casing (size, depth, etc.) required to prevent all shaft installation procedures from having an effect or impact on adjacent structures, railroads, and so forth.

3. The Engineer will evaluate the drilled shaft installation plan for conformance with the contract documents. Within 14 calendar days after receipt of the plan, the Engineer will notify the Contractor of additional information required or changes necessary to meet the contract requirements, or both. Field test the Engineer's procedural approvals. These approvals do not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the contract documents.

4. A pre-drilling conference, in which the Contracting Authority, Contractor, and drilling staff discuss the anticipated shaft process, will be required for this work prior to the start of shaft excavation.

C. Control and Disposal of Materials.

Dispose of excavated material, as well as slurry and/or water removed from the shaft excavation. Collect and properly dispose off site all slurry and water displaced during final cleaning and concrete placement. Open pits for collection of materials will not be allowed. Control all excavated material, slurry, water, and other matter so that at no time it enters or encroaches upon the adjacent travel lanes, railroad, water ways, and so forth.

D. Shaft Excavation.

1. General.

a. Construct drilled shafts by either the wet, dry, or casing method as necessary to produce sound, durable concrete foundation shafts free of defects. These methods are described below.

b. Remove surface and subsurface obstructions. Special tools and/or procedures may be required. No separate payment will be made for removing obstructions.

c. If the Engineer determines that the material encountered during excavation and/or present at tip elevation is unsuitable and/or differs from that anticipated in the design of the drilled shaft, extend the drilled shaft tip elevations.

d. Maintain a drilling log during shaft and socket excavation. In the log, place information such as elevation, depth of penetration, drilling time in each of the strata, material description, and remarks. Furnish two copies of the log (signed by the Contractor) to the Engineer within 1 week after completion of the excavation.

e. After the shaft excavation has been completed, immediately proceed with shaft construction.

2. Wet Method.

a. The wet method consists of:

- Keeping the shaft filled with slurry a minimum of 4 feet (1.3 m) above the highest expected water table during drilling and excavation,
- Desanding of the slurry when required,
- Final cleaning of the excavation by means of a bailing bucket, air lift, pump or other approved device, and
- Placing shaft concrete which displaces the slurry.

b. In the event that layers susceptible to cave-ins are encountered which cannot be controlled by slurry, install temporary removable casing according to Article 2433.03, D, 3.

3. Dry Method.

a. The dry method consists of:

- Drilling the shaft excavation,
- Removing accumulated water and loose material from the excavation,
- Placing the reinforcing cage, and
- Concreting the shaft in a relatively dry excavation.

b. Use the dry method only at sites where:

- The ground water level and soil and rock conditions are suitable to permit construction of the shaft in a relatively dry excavation, and
- The Engineer can visually inspect the sides and bottom of the shaft prior to placing the concrete.

c. The Engineer will approve the dry method only if the shaft excavation demonstrates:

- Less than 12 inches (0.305 m) of water accumulates above the base over a 1 hour period when no pumping is permitted,
- The sides and bottom of the hole remain stable without detrimental caving, sloughing, or swelling between completion of excavation and concrete placement, and
- All loose material and water can be satisfactorily removed prior to inspection and concrete placement (less than 3 inches (75 mm) of water will be permitted in the bottom of the shaft excavation at the time of concrete placement).

d. Use the wet or casing method for shafts that do not meet the dry method requirements.

4. Casing Method.

a. The casing method is used to advance the hole through unstable material. Over-reaming to the outside diameter of the casing may be required. Before the casing is to be removed, the level of fresh concrete must be a minimum of 5 feet (1.5 m) above the bottom of the casing so that fluid trapped behind the casing is displaced upward. As the casing is withdrawn, maintain the concrete level so that fluid trapped behind the casing is displaced upward without contamination or displacing shaft concrete.

b. Determine the appropriate depth to terminate the temporary casing to ensure the stability of the shaft. The purpose of the temporary casing is to stabilize the shaft walls during drilling to prevent cave-ins as the result of potential vibrations. The purpose of the casing is also to prevent shaft installation procedures from having an impact on adjacent structures, railroads, and so forth.

c. Permanent casing, if required, will be specified in the contract documents.

E. Grooving Sidewalls.

When identified in the contract documents, groove the sidewalls of the drilled shaft within the rock socket so as to produce channels with approximate dimensions of 2 inch (50 mm) depth by 3 inch (75 mm) height at intervals of 1 foot (0.3 m). Prior to grooving, use a method approved by the Engineer to remove excessive smearing of soft material that occurred on the rock socket wall. Clean the base of the shaft by spin bucket and air lift. Perform grooving prior to final cleaning of the base of the shaft.

F. Final Cleaning.

1. If a slurry cake builds up on the shaft sidewalls, remove it prior to concrete placement (at no additional cost to the Contracting Authority). If mineral slurry is used, ream the shaft sidewalls above the rock socket reamed prior to placement of reinforcement. Adjust operations so that the maximum time that the slurry is allowed to remain in the shaft is 24 hours.

2. Clean the base of each shaft so that a minimum of 50% of the base will have less than 1/2 inch (15mm) of sediment at the time of concrete placement. Ensure the maximum sediment or debris depth at the base of the shaft does not exceed 1 inch (25mm).

3. The Engineer will visually inspect dry shafts.

4. Use an air lift to clean the bottom of slurry shafts. After a waiting period equal to the time to set the reinforcing steel cage and set up for concrete placement, measure the amount of sediment in the bottom of the shaft. If the amount of sediment meets the requirements in Paragraph 2 above, clean the base of the shaft a second time with the air lift and immediately proceed with shaft construction. If after the described wait period the amount of sediment exceeds the requirements of Paragraph 2, clean the shaft by air lift and repeat the above procedure until the sediment accumulation meets the requirements. The Engineer may approve an alternate method to clean the bottom of the shaft. The Contracting Authority will not provide additional compensation for alternate methods.

G. Excavation Inspection.

Provide equipment for checking the dimensions and alignment of each shaft excavation. Under the direction of the Engineer, verify the dimensions and alignment of the shaft under construction. After final cleaning, use a suitable weighted tape or other approved methods to measure final shaft depths.

H. Reinforcing Steel Cage Construction and Placement.

1. Assemble the reinforcing steel cage (consisting of longitudinal bars, ties, cage stiffener bars, spacers, cage centering devices, and other necessary appurtenances). Place the steel cage immediately after the shaft excavation has been inspected and accepted, and prior to concrete placement. If the Engineer approves, the reinforcing steel cage may be placed as two approximately equal units joined together in the shaft excavation.

2. Ensure the reinforcing steel in the shaft is tied at intersections and supported in such a way that the reinforcing steel will remain within allowable tolerances given in this specification. Use concrete spacers or other approved non-corrosive spacing devices at sufficient intervals near the top and bottom, and at intervals not exceeding 10 feet (3 m) along the shaft, to ensure concentric spacing for the entire cage length. Ensure spacers are:

- Constructed of approved material equal in quality and durability to the concrete specified for the shaft.
- Of adequate dimension to ensure a minimum distance of 3 inches (75 mm) between the cage and the excavated hole.

3. When a full depth reinforcing steel cage is used, support it at the bottom using approved cylindrical feet to ensure that the bottom of the cage is maintained at the proper distance above the base. When a partial depth reinforcing steel cage is used, design and furnish a support system.

4. Check the elevation of the top of the steel cage before and after the concrete is placed. If the reinforcing cage is not maintained within the specified tolerances, make necessary corrections to the satisfaction of the Engineer. Do not construct additional shafts until after modifying the reinforcing cage support in a manner satisfactory to the Engineer.

I. Concrete Placement.

1. General.

a. Place shaft concrete within 24 hours of the start of excavation of the rock socket. Place concrete as soon as possible after placing reinforcing steel.

b. Coordinate concrete batching and delivery with the batch plant the time limits, as stated in the contract documents, between batching and delivery are not exceeded.

c. Place concrete in a continuous manner. Continue concrete placement after the shaft excavation is full until good quality concrete is evident at the top of shaft.

d. Before continuing with column construction, remove a sufficient volume of concrete to ensure elimination of all contaminated concrete at the top of shaft.

e. Place concrete through either a tremie or a concrete pump.

f. Complete placement of the concrete in the shaft within 3 hours. Adjust admixtures, when approved for use, for the conditions

encountered on the job so the concrete remains in a workable plastic state throughout the 3 hour placement limit.

g. For construction of shafts larger than 6 feet (2 m) in diameter, the Contractor may propose a placement time in excess of 3 hours provided the Contractor submits trial mix documentation that all concrete in the shaft will retain a minimum 4 inch (100 mm) slump for the entire placement period.

h. Remove all temporary casing.

2. Concrete Placement by Tremie:

a. For the tremie, comply with the following:

- Constructed so that it is watertight and will readily discharge concrete.
- No more than 12 inches (300 mm) in diameter.
- No aluminum parts in contact with concrete.
- Discharge end of the tremie constructed to prevent water or slurry intrusion and permit the free flow of concrete during placement operations.
- Sufficient mass so that it will rest on the shaft bottom before start of concrete placement.
- Sufficient length to extend to the bottom of the shaft.

b. Maintain the discharge orifice between 5 feet and 10 feet (1.5 m and 3.0 m) below the surface of the fluid concrete.

c. Support the tremie so that it can be raised to increase the discharge of concrete and lowered to reduce the discharge of concrete.

d. Maintain a continuous flow of concrete. Ensure the concrete in the tremie maintains a positive pressure differential at all times to prevent introduction of air pockets or contaminants into the concrete.

3. Concrete Placement by Pump.

a. Concrete pumps and lines may be used for concrete placement. Use minimum 4 inch (100 mm) diameter pump lines constructed with watertight joints. Do not begin concrete placement until the pump line discharge orifice is at the shaft base elevation.

b. Use a plug or similar device to separate the concrete from the fluid in the hole until pumping begins. Either remove the plug from the excavation, or use a plug of a material approved by the Engineer which will not be a detriment to the shaft if not removed.

c. Maintain the discharge orifice between 5 feet and 10 feet (1.5 m and 3.0 m) below the surface of the fluid concrete. When lifting the pump line during concreting, temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation.

d. Perform the pumping operation in a manner that prevents introduction of air pockets into the concrete. If breaking the pump line is required, temporarily position the discharge orifice 3 feet to 5 feet (1.0 m to 1.5 m) below the surface of the fluid concrete in the hole. The Contractor may propose additional methods to eliminate introduction of air into the concrete.

J. Crosshole Sonic Log (CSL) Testing.

1. Coordinate with an independent testing agency to perform CSL testing according to ASTM D 6760. Provide analysis and interpretation on each completed shaft.

2. The procedure in ASTM D 6760 will be followed with the exceptions listed below:
- **a.** Plastic access ducts and drilled boreholes will not be allowed unless the Engineer approves.
- **b.** A minimum of 4 access ducts are required.
- **c.** Perform CSL testing after the shaft concrete has cured at least 48 hours but no later than 7 calendar days.
- **d.** Grout the access ducts after the Engineer's approval of the testing results.
- **e.** Include the waterfall diagram (which is a nesting of ultrasonic pulses in an ultrasonic profile) in the report.

3. Furnish and install one access pipe per 1 foot (0.3 m) of shaft diameter, but no less than four per shaft, with external couplings for CSL testing. Furnish access pipes complying with the following:
- 2 inch (51 mm) diameter, Schedule 40 pipe conforming to ASTM A 53, Grade A or B, Type E, F, or S.
- Round, regular inside diameter free of defects and obstructions, including all pipe joints, in order to permit the unobstructed passage of 1 3/8 inch (35 mm) maximum diameter source and receiver probes used for the CSL tests.
- Watertight and free from corrosion with clean internal and external faces to ensure a good bond between the concrete and the access pipes.
- Fitted with a watertight cap on the bottom and a removable, watertight cap on the top to prevent debris from entering the pipes.
- Watertight joints to achieve the specified length.

4. Securely attach the access pipes to the interior of the reinforcing cage such that each pipe is equally spaced within the reinforcing cage. If a partial depth reinforcing cage is specified, design and furnish a support system to secure and properly align the CSL access pipes.

5. Install the access pipes in straight alignment and parallel to the vertical axis of the reinforcing cage. Access pipes shall have 2 inches (50 mm) concrete cover at the bottom of the shaft or extend to the top plate of a load cell placed at the bottom of the shaft. When a load cell is located above the bottom of the shaft, fit the access pipes with watertight slip joints between the load cell bearing plates. Extend the access pipe at least 2 feet (600 mm) above either the top of the continuous concrete placement operation or the top of the shaft. Do not damage the access pipes during the reinforcing steel cage installation.

6. Fill the access pipes with clean water prior to concrete placement. To prevent debris from entering the pipe, reseal each access pipe immediately after water placement. Prior to CSL testing, flush all access pipes containing debris, refill with water of similar temperature, and reseal. Use water of similar temperature to avoid debonding of access pipes with surrounding concrete. Dewater all access pipes and fill with grout after the tests are completed, and the shaft has been accepted by the Engineer. Use grout meeting the requirements of Materials I.M. 388.

7. Submit the test results, analysis, and interpretation for the shafts to the Engineer within 7 calendar days of testing. The Engineer will:

- Determine final acceptance of each shaft, based on the CSL test results and analysis for the tested shafts, and
- Provide a response within 5 working days after receiving the test results and analysis submittal.

8. Do not commence subsequent shaft excavations until receiving the Engineer's approval and acceptance of the first shaft based on the results, analysis, and interpretation of the CSL testing.

9. Do not commence subsequent construction of the structure until receiving the Engineer's approval and acceptance of the supporting shaft based on the results, analysis, and interpretation of the CSL testing.

10. For all shafts determined to be unacceptable, submit a plan for remedial action, including correction procedures and designs, to the Engineer for approval. Do not begin repair operations until receiving the Engineer's approval of the remedial action plan.

K. Demonstration Shaft.

1. Demonstrate equipment and methods, prior to construction of the first production drilled shaft, by installing a non-production drilled shaft. Install on site at a location the Engineer determines.

2. Construct the demonstration shaft a minimum of 3 feet (1 m) into bedrock. A reinforcing steel cage, designed by the Contractor, to adequately support the CSL tubes will be required.

3. Construct the demonstration shaft according to the requirements of this specification with special emphasis on slurry control and disposal, method of scouring, air lift pump usage, concrete delivery and coordination with the batch plant, concrete slump at the point of delivery, and concrete placement. Include one break of the concrete pump line.

4. If the demonstration shaft installation demonstrates the equipment and methods used to construct drilled shafts to the requirements of this specification are inadequate, the Engineer will require appropriate alterations in equipment or methods, or both, to eliminate the unsatisfactory results. The Contractor may be required to perform

additional demonstration shafts until an adequate procedure is demonstrated and approved by the Engineer.

5. Do not begin constructing production drilled shafts until the Engineer approves the methodology and reviews the CSL report. The Engineer will complete the review process within 5 working days.

6. The "Demonstration Shaft" item will be deleted from the contract if:
- The Contractor has demonstrated sufficient experience in the construction of drilled shaft foundations in soil/rock and under conditions similar to those at this site, and
- Other applicable factors indicate it to be acceptable.

L. Test Shaft.

1. When required in the contract documents, install a test shaft at the location indicated in the plans. Base the final selected depth of the test shaft on the confirmation boring.

a. Confirmation Boring and Sampling.

1) Prior to installation of the test shaft, complete a confirmation boring at the test shaft location to a depth 10 feet (3 m) below the bottom elevation as shown in the contract document or a minimum of 30 feet (10 m) into the bedrock, whichever is greater.

2) Perform standard penetration tests according to ASTM D 1586 in the soil overlying bedrock. Perform the tests on 5 foot (1.5 m) centers.

3) Determine moisture contents on the soil samples. Continue soil sampling and testing with split barrel (spoon) sampling, according to ASTM D 1586, until the top of bedrock is encountered.

4) Core the rock using double barrel diamond coring methods producing a minimum 1.75 inch (44.4 mm) core according to ASTM D 2113, or other approved sampling method. Keep records, including Percent Core Recovery and Rock Quality Designation, according to ASTM D 2113 and D 6032. Preserve rock samples at their natural moisture content and condition. Transport them to the laboratory for classification by a Professional Engineer licensed in the State of Iowa.

5) Test representative samples of intact rock for unconfined compressive strength according to ASTM D 2938, except record stress and strain according to ASTM D 2166, up to 20% strain or failure, whichever occurs first. Prepare a stress-strain plot. In addition, list the unconfined compressive strength.

6) Perform one unconfined compression test for every 3 feet (1.0 m) of rock core. The Engineer will select test samples.

7) Do not install test shafts until the results of the confirmation boring have been submitted and reviewed and incorporated in the proposed load test program to be submitted according to Materials I.M. 388.

8) The Engineer will complete the review of the confirmation boring report within 7 calendar days after submittal and the

proposed load cell test program report within 7 calendar days after submittal.

b. Load Cell Test.

1) When required by the contract documents, furnish all materials and labor necessary to conduct a load cell test according to Materials I.M. 388.

2) Install telltale casings to allow measurement of shaft movement during load cell test.

3) Use the utmost care in handling the rebar cage/test equipment assembly so as not to damage the load cell and instrumentation during installation.

4) After the CSL test has been approved and the concrete has reached a minimum required strength of 3500 psi (24 MPa), internally pressurize the load cell creating an upward force on the shaft and an equal, but downward force. The total load for a given internal pressure is found from the load cell's calibration. Ensure this is performed prior to load cell's shipment to the site. During the period required to perform the load cell test, no casings may be vibrated into place or steel piles installed within 200 feet (60 m) of the load test.

5) If the test shaft is a production shaft, monitor the load/deflection curve and halt testing so that the capacity of the shaft is not compromised. Then unload the load cell and reload it to verify that the test shaft has at least the design capacity. If the test shaft is not a production shaft, continue the load cell test until ultimate capacity is reached or the capacity of the load cell is reached.

6) If the test shaft is a production shaft, grout the hydraulic lines and load cell cavities after completion of the load cell test. Use a grout meeting the requirements of Materials I.M. 388.

7) Within 14 calendar days of the test completion, supply four printed copies and one electronic copy of the report for each load cell test, as prepared by the approved firm in Materials I.M. 388. Provide field results after completion of the test. In the report include, at a minimum, the following:

- **a)** Load distributions, skin friction, and end bearing for the various strata instrumented by the strain gauges.
- **b)** Summary of drilled shaft's dimensions, elevations, areas, and masses.
- **c)** Boring logs, test data, and other relevant information from the confirmation boring.
- **d)** Log of the Contractor's installation along with actual mapping of the shaft profile.
- **e)** Load movement for end bearing and upward shear.
- **f)** Equivalent top load movement curve.
- **g)** Side shear creep limit curve.
- **h)** End bearing creep limit curve.
- **i)** Side shear load transfer for each zone/layer identified in the confirmation boring report, where strain gauges were installed, or as modified by the Engineer and the approved firm in Materials I.M. 388.

j) Plots of mobilized side shear load transfer versus vertical displacement for each zone/layer identified in the confirmation boring report, where strain gauges were installed. Layers may be modified in final load test design, if approved of by the Engineer.

k) Tables with test data.

2. If the Engineer determines the test shaft to be unacceptable, submit a plan for remedial action to the Engineer for approval. The Engineer may require another load cell test on another shaft.

3. Do not begin construction of the production shafts until the Engineer approves the methodology, reviews CSL report, and reviews load cell test results.

4. Prior to commencement of the load cell test, repair all cavities or inclusions. Obtain the Engineer's approval for the repairs.

5. The Engineer will complete the review process within 14 calendar days of the load test report submittal.

6. The load test results will be used to evaluate the shaft capacities within the bedrock and to define the final bottom elevation of the remaining productions shafts. The final bottom elevation of the remaining production shafts may vary from what is shown on the plans.

7. Once the load cell test has been completed and the Engineer has approved it, clean up the test shaft site. If the test shaft is a production shaft, clean up the site using whatever measures are required to incorporate the test shaft into the foundation, subject to the Engineer's approval. If the test shaft is not a production shaft, remove it to 3 feet (1 m) below final ground level and clean the area according to Article 1104.08.

2433.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Concrete Drilled Shaft.
Feet (meters), to the nearest 6 inches (0.15 m), constructed.

B. Reinforcing Steel.
Section 2404 applies.

C. Load Cell Test.
By count.

D. Demonstration Shaft
Feet (meters), to the nearest 6 inches (0.15 m), constructed and approved.

2433.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Concrete Drilled Shaft.

1. Per foot (meter).

2. Payment is full compensation for all equipment, labor, and materials (except reinforcing steel) necessary to satisfactorily construct the shafts including:

- Drilling and excavation of shaft and rock socket,
- Casing,
- Installation and removal of temporary casing,
- Furnishing and placing concrete,
- CSL pipe and testing, shaft inspection, and
- Disposal of excavated materials and water, and all other materials.

B. Reinforcing Steel.
Section 2404 applies.

C. Load Cell Test.

1. Each.

2. Payment is full compensation for:

- Performing confirmation boring and testing and all costs incurred during the procurement,
- Installation,
- Instrumentation with strain gauges and telltales,
- Conducting of the test,
- Subsequent removal of test apparatus, appurtenances, grouting cell tubes, and
- Reporting.

D. Demonstration Shaft.

1. Per foot (meter).

2. Payment is full compensation for all equipment, labor, and materials necessary to satisfactorily construct the approved shaft including:

- Drilling and excavation of drilled shaft and rock socket,
- Installation and removal of temporary casing,
- Furnishing and placing reinforcing bars,
- Furnishing and placing concrete,
- CSL pipe and testing,
- Shaft inspection, and
- Disposal of excavated materials and water, and all other materials.

Section 2434. Disc Bearing Assembly

2434.01 DESCRIPTION.

A. Furnish, test, and install complete in-place, factory-produced disc bearing assemblies according to details shown on the contract documents and with the requirements of this specification.

B. Ensure disc bearing assembly design, materials, shop drawings and documentation, fabrication, testing and acceptance, packaging, and installation are according to the contract documents and this specification, as well as the most recent edition of the AASHTO Standard Specifications for Highway Bridges.

2434.02 DISC BEARING ASSEMBLY DESIGN, MATERIALS, FABRICATION, AND TESTING.

A. Disc Bearing Assembly Design.

1. Ensure the Manufacturer has designed the disc bearing assemblies for the service loads and movements as shown on the contract documents. Ensure the minimum horizontal load capacity of the bearing is a minimum of 10% of the vertical capacity.

2. Polytetrafluoroethylene (PTFE) sliding surfaces for expansion bearings are designed to translate by the sliding of a PTFE surface across a smooth hard mating surface of stainless steel. Ensure the maximum coefficient of friction within the range of loads and service temperatures is 0.03.

3. Ensure the finished PTFE sheet is no less than 1/8 inch (3 mm) and no more than 3/16 inch (5 mm) thick. Ensure the PTFE sheet is recessed according to Article 18.5.3.2 Div. II of the AASHTO Standard Specifications for Highway Bridges.

B. Disc Bearing Assembly Requirements.

1. Polyether urethane structural element (disc) confined by upper and lower steel bearing plates.

2. Equipped with a shear restriction mechanism to prevent lateral movement of the disc.

3. Adequate provision for the thermal expansion and contraction, rotation, camber changes, and creep and shrinkage of structural members.

4. Supplied as guided expansion or fixed bearings, as designated on the contract documents.

5. Supplier meeting Article 18.7.4.8 Division II of the AASHTO Standard Specifications for Highway Bridges and approved by the Contracting Authority.

6. Sliding bearings stiff in shear (i.e. negligible shear displacements occurs within the load-bearing element).

C. Disc Bearing Assembly Materials.

1. **Steel components:** meet the material requirements as designated on the contract documents.

2. **Anchor bolts:** meet the material requirements as designated on the contract documents.

3. **Stainless steel mating surfaces:** conform to ASTM A 240/A 240M Type 304. Minimum No. 8 mirror finish for mating surface. Minimum 16 gauge thickness for the stainless steel plate.

4. **The PTFE sheets:** manufactured from pure virgin (not reprocessed) unfilled PTFE resin.

5. **Guiding arrangements:** PTFE to stainless steel sliding surfaces.

6. **Structural element (disc):** new and unused polyether urethane, with no reclaimed material incorporated into the finished disc bearing assembly, complying with Article 14.6.8.2 of the AASHTO Standard Specifications for Highway Bridges and tested according to ASTM D 2240.

D. Disc Bearing Assembly Fabrication.
Ensure the following:

1. Fabrication of all parts of the disc bearing assembly is done according to the approved shop drawings.

2. The surface of the stainless steel plates is protected from weld splatter during the welding procedure of the stainless steel plates to the backing plate,

3. PTFE sheet bonding is performed at the expansion bearing manufacturer's factory under controlled conditions and according to the written instructions of the manufacturer of the approved adhesive system.

4. The PTFE surface is smooth and free from bubbles after completion of the bonding operation.

E. Disc Bearing Assembly Shop Drawings and Documentation.
Ensure shop drawings are:

- Prepared according to the requirements of Article 2408.02.
- Certified by a Professional Engineer licensed in the State of Iowa.
- Submitted with design computations for review for conformance with the loads shown on the contract documents.

F. Disc Bearing Assembly Surface Coating.

Ensure that exposed surfaces of steel components of the disc bearing assemblies, except for the stainless steel surface and the masonry plate, are shop primed and painted according to the Standard Specifications. Ensure the masonry plate is galvanized according to ASTM A 123.

G. Disc Bearing Assembly Testing and Acceptance.

1. General.

a. Ensure each manufactured lot of disc bearing assemblies is accompanied by a manufacturer's certificate stating that the steel, neoprene elastomer, and PTFE material meet the requirements of the materials specified above. Ensure certificates show actual test results for the materials used in the manufacture of the disc bearing assemblies.

b. Acceptance of disc bearing assemblies will be based on satisfactory manufacturer's certification, acceptable test results, and inspection at the time of installation.

2. PTFE Sliding Surfaces.

The Manufacturer is to furnish facilities for and perform the testing and inspection of the completed disc bearing assemblies or representative samples in their plant or at an independent test facility according to Article 18.7.4.2 of the AASHTO Standard Specifications for Highway Bridges.

2. Disc Bearing Assemblies.

a. The Manufacturer is to supply the complete disc bearing assembly, including, but not limited to, disc bearing, sole plate, guide bars, slider plate, masonry plate, the 1/8” (3 mm) preformed masonry pads, and the anchor bolts.

b. The Manufacturer is to furnish facilities for the Contracting Authority or an independent agency to perform the testing and inspection of the completed disc bearing assemblies or representative samples in their plant or at an independent test facility according to Article 18.7.4.8 of the AASHTO Standard Specifications for Highway Bridges. These tests include those listed below, but do not include a long-term deterioration test (Article 18.7.2.8 of the AASHTO Standard Specifications for Highway Bridges):

- A dimensional check (Article 18.7.2.3 of the AASHTO Standard Specifications for Highway Bridges),
- A clearance test (Article 18.7.2.4 of the AASHTO Standard Specifications for Highway Bridges),
- A bearing horizontal capacity test (Article 18.7.2.9 of the AASHTO Standard Specifications for Highway Bridges), and
- A short-term compressive proof load test (Article 18.7.2.5 of the AASHTO Standard Specifications for Highway Bridges).

c. Disc bearing assemblies represented by the test specimen passing the above requirements will be approved for use in the structure, subject to on-site inspection for visible defects.

2434.03 CONSTRUCTION.

A. Packaging.
Replace disc bearing assemblies damaged during handling, transporting, or storing at no additional cost to the Contracting Authority.

B. Disc Bearing Assembly Installation.

1. The bridge bearings are not designed to accept bending stresses and must be fully supported over the entire area of the bottom and upper surfaces at all times when under load.

2. Set the bearing masonry plate to line and grade. Locate the disc bearing assemblies at the proper elevation and orient them in the proper direction. Obtain the Engineer’s approval for the location and orientation of the bridge disc bearing assembly. Locate the upper part of the disc bearing assembly relative to the base of the disc bearing assembly according to the Engineer's recommendations for the temperature at the time of erection.

3. Do not disassemble disc bearing assemblies without the Engineer’s permission.

4. Exercise care when aligning both the base and upper part of the guided expansion bearing as detailed on the contract documents; otherwise, a wedging action will occur resulting in unsought horizontal forces.

5. Avoid scratching, gouging, or otherwise marking the PTFE or mating stainless steel surfaces of the disc bearing assemblies during handling or erection. Use whatever means necessary to protect the disc bearing assemblies from dirt, grout, or other foreign materials during the construction of other elements of the structure.

6. Modifications required to meet the height of disc bearing assemblies shown in the contract documents are the responsibility of the Contractor, with no additional cost to the Contracting Authority.

2434.04 METHOD OF MEASUREMENT.
The quantity of Disc Bearing Assemblies will be shown in the contract documents.

2434.05 BASIS OF PAYMENT.
Payment for Disc Bearing Assemblies completed and in place will be at the contract unit price. Payment includes the 1/8 inch (3 mm) preformed masonry pad, anchor bolts, work and materials required to drill and fill the anchor bolt holes with approved grout, surface preparation, and painting of steel surfaces as described herein.

Section 2435. Sanitary and Storm Sewer Structures

2435.01 DESCRIPTION.

This section was developed in conjunction with Sections 6010 and 6030 of the SUDAS Standard Specifications, with modifications to suit the needs of the Department.

A. Construct sanitary and storm sewer manholes to provide access to sewer systems for maintenance and cleaning purposes.

B. Construct storm sewer intakes for collection of surface water and conveyance to the storm sewer system.

C. Modify existing manholes and intakes as necessitated by other improvements adjacent to the manholes or intakes.

D. Clean and inspect sanitary and storm sewer manholes, intakes, and other utility structures. Test sanitary sewer manholes.

2435.02 MATERIALS.

Apply Article 4149.04.

2435.03 CONSTRUCTION.

A. General Requirements for Installation of Manholes and Intakes.

1. Excavation.
Excavate according to Section 2552.

2. Subgrade Preparation.
- **a. Cut Sections (Undisturbed Soil):** Prepare subgrade to accurate elevation required to place structure base or subbase.
- **b. Fill Sections:** Compact to 95% of maximum Standard Proctor Density and hand grade to accurate elevation required to place structure base or subbase, or install stabilization material as directed by the Engineer.
- **c. Unstable Soil:** Install stabilization material as directed by the Engineer.

3. Subbase.
- **a. Cast-in-place Structures:** No subbase material is required.
- **b. Precast Structures:** If precast structure is provided, install 8 inch (200 mm) thick pad of Class I bedding material a minimum of 12 inches (300 mm) outside the footprint of the structure.

4. Installation of Manhole or Intake Structure.
Adjust wall height and depth of base, when necessary, to provide a minimum of 48 inches (1200 mm) between form grade elevation and top of base.
- **a. Cast-in-place:** Apply Article 2435.03, B.
- **b. Precast:** Apply Article 2435.03, C.

5. Pipes.
Install and bed pipes and connect to manhole or intake. Install pipe flush with inside wall of structure. Place bedding and pipe embedment material according to Section 2552.

a. Cast-in-place Structures.
1) Storm: Form structure walls around pipe.
2) Sanitary: Form or core circular opening and install flexible watertight gasket according to Article 4149.04, G. Keep void between pipe and manhole section free of debris and concrete.

b. Precast Storm Sewer Manholes or Intakes.
Fill space between pipe and structure with non-shrink grout.

c. Precast Sanitary Sewer Manholes.
Connect to structure with flexible watertight gasket according to Article 4149.04, G. Keep void between pipe and manhole section free of debris and concrete.

d. Sanitary Sewer Manholes on Existing Pipe.
Install waterstop according to Article 4149.04, G.

6. Joint Sealant.

a. Sanitary Sewer Manholes.
1) Install rubber O-ring or profile gasket (precast structures).
2) Apply bituminous jointing material or butyl sealant wrap to exterior of all sanitary sewer manhole joints.

b. Storm Sewer Manholes and Intakes.
1) Apply bituminous jointing material or install rubber rope gasket.
2) If indicated in the contract documents, apply engineering fabric wrap to joints.

7. Invert.
a. Construct manhole invert up to one half of pipe diameter to produce a smooth half pipe shape between pipe inverts.
b. Shape invert to provide a smooth transition between pipe inverts.
c. Slope invert top toward pipe 1/2 inch per foot (40 mm per meter) perpendicular to flow line.
d. For sanitary sewer, keep void between pipe and structure wall free of debris and concrete.
e. For precast inverts, remove projections and repair voids to provide a hydraulically smooth channel between ends of pipes.

8. Top Sections.
Install manhole eccentric cone or flat top section or install intake top.

9. Adjustment Ring(s).
Bed each concrete ring with bituminous jointing material in trowelable or rope form. Bed each polyethylene ring with the manufacturer's approved product. Do not install more than a total ring stack height of 12 inches (300 mm). For greater adjustment, modify lower riser section(s).

10. Casting.
Install the type of casting specified in the contract documents and adjust to proper grade. Where a manhole or intake is to be in a paved area, adjust the casting to match the slope of the finished surface. When

specified in the contract documents, attach a casting frame to the structure with four anchor bolts.

11. Chimney Seal.

For sanitary sewer manholes, install an internal or external rubber chimney seal.

- **a.** Do not use external chimney seal if seal will be permanently exposed to sunlight.
- **b.** Extend seal 3 inches (75 mm) below the lowest adjustment ring.
- **c.** Extend seal to 2 inches (50 mm) above the flange of the casting for a standard two piece casting, or 2 inches (50 mm) above the top of the base section of the casting for an adjustable three piece casting.
- **d.** Use multiple seals, if necessary.
- **e.** Install compression bands (external chimney seal) or expansion bands (internal chimney seal) to lock the rubber sleeve or extension into place and to provide a positive watertight seal. Once tightened, lock bands into place. Use only manufacturer recommended installation tools and sealants.

12. Placing and Compacting Backfill Material.

- **a.** Place suitable backfill material after concrete in structure has reached at least 3000 psi (21 MPa) compressive strength or 550 psi (3850 kPa) flexural strength. If concrete strength is not determined, place backfill material at least 14 calendar days after initial concrete placement.
- **b.** Place backfill material simultaneously on all sides of walls and structures so the fill is kept at approximately the same elevation at all times.
- **c.** Compact the 3 feet (1 m) closest to all walls for wing faces using pneumatic or hand tampers only. Ensure proper and uniform compaction of backfill material around structure.

B. Additional Requirements for Cast-In-Place Concrete Structures.

1. Forms.

- **a.** Apply Article 2403.03, B, 5.
- **b.** Form all cast-in-place manholes and intakes on both the inside and the outside face above the base. Do not form against excavated earthen surface.

2. Reinforcing Steel.

- **a.** Apply Section 2404.
- **b.** Lap bars a minimum of 36 diameters, unless specified otherwise in the contract documents.
- **c.** Provide a minimum of 3 inches (75 mm) of clearance for structure bases and 2 inches (50 mm) of clearance for walls and tops.

3. Concrete Mixing.

- **a.** Apply Article 2403.02, D.
- **b.** When using ready-mixed concrete, comply with ASTM C 94/C 94M.

4. Concrete Placing.

a. Apply Article 2403.03, C.

b. Do not place concrete when the air temperature is less than 40°F (5º C) without the approval of the Engineer. When placement below 40ºF (5ºC) is allowed, apply Article 2403.03, F.

c. Place concrete continuously in each section until complete. Do not allow more than 30 minutes to elapse between depositing adjacent layers of concrete within each section.

d. Apply Article 2403.03, D, for concrete vibration.

e. Form 1 1/2 by 3 inch (38 mm by 75 mm) keyed construction joints at locations shown in the contract documents.

f. Provide a broom finish on portions of structure that are to become part of exposed pavement.

5. Stripping and Cleaning.

a. Remove forms for manhole and intake walls and tops according to Article 2403.03, M. References to culverts include all sanitary and storm structures. When allowed by the Engineer, compressive strengths at six times the stated flexural strengths may be used in determining concrete strength of structure tops.

b. Finish surfaces according to Article 2403.03, P. Give exposed surfaces a Class 2 finish.

6. Curing.

a. Apply Article 2403.03, E.

b. For surfaces visible to the public, use only curing compounds complying with ASTM C 309, Type 1-D or Type 2.

7. Exterior Loading.

a. Restrict exterior loads on concrete according to Article 2403.03, N.

b. When allowed by the Engineer, compressive strengths at six times the stated flexural strengths may be used.

8. Repairs.

After visual inspection of the completed manhole or intake, repair honeycomb areas, visible leaks, tie holes, or other damage areas. Remove concrete webs or protrusions.

C. Additional Requirements for Precast Concrete Structures.

1. Substitutions.

Precast structures may be substituted for designated cast-in-place structures so long as structure is constructed as specified in the contract documents and according to Article 2435.03, B.

2. Cast-in-place Base.

a. Apply Article 2435.03, B, for placement of concrete.

b. Ensure proper vertical and horizontal alignment of base riser section.

3. **Precast Base or Base with Integral Riser Section.**
   Place base or base with integral riser section and ensure proper vertical and horizontal alignment.

4. **Additional Riser Sections.**
   Install additional riser sections as required.

5. **Lift Holes.**
   Install rubber plug in lift holes. Cover plug and hole with non-shrink grout.

D. Adjustment of Existing Manhole or Intake.

1. **Casting Extension Rings.**
   - **a.** Only install casting extension rings when allowed by the contract documents, and only in conjunction with pavement overlays.
   - **b.** Install according to the manufacturer's recommendation and adjust for proper alignment.

2. **Minor Adjustment (Adding or Removing Adjustment Rings).**
   - **a.** Remove casting.
   - **b.** Modify adjustment ring stack height by one of the following methods:
     - **1)** Add adjustment rings as necessary to adjust existing manhole or intake to finished pavement grade or finished topsoil grade, to a maximum ring stack height of 16 inches (400 mm). Bed each concrete ring with bituminous jointing material. Bed each polyethylene ring with manufacturer's approved product.
     - **2)** Remove one or more adjustment rings, as appropriate, to reduce casting elevation.
   - **c.** Install new casting on modified adjustment ring stack. Existing casting may be reinstalled when specified in the contract documents.
   - **d.** Replace chimney seal for sanitary sewer manhole using only new materials.

3. **Major Adjustment (Adding, Removing, or Modifying Riser or Cone Section).**
   When adjustment is greater than can be accomplished through adding or removing adjustment rings, a major adjustment will be required.
   - **a.** Remove casting.
   - **b.** Remove top.
   - **c.** Remove and replace or modify existing riser section and/or top section, as appropriate.
   - **d.** Install new frame and cover or grate. Existing casting may be reinstalled when allowed by the contract documents.
   - **e.** Replace chimney seal for sanitary sewer manhole using only new materials.

E. Connection to Existing Manhole or Intake.

1. Sanitary Sewer.

a. General.

1) Excavate as required.

2) Divert flow as necessary. Obtain approval of the diversion plan from the Engineer. Maintain sanitary sewer service at all times unless specified otherwise in the contract documents.

3) Remove existing invert as necessary to install pipe at required elevation and develop hydraulic channel.

b. Cored Opening.

1) Insert flexible watertight connector into new opening.

2) Install and tighten internal expansion sleeve to hold flexible connector in place.

3) Insert pipe through flexible connector and tighten external compression ring.

4) Do not grout opening or pour collar for cored opening with flexible connector.

c. Cut and Chipped Opening (Knockout).

1) Saw opening to approximate dimensions with a masonry saw. Saw to depth sufficient to sever reinforcing steel.

2) Remove concrete and expand opening to a diameter at least 6 inches (150 mm) larger than the outside diameter of the new pipe.

3) Cut off all reinforcing steel protruding from the structure wall.

4) Remove existing concrete invert as required to accommodate new pipe.

5) Insert pipe into structure and trim end flush with inside wall of structure.

6) Install waterstop around new pipe centered within structure wall.

7) Fill opening between structure and pipe with non-shrink grout.

8) Construct concrete collar around pipe and exterior manhole opening.

a) For new pipes 12 inches (300 mm) or smaller, install two No. 3 steel reinforcing hoops on collar around pipe. Pour concrete collar around pipe/structure junction to a minimum thickness and width of 6 inches (150 mm).

b) For new pipes larger than 12 inches, install two No. 4 steel reinforcing hoops in collar around pipe. Pour concrete collar around pipe/structure junction to a minimum thickness and width of 9 inches (230 mm).

9) Provide pipe joint, non-shear coupling, or other approved flexible coupling within 2 feet (600 mm) of structure wall to allow for differential settlement between the new sewer and the structure.

10) Reconstruct structure invert to provide a well defined channel between pipes.

2. Storm Sewer.

a. Excavate as required.

b. Cut opening to manhole or intake to 3 to 6 inches (75 to 150 mm) beyond the outside of the pipe. Remove existing invert as necessary to install pipe at required elevation and develop hydraulic channel.
c. Position end of pipe flush with interior wall of manhole.
d. Fill opening between manhole wall and outside of pipe with non-shrink grout. Construct a concrete collar around the pipe.
e. Reconstruct invert according to Article 4149.04, K
f. Place backfill material according to Section 2533.

F. Cleaning, Inspection, and Testing of Structures.

1. Cleaning.

a. Clean all manholes, intakes, and structures by removing sheeting, bracing, shoring, forms, soil sediment, concrete waste, and other debris.
b. Do not discharge soil sediment or debris to drainage channels, existing storm sewer, or existing sanitary sewer system.

2. Visual Inspection.

a. Examine structure for:
1) Damage.
2) Slipped forms.
3) Indication of displacement of reinforcement.
4) Porous areas or voids.
5) Proper placement of seals, gaskets, and embedments.
b. Verify that the structure is set to true line, grade, and plumb.
c. Verify structure dimensions and thicknesses.

3. Repair.

Apply Article 2435.03, B, 8.

4. Sanitary Sewer Manhole Testing.

a. General.
1) Use vacuum testing for new sanitary sewer manholes unless exfiltration testing is specified in the contract documents.
2) Conduct final test after manhole construction is complete, all repairs and connections have been made, and invert has been installed.
b. Vacuum Test.
1) Applicable only for new manholes isolated from connecting sewer lines.
2) Use manufactured vacuum test equipment meeting the Engineer's approval. Follow the equipment manufacturer's recommended procedures throughout.
3) Use extreme care and follow safety precautions during testing operations. Keep personnel clear of manholes during testing.
4) Seal all openings except manhole top access using pneumatic plugs rated for test pressures. Install plugs according to the test equipment manufacturer's recommendations.
5) Brace pipe inverts if backfill material has not been placed around connecting pipes.

6) Install the vacuum tester head assembly on the manhole top access, and inflate the seal.
7) Evacuate the manhole to 5 psi (35 kPa). Close the isolation valve and start the test. Record the starting time.
8) Maintain vacuum in the manhole for the time indicated in Table 2435.03-1 below for the diameter and depth of manhole being tested.
9) Test failure is indicated by vacuum loss greater than 0.5 psi (4 kPa) within the minimum test time indicated in Table 2435.03-1 below for the depth and diameter of the manhole being tested.

Table 2435.03-1: Minimum Vacuum Test Times for Various Manhole Diameters

Depth feet (m)	Diameter inches (mm)				
	48 (1200)	54 (1350)	60 (1500)	66 (1650)	72 (1825)
	Time, Seconds				
8 (2.45)	20	23	26	29	33
10 (3.28)	25	29	33	36	41
12 (3.66)	30	35	39	43	49
14 (4.27)	35	41	46	51	57
16 (4.88)	40	46	52	58	67
18 (5.49)	45	52	59	65	73
20 (6.10)	50	53	65	72	81
22 (6.71)	55	64	72	79	89
24 (7.32)	59	64	78	87	97
26 (7.93)	64	75	85	94	105
28 (8.54)	69	81	91	101	113
30 (9.15)	74	87	98	108	121

c. Exfiltration Test.
1) Applicable to new manholes (when specified in the contract documents) or rehabilitated manholes.
2) Testing may be performed in conjunction with sanitary sewer line testing. Apply Section 2504.
3) Do not test by this method if water may potentially freeze during the test.
4) Plug the manhole inlet and outlet.
5) Fill the manhole with water to 2 feet (600 mm) above the outside top of the connecting pipe. If groundwater is present, fill the manhole to no less than 2 feet (600 mm) nor more than 5 feet (1.5 meters) above the groundwater level. Do not fill above the top of the standard barrel sections.
6) Mark the water level.
7) Allow water to stand in the manhole for 1 hour, then refill to the original water level and begin the test.

8) Determine the allowable drop in water level by using the equation given in Article 2504.03, C, 6, i. After 1 hour, measure the drop in water level.

9) Test failure is indicated by water loss greater than maximum allowable calculated exfiltration.

5. Test Failure.
If testing fails, reseal the openings, repair the manhole, and retest. An alternate test method complying with these specifications may be used for a retest if desired.

2435.04 METHOD OF MEASUREMENT.

A. Manhole.
Each type and size of manhole will be counted.

B. Intake.
Each type and size of intake will be counted.

C. Drop Connection.
Each drop connection will be counted.

D. Casting Extension Rings.
Each casting extension ring will be counted.

E. Manhole or Intake Adjustment, Minor.
Each existing manhole or intake adjusted to finished grade by addition or removal of adjustment rings or adjustment of adjustable casting will be counted.

F. Manhole or Intake Adjustment, Major.
Each existing manhole or intake adjusted to grade by addition or removal of riser, cone or flat top sections, or the exchange of existing riser sections with sections having different vertical dimensions will be counted.

G. Connection to Existing Manhole or Intake.
Each connection made to an existing manhole or intake will be counted.

H. Cleaning, Inspection, and Testing.
None.

2435.05 BASIS OF PAYMENT.

A. Manhole.

1. Payment will be at the contract unit price for each type and size of manhole.

2. Payment is full compensation for excavation, placing bedding and backfill material, compaction, base, structural concrete, reinforcing steel, precast units (if used), chimney seals, castings, and adjustment rings.

B. Intake.

1. Payment will be at the contract unit price for each type and size of intake.

2. Payment is full compensation for excavation, placing bedding and backfill material, compaction, base, structural concrete, reinforcing steel, precast units (if used), castings, adjustment rings, and all appurtenances necessary for proper installation.

C. Drop Connection.

1. Payment will be at the contract unit price for each drop connection.

2. Payment is full compensation for the connection to the manhole and all pipe, fittings, concrete encasement, and bedding and backfill material.

D. Casting Extension Rings.
Payment will be at the unit price for each casting extension ring.

E. Manhole or Intake Adjustment, Minor.

1. Payment will be made at the contract unit price for each minor manhole or intake adjustment.

2. Payment is full compensation for:
- Removing existing casting and existing adjustment rings,
- Furnishing and installing adjustment rings,
- Furnishing and installing new casting, and
- Installing new chimney seal (sanitary sewer manholes only).

F. Manhole or Intake Adjustment, Major.

1. Payment will be at the contract unit price for each major adjustment.

2. Payment is full compensation for:
- Removal of existing casting, adjustment rings, top sections and risers,
- Excavation,
- Concrete and reinforcing steel or precast sections,
- Furnishing and installing new casting
- Installing new chimney seal (sanitary sewer manholes only),
- Placing backfill material, and
- Compaction.

G. Connection to Existing Manhole or Intake.

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

2. Payment is full compensation for coring into the existing manhole or intake, pipe connectors, grout, and waterstop (when required).

H. Cleaning, Inspection, and Testing.
Cleaning, inspection, and testing of structures are incidental to construction of structures and will not be paid for separately.