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Standard Specifications for Road and Bridge Construction, March 1, 2006, Part 6 - Structures

Tennessee. Department of Transportation.

Part 6-Structures

SECTION 601-TIMBER STRUCTURES

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601.01-Description. This work shall consist of constructing structures or parts of structures, other than piling, composed of timber, treated or untreated, or a combination of both. Timber structures shall be constructed on prepared foundations at the locations indicated or directed, in reasonably close conformity with the dimensions, lines, and grades shown on the Plans or as directed by the Engineer, and in accordance with these Specifications.

Parts of timber structures to be constructed with materials other than timber, such as concrete, steel, etc., shall be constructed in accordance with the requirements of the Sections pertaining to the respective types of structure.

MATERIALS

601.02-Materials. Materials used in this construction shall meet the following requirements, in addition to the general requirements of these Specifications.

Material	Subsection
Timber	**911**

Timber shall be of the dimensions shown on the Plans. The dimensions indicated on the Plans are intended to represent the commercial product.

Untreated timber used for mud sills shall be heart cedar, heart cypress, redwood, or other durable timber.

The design of ring or shear plate timber connectors shall be as approved by the Engineer. Connectors shall be of galvanized metal meeting the appropriate ASTM standard.

Hardware for timber structures shall be of the design, size, kind and composition shown on the Plans or as directed by the Engineer.

EQUIPMENT

601.03-Equipment. All equipment necessary for the satisfactory performance of this construction shall be on the project and approved by the Engineer before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

601.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, Structure Excavation, Foundation Preparation and Backfill and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203, 204**, and **205**, respectively.

601.05-Care and Protection of Timber. Timber, either treated or untreated, shall be carefully handled by the Contractor.

All timber shall be stored upon platforms, skids or other supports at least 12 in. (300 mm) above the ground surface and shall be so stacked and stripped as to permit free circulation of air between-the tiers and courses. The stacked timber shall be covered as directed. The ground underneath and in the vicinity of the timber shall be cleared of weeds and rubbish, and shall be shaped to allow surface water flow to drain away from the stockpiled material.

601.06-Components of Timber Structures.

(a) Mud Sills.

Mud sills shall be firmly and evenly bedded to a solid bearing, and tamped in place.

(b) Concrete Pedestals.

Concrete pedestals for the support of framed bents shall be so finished that the sills or posts will receive an even and uniform bearing. The tops of pedestals projecting outside the bearing area shall be sloped downward to direct water away from the bearings. Dowels, not less than 3/4 in. (19 mm) in diameter and projecting the proper distance above the tops of the pedestals, shall be set 9 in.(225 mm) in the pedestal when they are being cast.

(c) Sills.

Sills shall be drift-bolted with 3/4 in.(19 mm) diameter bolts extending into the mud sills, piles or pedestals at least 9 in. (225 mm). When possible, all earth shall be removed from contact with sills in order to provide free circulation of air around the sills.

(d) Caps.

Caps shall be set as shown on the Plans, and shall be set so as to have full and even bearing on piles or other supports in the bent, and to provide even bearing and full contact with the stringers placed on the caps. They shall be secured to each pile or post by a 3/4 in. (19 mm) drift bolt placed as nearly as possible in the center of the pile or post, and extending through the cap and at least 9 in. (225 mm) into the pile or post. They shall be secured to other supports as shown on the Plans.

(e) Posts for Bents.

Posts shall be fastened to sills and pedestals with dowels of not less than 3/4 in. (19 mm) diameter extending into posts and sills as shown on the Plans.

(f) Framing.

Truss and bent timbers shall be cut and framed to a close fit in such manner that they will have an even bearing over the entire contact surface of the joint. No blocking or shimming will be allowed in making joints, nor will open joints be permitted.

Mortises shall be true to size for their full depth, and tenons shall make snug fit therein. Mortises and tenons shall be draw-bored.

(g) Stringers.

All stringers shall be so set or placed to required elevations as to give flooring an even bearing at all contacts or intersections.

Stringers shall be sized at bearings and shall be so placed in position that knots near edges will be in the top portion of the stringer.

Unless otherwise specified, outside stringers shall have butt joints, but interior stringers shall be framed to bear over the full width of floor beam or cap at each end of the stringer.

The ends of untreated stringers shall be separated at least 1/2 in. (13 mm) for the circulation of air and shall be securely fastened to the timber upon which they rest.

Cross-bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails in each end.

(h) Flooring.

All flooring shall be constructed as indicated on the Plans, or as directed by the Engineer. Flooring shall have even, full, and uniform free bearing on each and all stringers and shall not be pulled or warped so as to have such bearing. Shims and wedges will not be permitted unless approved by the Engineer. When constructed of timber, special care shall be taken to place flooring pieces of the same thickness adjacent to each other.

(i) Wheel Guards.

Wheel guards shall be constructed on each side of the roadway as indicated on the Plans. They shall be laid in sections not less than 12 ft. (3.6 m) long, unless otherwise indicated or directed.

Unless otherwise indicated, wheel guards shall be fastened, by means of 5/8 in. (16 mm) bolts not to exceed 5 ft. 3 in. (1.6 m) centers. The ends of sections of all wheel guards shall be fastened. The bolts shall extend entirely through the riser blocks and floor plank.

(j) Railing.

Unless otherwise indicated or directed, railings shall be constructed of untreated, dressed lumber and shall be painted. They shall be built in accordance with the designs indicated on the Plans, shall be reasonably true to line and grade, and shall be constructed in a workmanlike and substantial manner.

(k) Bore Holes.

Holes shall be bored for round bolts, spikes, and dowels with a bit 1/16 in. (2 mm) less in diameter than the bolt, spike, or dowel to be used. The diameter of the holes for square bolts, spikes, or

dowels shall be equal to the least dimension of the bolt or dowel. Holes for machine bolts shall be bored with a bit of the same diameter as the bolt. Holes for rods shall be bored with a bit 1/16 in. (2 mm) greater in diameter than the rod. Holes for screws shall be bored with a bit slightly smaller than the body of the screw at the base of the thread, but not to the full depth of the screw.

All bolt holes bored after treatment shall be retreated with an approved treatment. Any unfilled holes, after being treated, shall be plugged with treated plugs.

(l) Bolts, nuts, and Washers.

Bolts, nuts, and washers shall be of the kinds and sizes specified. Bolts shall have square heads and nuts. All bolts shall be galvanized. Vertical bolts shall have the nuts on the lower end.

A washer shall be used underneath the head or nut of all bolts or lag screws coming in contact with timber. Washers shall be of the same character as the bolt or screw with which they are used.

(m) Countersinking.

Countersinking shall be performed as directed. Recesses formed by countersinking shall be neatly filled with hot tar pitch.

(n) Spiking.

When using spikes to spike one member to another, with spikes 7 in. (175 mm), or longer as indicated on the plans, or when necessary in erection, holes shall be drilled through the member 1/16 in. (2 mm) less than the diameter of the spike that is to be driven. Spikes shall be driven to such depth as required to embed the full thickness of the head into the timber.

601.07-Erection. In erecting timber structures, or parts of structures, to finished or required elevations and required dimensions, knowledge of the variations in Plans dimensions from commercial dimensions of timber shall be exercised in order that the required finished elevations and finished dimensions of the structure will be obtained, without the use of shims or blocks.

Timbers shall be positioned and fastened as shown on the Plans or as directed by the Engineer.

All construction shall be performed in a workmanlike manner and the structure shall present a neat finish and appearance when completed.

Planks shall be laid with the heart side down, with 1/4 in. (6 mm) openings between planks, unless otherwise indicated or directed and shall be fastened at each intersection to a nail strip or joist with two wire spikes of the size indicated or directed.

All places in structures constructed in whole or in part of treated timber, where the surface of timber is broken after treatment, shall be thoroughly coated with an approved treatment. Holes in treated timber caused by withdrawing bolts, nails, spikes, or other causes shall be completely filled with an approved treatment.

In structures constructed in whole or in part of untreated timber, heads of piles not encased in concrete, ends, tops, and all contact surfaces of truss members, laterals, and braces, shall be thoroughly treated as specified above before assembling.

The back face of bulkheads and all other parts of timber in contact with earth shall be thoroughly coated as specified above.

Timber which is to have its surface painted in the completed structure shall have that part of its surface coming in contact with other timber or material painted before being fastened or placed, as set out for railings in Subsection 601.08.

Any timber damaged or found unsatisfactory in the structure shall be removed and replaced at the Contractor's expense.

601.08-Paint and Painting. Railings, except those or parts of those constructed of treated timber, shall be painted with three coats of paint and applied in accordance with the requirements of Sections 603. The type, sequence, and colors shall be as shown on the Plans.

All metals, unless otherwise specified, shall be painted in accordance with the requirements of Section 603.

601.09-Final Cleanup. When finishing a structure, the exposed parts of timber shall be cleaned of discoloration caused by the construction operations.

All material becoming the property of the Department shall be stored as directed by the Engineer.

Final cleanup shall be performed in accordance with the provisions of Subsection 104.11.

COMPENSATION

601.10-Method of Measurement. Untreated Timber and Treated Timber, complete in place and accepted, will be measured for payment by the 1,000 ft board measure (MBM)(m^3) in accordance with the provisions of **Section 109**, Measurement and Payment.

No allowance will be made for hardware used in a structure as this is a necessary part of the structure and is to be included in the unit price bid for timber.

601.11-Basis of Payment. The accepted quantities of timber structures will be paid for at the contract unit price per 1,000 ft. board measure (MBM) (m^3) for Untreated Timber and Treated Timber, complete in place.

SECTION 602-STEEL STRUCTURES

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602.01-Description. This work shall consist of furnishing the various materials for the fabrication, erection and painting of, bridges and such other parts of bridges which are composed of structural steel and miscellaneous metals, except steel piling or metal reinforcement for concrete. Erection shall be within reasonably close conformity to the lines, grades, dimensions and details shown on the Plans, or as otherwise specified, and in compliance with the pertinent requirements of these Specifications.

MATERIALS

602.02-Materials. The materials used shall be those prescribed for the several items which constitute finished work and shall conform with all requirements for such materials as set out in these Specifications. Specific reference is made to **Section 908**, Structural Steel and Appurtenant Materials and **Section 910**, Paint. Materials not covered by these Specifications shall conform to all requirements of AASHTO Bridge Specifications, identified on the plans. Testing requirements and dimensions of materials will be included in the Plans.

EQUIPMENT

602.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on hand and approved before the work will be permitted to begin.

CONSTRUCTION REQUIREMENTS-FABRICATION

602.04-Shop Inspection. The Contractor shall notify in writing the Division of Structures, with a copy to the project Engineer, as to the location and schedule of the fabrication of structural steel, so that the Department may make the necessary arrangements for Quality Assurance (QA) shop inspection. This notification shall be at the earliest possible date after the award of the contract and shall precede the start of fabrication by at least six weeks.

Fabricators of welded plate girders shall be certified under the AISC Quality Certification, Major Steel Bridges Category.

Fabricators of rolled beams, x-frames, floor-beams, diaphragms, stringers, x-bracing, steel bearing devices and roadway expansion devices shall be certified under the AISC Quality Certification, Simple Steel Bridges Category.

Fabricators of fracture critical steel bridge members shall be certified under the AISC Quality Certification, Fracture Critical Endorsement.

The cost of structural steel inspection (QA), limited to the rates set forth in the Special Provisions for each weight range, will be paid by the Department.

The per pound inspection cost for each specified weight range will be multiplied by the applicable steel poundage within its weight range to establish the maximum inspection cost to be paid by the Department. The cost of all structural steel inspection (QA) in excess of the maximum cost to be paid by the Department shall be deducted from monies due the Contractor. The cost for structural steel inspection (QA) shall include the cost of an inspection agency, hired by the Department to perform shop inspection (QA) of steel fabrication. A detailed description of the duties of an inspection agency may be obtained from the Engineer.

The shop inspection performed by the inspection agency hired by the Department is intended as Quality Assurance (QA) to assure to the Department that the fabricator is following all Quality Control requirements and providing a product conforming to the contract requirement. The inspection agency is not instructed or expected to replace the fabricator's quality control. The inspection and acceptance of the work performed by the Department's inspection agency, in no way acts to guarantee or warranty the product to the contractor. Acceptance by the inspection agency, of the product at the fabrication shop shall not be a bar to subsequent rejection of material, if found defective or non-conforming.

The cost of nondestructive testing is to be included in the lump sum bid price for steel structures.

602.05-General.

(a) Type of Construction.

The type of construction shall be welded or bolted, as indicated on the Plans.

(b) Workmanship and Finish.

Workmanship and finish shall be in accordance with the best general practice in modern bridge shops. Portions of the work exposed to view shall be finished neatly.

(c) Storage of Materials.

Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease, or other foreign matter, and shall be protected as far as practicable from corrosion.

(d) Straightening Material.

Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Heat straightening of ASTM A709, Grad HPS 100W, 244 (ASTM A 514) or ASTM A 517 steel shall be done only under rigidly controlled procedures, with each application subject to the approval of the Engineer. In no case shall the maximum temperature of the steel exceed 1125 F (607° C) as set forth in the ASSHTO "Guide Specifications for Highway Bridge Fabrication with High Performance Steel", current edition, and the AASHTO "Bridge Welding Code", current edition. Sharp

kinks and bends shall be cause for rejection of the material. The straightening of plates, angles, other shapes, built-up members when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury to the metal. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by carefully planned procedures and supervised application of a limited amount of localized heat. An exception being that heat straightening of AASHTO M 270 (ASTM A 709) Grades 70W, 100 and 100W steel members shall be done only under rigidly controlled procedures, with each application subject to the approval of the Engineer. In no case shall the maximum temperature in degrees F (C) exceed values in the following table.

Grade HPS 70W from weld	1100° F (600° C)
Grade HPS 100W > 150 mm (6") from weld	1,100° F (600° C)

In all other steels, the temperature of the heated area shall not exceed 1,200° F (649° C) as controlled by temperature indicating crayons, liquids, contact or non-contact infrared thermometers. Heating in excess of the limits shown shall be cause for rejection, unless the Engineer allows testing to verify material integrity.

Parts to be heat straightened shall be substantially free of stress and from external forces, except stress resulting from mechanical means used in conjunction with the application of heat.

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

(e) Heat Curving Rolled Beams and Welded Girders.

(1) Materials.

Steels that are manufactured to a specified minimum yield point greater than 70,000 psi (485 MPa) shall not be heat curved.

(2) Type of Heating.

Beams and girders may be curved by either continuous or V-type heating as approved by the Engineer. For the continuous method, a strip along the edge of the top and bottom flange shall be heated simultaneously; and the strip shall be of sufficient width and temperature to obtain the required curvature. For the V-type heating, the top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange. The spacing and temperature shall be as required to obtain the required

curvature, and heating shall progress along the top and bottom flange at approximately the same rate.

For the V-type heating, the apex of the truncated triangular area applied to the inside flange surface shall terminate just before the juncture of the web and the flange is reached. To avoid web distortion, special care shall be taken when heating the inside flange surfaces (the surfaces that intersect the web) so that heat is not applied directly to the web. When the radius of curvature is 1,000 ft. (300 m) or more, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend to the juncture of the flange and web. When the radius of curvature is less than 1,000 ft. (300 m), the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend past the web for a distance equal to 1/8 of the flange or 3 in. (75 mm), whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees, but the base of the triangle shall not exceed 10 in. (250 mm). Variations in the patterns prescribed above may be made with the approval of the Engineer.

For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is only mandatory when the flange thickness is 1-1/4 in. (32 mm) or greater, in which case, the two surfaces shall be heated concurrently. The maximum temperature shall be as prescribed below.

(3) Temperature.

The heat-curving operation shall be conducted in such a manner that the temperature of the steel does not exceed 1100° F (600° C) as measured by temperature-indicating crayons or other suitable means. The girder shall not be artificially cooled until after naturally cooling to 600° F (315° C), the method of artificial cooling is subject to the approval of the Engineer.

(4) Position for Heating.

The girder may be heat-curved with the web in either a vertical or a horizontal position. When curved in the vertical position, the girder must be braced or supported in such a manner that the tendency of the girder to deflect laterally during the heat-curving process will not cause the girder to overturn.

When curved in the horizontal position, the girder must be supported near its ends and at intermediate points, if required, to obtain a uniform curvature; the bending stress in the flanges due to the dead weight of the girder and externally applied loads must not exceed the usual allowable design

stress. When the girder is positioned horizontally for heating, intermediate safety catch blocks must be maintained at the mid-length of the girder within 2 in. (50 mm) of the flanges at all times during the heating process to guard against a sudden sag due to plastic flange buckling.

(5) Sequence of Operations.

The girder shall be heat-curved in the fabrication shop before it is painted. The heat curving operation may be conducted either before or after all the required welding of transverse intermediate stiffeners is completed. However, unless provisions are made for girder shrinkage, connection plates and bearing stiffeners shall be located and attached after heat curving. If longitudinal stiffeners are required, they shall be heat-curved or oxygen-cut separately and then welded to the curved girder. When cover plates are to be attached to rolled beams, they may be attached before heat curving if the total thickness of one flange and cover plate is less than 2-1/2 in. (64 mm) and the radius of curvature is greater than 1,000 ft. (300 m). For other rolled beams with cover plates, the beams must be heat-curved before the cover plates are attached; cover plates must be either heat-curved or oxygen-cut separately and then welded to the curved beam.

(6) Camber.

Girders shall be cambered before heat curving. Camber for rolled beams may be obtained by heat-cambering methods approved by the Engineer. For plate girders, the web shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving. However, subject to the approval of the Engineer, moderate deviations from specified camber may be corrected by a carefully supervised application of heat.

(7) Measurement of Curvature and Camber.

Horizontal curvature and vertical camber shall be measured for final acceptance after all welding and heating operations are completed and the flanges have cooled to a uniform temperature. Horizontal curvature shall be checked with the girder in the vertical position.

(f) Finish.

Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting and chipping shall be done carefully and accurately.

602.06-Bolt Holes.

(a) Holes for High Strength Bolts and Unfinished Bolts[**]

All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 in. (1.6 mm) larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than 3/4 in. (19 mm) for structural steel, 5/8 in. (16 mm) for high-strength steel or 1/2 in. (13 mm) for quenched and tempered alloy steel, unless sub-punching and reaming is required under Subsection 602.09.

When there are more than 5 thicknesses, or when any of the main material is thicker than 3/4 in. (19 mm for structural steel, 5/8 in. (16 mm) for high-strength steel or 1/2 in. (13 mm) for quenched and tempered alloy steel, all holes shall either be sub-drilled or drilled full size.

When required under Subsection 602.09, all holes shall be either sub-punched or sub-drilled (sub-drilled if thickness limitation governs) 3/16 in. (5 mm) smaller and, after assembling, reamed 1/16 in. (1.6 mm) larger or drilled full size to 1/16 in. (1.6 mm) larger than the nominal diameter of the bolts.

Only where shown on the design drawings, are enlarged or slotted holes allowed with high-strength bolts 5/8 in. (16 mm) or larger in diameter.

(b) Holes for Ribbed Bolts, Turned Bolts or other Approved Bearing Type Bolts.

All holes for ribbed bolts, turned bolts or other approved bearing-type bolts shall be sub-punched or sub-drilled 3/16 in. (5 mm) smaller than the nominal diameter of the bolt and reamed, assembled or drilled to a steel template or, after assembly, drilled from the solid at the option of the Fabricator. In any case the finished holes shall provide a driving fit as specified on the Plans or in the Special Provisions.

602.07-Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 in. (1.6 mm). If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

602.08-Reamed or Drilled Holes. Reamed or drilled holes shall be cylindrical, perpendicular to the member and shall comply with the requirements of **Subsection 602.06** as to size. Where practicable, reamers shall be directed by mechanical means. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required by the Engineer, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and

[**]See **Subsection 602.16** for bolts included in designation "Unfinished Bolts."

securely held while being reamed or drilled and shall be match marked before disassembling.

602.09-Preparation of Field Connections.

(a) Sub-punching and Reaming of Field Connections.

Unless otherwise specified in the Special Provisions or on the Plans, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames shall be sub-punched (or sub-drilled if sub-drilling is required) according to **Subsection 602.06**) and subsequently reamed while assembled or to a steel template, as required by **Subsection 602.13**. All holes for floor beam and stringer field connections shall be sub-punched and reamed to a steel template or reamed while assembled. Reaming or drilling full size of field connection holes through a steel template shall be done after the template has been located with utmost care as to position and angle and firmly bolted in place. Templates used for reaming matching members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts or members shall be so accurately located that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of sub-punching and reaming or sub-drilling and reaming, the fabricator may, at his option, drill holes full size with all thicknesses of material assembled in proper position.

If additional sub-punching and reaming is required, it shall be specified in the Special Provisions or on the Plans.

(b) Numerically Controlled Drilled Field Connections.

(1) General.

Alternately, for any connection or splice designated in **Subsection 602.09(A)**, in lieu of sub-sized holes and reaming while assembled, the Contractor shall have the option to drill bolt holes full-size in unassembled pieces and/or connections including templates for use with matching sub-sized and reamed holes by means of suitable numerically controlled (N/C) drilling equipment subject to the specific provisions contained in this Subsection.

If N/C drilling equipment is used, the Engineer, unless otherwise stated in the Special Provisions or on the Plans, may require the Contractor, by means of check assemblies to demonstrate that this drilling procedure consistently produces holes and connections meeting the requirements of **Subsections 602.11** and **602.13**. The Contractor shall submit to the Engineer for approval a detailed outline of the procedures that he proposes to follow in accomplishing the work from initial drilling through check assembly, if required, and he shall include the specific members of the structure that may be N/C drilled, the sizes of the holes, the location of

common index and other reference points, composition of check assemblies and all other pertinent information.

(2) Holes.

Holes drilled by N/C drilling equipment shall be drilled to appropriate size either through individual pieces, or any combination of pieces held tightly together.

602.10-Accuracy of Punched and Drilled Holes. All holes punched full size, sub-punched, or sub-drilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin 1/8 in. (3 mm) smaller in diameter than the nominal size of the punched 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 this requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin 3/16 in. (5 mm) smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

602.11-Accuracy of Reamed and Drilled Holes. When holes are reamed or drilled, 85 per cent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 in. (0.8 mm) between adjacent thicknesses of metal. All steel templates shall have hardened steel bushings in holes accurately dimensioned from the center lines of the connection as inscribed on the template. The center lines shall be used in locating accurately the template from the milled or scribed ends of the members.

602.12-Fitting for Bolting. Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformation.

602.13-Shop Assembling. The field connections of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing, and then shall have their sub-size holes reamed to specified size while the connections are assembled. Assembly may be full truss or girder assembly, full chord assembly or progressive truss or girder assembly, progressive chord assembly or special complete structure assembly unless otherwise specified in the Special Provisions or on the Plans.

Check Assemblies with Numerically Controlled Drilled Field Connections shall be in accordance with the Provisions of **Subsection 602.13(**F).

Each assembly, including camber, alignment, accuracy of holes and fit of milled joints, shall be approved by the Engineer before reaming is commenced or before an N/C drilled check assembly is dismantled.

A camber diagram shall be furnished the Engineer by the Fabricator showing the camber at each panel point in the cases of trusses or arch ribs and at the location of field splices and fractions of span length (1/4 points minimum, 1/10 points maximum) in case of continuous beam and girders or rigid frames. When the shop assembly is Full Truss or Girder Assembly or Special Complete Structure Assembly, the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly is used, the camber diagram shall show calculated camber.

(a) Full Truss or Girder Assembly.

Full Truss or Girder Assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder or rigid frame at one time.

(b) Progressive Truss or Girder Assembly.

Progressive Truss or Girder Assembly shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at least three contiguous shop sections or all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices) and not less than 150 ft (45 m) in the case of structures longer than 150 ft. (45 m). At least one shop section or panel or as many panels as are associated with a chord length shall be added at the advancing end of the assembly before any member is removed from the rearward end, so that the assembled portion of the structure is never less than that specified above.

(c) Full Chord Assembly.

Full Chord Assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connections to steel templates set at geometric (not cambered) angular relation to the chord lines.

Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member and the templates at both ends of the member shall be accurately located from one of the milled ends or scribed lines.

(d) Progressive Chord Assembly

Progressive Chord Assembly shall consist of assembling contiguous chord members in the manner specified for Full Chord Assembly and in the number and length specified for Progressive Truss or Girder Assembly.

(e) Special Complete Structure Assembly.

Special Complete Structure Assembly shall consist of assembling the entire structure, including the floor system. (This procedure is ordinarily needed only for complicated structures such as those having curved girders, or extreme skew in combination with severe grade or camber.)

(f) Check Assemblies with Numerically Controlled Drilled Field Connections.

A check assembly shall be required for each major structural type of each project, unless otherwise designated on the Plans or in the Special Provisions, and shall consist of at least three contiguous shop sections or, in a truss, all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices). Check assemblies should be based on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Such special points could be the portals of skewed trusses, etc.

Use of either geometric angles (giving theoretically zero secondary stresses under dead load conditions after erection) or cambered angles (giving theoretically zero secondary stresses under no load conditions) should be designated on the Plans or in the Special Provisions.

The check assemblies shall preferably be the first such sections of each major structural type to be fabricated. No matchmaking and no shop assemblies other than the check assemblies shall be required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required by the Engineer for which there shall be no additional cost to the contracting authority.

602.14-Drifting of Holes. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.

602.15-Match-Marking. Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished the Engineer.

602.16-Bolts and Bolted Connections. The specifications of this Subsection do not pertain to the use of high strength bolts. Bolted connections fabricated with high strength bolts shall conform to **Subsection 602.17.**

(a) General.

Bolts shall be unfinished, turned or ribbed bolts conforming to the requirements for Grade A Bolts of Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners, ASTM A 307. Bolted connections shall be used only as

indicated by the Plans or Special Provisions. Bolts shall have single self-locking nuts or double nuts unless otherwise shown on the Plans or in the Special Provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

(b) Unfinished Bolts.

Unfinished bolts shall be furnished unless other types are specified.

(c) Turned Bolts.

The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed with bolts furnished to provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

(d) Ribbed Bolts.

The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 in. (2 mm) greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads conforming to ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement.

602.17-Connections Using High Strength Bolts.

(A) General.

This Subsection covers the assembly of Structural joints using AASHTO M 164 (ASTM A 325) or AASHTO M253 (ASTM A490) high strength bolts, or equivalent fasteners, tightened to a high tension. The bolts are used in holes conforming to the requirements of **Subsection 602.06, 602.07,** and **602.08**.

(B) Bolts, Nuts and Washers.

Bolts, nuts, and washers shall be pre-tested by TDOT in accordance with **Subsection 908.04.** Bolts used with weathering steel shall be ASTM A 325 Type 3 and all bolts, nuts and washers shall have the same weathering characteristics as the structural steel. Galvanized nuts shall be grade DH. The Contractor shall

supply the Materials and Tests Division with samples of bolts, nuts, and washers used on the project for purposes of testing (3 per shipping lot will be required).

Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, a hardened beveled washer shall be used to compensate for the lack of parallelism.

Hardened beveled washers for American Standard Beams and Channels shall be required and shall be square or rectangular, shall conform to the requirements of AASHTO M 293 (ASTM A 436) and AASHTO M 253 and shall taper in thickness.

When necessary, washers may be clipped on one side from the center of the washer to a point not closer than 7/8 in (22 mm) of the bolt diameter.

Hardened washers are not required for connections using AASHTO M 164(ASTM A 325) and AASHTO M 253 (ASTM A 490) bolts except as follows:

- Hardened washers shall be used under the turned element when tensioning is to be performed by calibrated wench method.
- Irrespective of the tensioning method, hardened washers shall be used under both the head and the nut when AASHTO M 253(ASTM A 490) bolts are to be installed in material laving a specified yield point less than 40 ksi(275,800 kPa). However, when DTI's are used they may replace a hardened washer provided a standard hole is used.
- Where AASHTO M 164 (ASTM A 325) bolts of any diameter or AASHTO M 253 (ASTM A 490) bolts equal to or less than 1 in. (25 mm) in diameter are to be installed in oversize or short-slotted holes in an outer ply, a hardened washer conforming to AASHTO M 293 (ASTM F 436) bolts over 1 in. (25 mm) in diameter are to be installed.
- When AASHTO M 253 (ASTM A 490) bolts over 1 in. (25 mm) in diameter are to be installed in an oversized or short-slotted hole in an outer ply, hardened washer conforming to AASHTO M 293 (ASTM F 436) shall be used.
- When AASHTO M 293 (ASTM A 490) bolts over 1 inch in diameter are to be installed in an oversized or short-slotted hole in an outer ply, hardened washers conforming to AASHTO M 293 (ASTM F 436) except with 5/16 in. (8 mm) minimum thickness shall be used under both the head and the nut in lieu of standard thickness hardened washers. Multiple hardened washers with combined thickness equal to or greater than 5/16 in. (8 mm) do not satisfy this requirement.

- When AASHTO M 164 (ASTM A 325) bolts of any diameter or AASHTO M 253 (ASTM A 490) bolts equal to or less than 1 in. (25 mm) in diameter are to be installed in a long slotted hole in an outer ply, a plate washer or continuous bar of at least 5/16 in. (8 mm) thickness with standard holes shall be provided. The washers or bars shall have a size sufficient to completely cover the slot after installation and shall be of structural grade material, but need not be hardened except as follows. When AASHTO M 253 (ASTM A 490) bolts over 1 inch in diameter are to be used in long slotted holes in external plies, a single hardened washer confirming to AASHTO M 293 (ASTM F 436) but with 5/16 inch minimum thickness shall be used in lieu of washers or bars of structural grade material. Multiple hardened washers with combined thickness equal to or greater than 5/16 in. (8 mm) do not satisfy this requirement.
- Alternate design fasteners meeting the requirements of Article 11.3.2.6 with a geometry which provides a bearing circle on the head or nut with a diameter equal to or greater than the diameter of hardened washers meeting the requirements of AASHTO M 293 (ASTM F 436) satisfy the requirements for washers specified herein and may be used without washers.

(C) Bolted Parts.

The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

When assembled, all joint surfaces, including those adjacent to the bolt head, nuts or washers, shall be free of scale, except tight mill scale, and shall also be free of burrs, dirt, and other foreign material that would prevent solid seating of the parts. Paint is permitted unconditionally in bearing type connections.

Unless otherwise specified on the Plans, all contact surfaces of bolted parts shall be Class B as described in the AASHTO Bridge Specifications identified in the Contract Plans.

(D) Installation.

The following provisions apply in addition to the requirements of Division II, Section 11 of the AASHTO Standard Specifications for Highway Bridges when high strength bolts are installed in the field or shop.

1. Bolts shall be installed in accordance with the construction specifications of the AASHTO Bridge Specifications identified in the plans. During installation, particular care

should be exercised so that the snug tight condition as defined in Article 11.5.6.4 is achieved.

2. The rotational capacity test described in **Subsection 602.17(E)** (1) and (2) shall be performed on each rotational capacity lot prior to the start of bolt installation. Hardened steel washers are required as part of the test.
3. Bolt, nut, and washer combinations as installed shall be from the same rotational capacity lot.
4. Un-galvanized bolts shall be "oily" to the touch when delivered and installed.
5. Weathered or rusted bolts or nuts not satisfying the requirements of paragraph (d)(2) above shall be cleaned and re-lubricated prior to installation. Re-cleaned or re-lubricated bolt, nut, and washer assemblies shall be re-tested in accordance with paragraph (d)(2) above prior to installation.
6. Direct Tension Indicators (DTI's)

    a. Direct Tension Indicators (DTI's) shall be used for each bolt. Direct tension indicators will not be used on weathering steel and therefore all bolts shall be installed by either turn-of-nut tightening or calibrated wrench tightening in accordance with the construction specifications of the AASHTO Bridge Specifications identified in the Contract plans. The load indicator average gap shall be 0.005 in. (125 µm). After the joint has been properly pinned, the joint shall be tightened to approximately 1/2 the specified tension to insure firm contact of all plies, and then the joint shall be final tightened progressing from the center most rigid part to the free edges. Re-tightening may be necessary to restore tension if gaps increase from original measurements.
    b. A tension calibrator, such as a Skidmore Wilhelm, shall be on the project during all bolting operations. The bolt tension versus the average gap of the DTI shall be checked daily by the Engineer to insure correct tension.
    c. The Contractor shall supply the Materials and Tests Division with samples of bolts, nuts, and washers used on the project for purposes of testing (3 per shipping lot will be required).
    d. Bolts, nuts, and washers shall be shipped in sealed containers, labeled with the supplier’s name and lot identification. The containers shall be capable of protecting the bolts from moisture and other contaminants until they are opened at the project site. Damaged containers shall be cause for rejection.
    e. For verification of DTI's performance, see **Subsection 602.17(E)(3).**
    f. Installation of DTI’s shall be by method one of the following three methods unless otherwise approved by the Engineer.

1. Place the DTI under the bolt head and turn the nut to tighten. The protrusions on the DTI shall face the under side of the bolt head. The hardened flat washer shall be placed under the nut and the gap in the DTI reduced to 0.005 in. (125 µm).
2. Place the DTI under the nut and turn the nut to tighten. The hardened flat washer shall be placed between the nut and the DTI. The protrusions on the DTI shall face the under side of the hardened flat washer and nut and the gap in the DTI reduced to 0.005 in. (125 µm). This method is suggested when it is too difficult to see the bolt head for inspection, or when the wrench operator wants to the see the gap.
3. Place the DTI under the bolt head and turn the bolt head to tighten. The hardened flat washer shall be placed between the bolt head and the DTI. The protrusions on the DTI shall face the under side of the hardened flat washer and bolt head and the gap in the DTI reduced to 0.005 in. (125 µm). This method is suggested when it is too difficult to see the nut for inspection, or when the wrench operator wants to the see the gap.

TABLE 602.17A-BOLT TENSION

Bolt Size in inches(mm)	Minimum Bolt Tension (1) in Pounds(kilograms) AASHTO M 164 (ASTM A 325) Bolts	AASHTO M 253 (ASTM A 490) Bolts
1/2(13 mm)	12,000(5,440)	15,000(6,800)
5/8(16 mm)	19,000(8,620)	24,000(10,900)
3/4(19 mm)	28,000(12,700)	35,000(15,900)
7/8(22 mm)	39,000(17,690)	49,000(22,200)
1(25 mm)	51,000(23,130)	64,000(29,000)
1-1/8(28 mm)	56,000(25,400)	80,000(36,300)
1-1/4(32 mm)	71,000(32,200)	102,000(46,300)
1-3/8(35 mm)	85,000(38,500)	121,000(55,000)
1-1/2(38 mm)	103,000(46,700)	148,000(67,000)

(1) Equal to 70% of specified minimum tensile strength of bolts.

(E) Inspection.

The following tests shall be conducted for certification of materials as required in **Subsection 908.04** and prior to installation:

1. Procedure for Performing Rotational Capacity Test on Long Bolts in Tension Calibrator

(a) Equipment Required:

1. Calibrated bolt tension measuring device of size required for bolts to be tested. Mark off a vertical line and lines 1/3 of a turn (120 degrees); and 2/3 of a turn (240 degrees), from vertical in a clockwise direction on the face plate of the calibrator.
2. Calibrated torque wrench.
3. Spacers and/or washers with hole size no larger than 1/16 in. (1.6 mm) greater than bolt to be tested.
4. Steel section to mount bolt calibrator. Flange of girder or cross frame accessible from the ground is satisfactory.

(b) Procedure:

1. Install nut on bolt and measure stick-out of bolt when 3 to 5 full threads of the bolt are located between the bearing face of the nut and the bolt head. Measure

the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.

2. Install the bolt into the tension calibrator and install the required number of shim plates and/or washer (one washer under the nut must always be used) to produce the thread stick-out measured in Step 1.
3. Tighten bolt using a hand wrench to the snug tensions listed below -0 kips, +2 kips.

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Snug Tension (kips)								
1	2	3	4	5	6	7	9	10

4. Match mark the nut to the vertical stripe on the face plate of the bolt calibrator.

5. Using the calibrated manual torque wrench, tighten the bolt to at least the tension listed below and record the torque required to reach the tension and the value of the bolt tension. Torque must be measured with the nut in motion.

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Tension (kips)								
12	19	28	39	51	56	71	85	103

6. Further tighten the bolt to the rotation listed below. The rotation is measured from the initial marking in Step 4. Record the bolt tension. Assemblies which fail prior to this rotation either by stripping or fracture fail the test.

Bolt Length (measured in Step 1)	4 x bolt dia. or less	> 4 but $\leq$ 8 x bolt dia.	> than 8 x bolt dia.
Required Rotation	2/3	1	1-1/3

7. The bolt tension measured in Step 6 after the required rotation must equal or exceed the values in the table shown below. Assemblies which do not meet this tension have failed the test.

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/6
Tension (kips)								
14	22	32	42	59	64	82	98	118

8. Loosen and remove nut and examine the threads on the nut and bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt should be evident. Assemblies which have evidence of stripping have failed the test.
9. Calculate and record the value of 0.25 x the tension (lbs. = kips x 1,000) measured in Step 5 x the bolt diameter in feet. The torque measured and recorded in Step 5 must be equal to or less than this calculated value. Assemblies with torque values exceeding this calculated value failed the test.

2. Procedure for Performing Rotational Capacity Test on Bolts too Short to fit Tension Calibrator

(a) Equipment Required:

1. Calibrated torque wrench and a spud wrench or equivalent.

2. Spacers and/or washers with hole size no larger than 1/16 in. (16 mm) greater than bolt to be tested.

3. Steel section with normal size hole to install bolt. Any available splice hole can be used with a plate thickness that will provide the number of threads under the nut required in Step 1 below. Mark off a vertical line and lines 1/3 of a turn, 120 degrees; 1/2 of a turn, 180 degrees; and 2/3 of a turn, 240 degrees, from vertical in a clockwise direction on the plate.

(b) Procedure:

1. Install nut on bolt and measure stick-out of bolt when 3 to 5 full threads of the bolt are located between the bearing face of the nut and the bolt head. Measure the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.

2. Install the bolt into the hole and install the required number of shim plates and/or washer (one washer under the nut must always be used) to produce the thread stick-out measured in Step 1.

3. Snug the bolt using a hand wrench. The snug condition should be the normal effort applied to a 12 in. (300 mm) long wrench. The applied torque should not exceed 20% of the torque determined in Step 5.

4. Match mark the nut to the vertical stripe on the plate.

5. Tighten the bolt by turning the nut using the torque wrench to the rotation listed below. A second wrench must be used to prevent rotation of the bolt head during tightening. Record the torque required to reach this rotation. Torque must be measured with the nut in motion.

Bolt Length (measured in Step 1)	4 x bolt dia. or less	>4 but $\leq$ 8 x	$\geq$than 8 x bolt dia.
Required Rotation	1/3	1/2	2/3

The measured torque should not exceed the values listed below. Assemblies which exceed the listed torques have failed the test.

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Torque (ft-lbs)								
150	290	500	820	1230	1500	2140	2810	3690

6. Tighten the bolt further to the rotation required below. The rotation is measured from the initial marking in Step 4. Assemblies which fail prior to

this rotation either by stripping or fracture fail the test.

Bolt Length (measured in Step 1)	4 x bolt dia. or less
Required Rotation	2/3

7. Loosen and remove nut and examine thread on the nut and bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt should be evident. Assemblies which have evidence of stripping have failed the test.

3. Procedure for Verification and Installation of High Strength Bolts with Direct Tension Indicators (DTI's)

(a) **Verification of DTI Performance**. When Direct Tension Indicators (DTIs) are to be installed with high strength bolts to indicate bolt tension, they shall be subjected to the verification testing described below and installed in accordance with the method specified below. Unless otherwise approved by the Engineer, the DTIs shall be installed under the head of the bolt and the nut turned to tighten the fastener. The manufacturer's recommendations shall be followed for the proper orientation of the DTI and additional washers, if any, required for the correct use of the DTI.

Verification testing shall be performed in a calibrated bolt tension measuring device. A special flat insert shall be used in place of the normal bolt head holding insert. Three verification tests are required for each combination of fastener rotational-capacity lot, DTI lot and DTI position relative to the turned element (bolt head or nut) to be used on the project. The fastener shall be tightened by turning the element not against the DTI. The element (bolt head or nut) against the DTI shall be prevented from rotating. The purpose of the verification testing is to ensure that the fastener will be at or above the desired installation tension when half or more of the spaces in the DTI have a gap of less than 0.005 in. (125 µm) and that the fastener will not undergo excessive plastic deformation at the minimum gap allowed on the project.

The verification test shall be conducted in two stages. The bolt, nut and DTI assembly shall be installed in a

manner so that at least 3 and preferably not more than 5 threads are located between the bearing face of the nut and the bolt head. The fastener shall be tightened first to the load equal to that listed in the table in (b) below under Verification Tension for the grade and diameter of fastener. If an impact wrench is used, it is acceptable to tighten to a load slightly below the required and subsequently a manual wrench used to attain the required tension. Determine and record the number of refusals of a 0.005 in. (125 µm) tapered feeler gage in the spaces between the protrusions. The number of spaces is listed in the table in (b) below. The number of refusals shall not exceed the number listed under Maximum Verification Refusals in the table in (b) below for the grade and diameter of bolt for un-coated DTIs. The maximum number of refusals for coated DTIs (galvanized, painted or epoxy coated), used under the turned element shall be no more than the number of spaces on the DTI less one. The DTI lot is rejected if the number of refusals exceeds the values in the table or, for coated DTIs if the gage is refused in all spaces.

After the number of refusals is recorded at the verification load, the fastener shall be further tightened until the 0.005 in. (125 µm) feeler gage is refused at all the spaces and a visible gap exists in at least one space. Record the load at this condition and remove the fastener from the tension measuring device. The nut must be able to be reassembled by hand for the complete thread length of the bolt excluding thread run-out. If the nut cannot be assembled for this thread length, the DTI lot is rejected unless the load recorded is less than 95% of the average load measured in the rotational capacity test of the fastener lot as specified in **Subsection 908.04 (c) g**. If the bolt is too short to be tested in the calibration device the DTI shall be tested on a long bolt in a calibrator to determine the number of refusals at the Verification Tension listed in the table in (b) below. The number of refusals shall not exceed the values listed under Maximum Verification Refusals. Another DTI from the same lot shall then be tested with the short bolt in a convenient hole in the work. The fastener assembly shall be tightened until the 0.005 in. (125 µm) feeler gage is refused in all spaces and a visible gap exists in at least 1 space. The fastener shall then be disassembled. Subsequently the nut must be able to be reassembled by hand for the complete thread length of the bolt excluding thread run-out. The DTI lot shall be rejected if the nut cannot be assembled to this thread length.

(b) Installation

Installation of fasteners using DTIs shall be performed in two stages. The fastener element shall be held against rotation during each stage of the installation. First, snug the connection with bolts installed in all the holes of the connection. Then tighten the bolts sufficiently to bring all the plies of the connection into firm contact. The number of spaces in which a 0.005 in. (125 µm) feeler gage is refused in the DTI after snug, shall not exceed those listed under Maximum Verification Refusals in the table below. If the numbers exceed the values in the table, the fastener must be removed and another DTI installed followed by re-snugging of the fastener.

The connection shall be further tightened until the number of refusal of the 0.005 in.(125 µm) feeler gage is equal to or greater than the number listed under Minimum Installation Refusal in the tables below. If the fastener is tightened so that no visible gap in any space remains, the bolt and DTI shall be removed, and replaced by a new properly tightened fastener and DTI.

DTI REQUIREMENTS FOR A325 BOLTS

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Verification Tension (kips)								
13	20	29	41	54	59	75	89	108
Maximum Verification Refusals								
1	1	2	2	2	2	3	3	3
DTI Spaces								
4	4	5	5	6	6	7	7	8
Minimum Installation Refusals								
2	2	3	3	3	3	4	4	4

DTI REQUIREMENTS FOR A490 BOLTS

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Verification Tension (kips)								
16	25	37	51	67	84	107	127	155
Maximum Verification Refusals								
2	2	2	2	3	3	3	3	4
DTI Spaces								
5	5	6	6	7	7	8	8	9
Minimum Installation Refusals								
3	3	3	3	4	4	4	4	5

(c) Equipment Required:

1. Calibrated bolt tension measuring device with a special flat insert in place of normal bolt head holding insert. Special insert required to allow access to measure DTI gap.

2. Tapered leaf thickness (feeler) gage 0.005 in. (125 μm). Same gage as to be used to inspect the bolts after installation.

3. Bolts, nuts, and standard washers to be used in the work with the DTI's.

4. Impact and manual wrench to tighten bolts. Equipment should be the same as to be used in the work.

(d) Verification Test Procedure: (Conduct three tests for each R-C lot and position of DTI)

1. Install bolt, nut, DTI, and standard washer (if used) into bolt tension measuring device. Assembly should match that to be used in the work.

2. Snug the bolt to no more than 50% of the required installation tension using the equipment that will be used in the work. Use another wrench on the bolt

head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element.

3. Further tighten bolt to tension listed below (1.05 times the required installation tension of the bolt). Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element. If an impact wrench is used, tighten to a load slightly below the required load and use a manual wrench to attain the required tension. The load indicating needle of the bolt calibrator cannot be read accurately when an impact wrench is used.

Bolt Tension (kips)

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
M 164 (A 325)								
13	20	29	41	54	59	75	89	108
M 253(A 490)								
na	na	37	51	67	84	107	127	na

4. Determine and record the number of spaces between the each protrusion on the DTI that a 0.005 in. (125 µm) thickness gage is refused. The total number of spaces in the various sizes and grade of DTI's is shown below.

Number of Spaces

Bolt Dia. (in.)								
1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
M 164 (A 325)								
4	4	5	5	6	6	7	7	8
M 253(A 490)								
na	na	6	6	7	7	8	8	na

5. The number of spaces that the 0.005 in. (125 µm) gage is refused should not exceed the number given in the table below. If the number of spaces exceeds the number in the table, the DTI fails the verification test.

Verification Criteria*

Number of spaces in washer	4	5	6	7	8
Maximum number of spaces gage is refused	1	2	2	3	3

*If the test is a coated DTI under the turned element, the maximum number of spaces the gage is refused is the number of spaces on the washer minus one.

6. The bolt should be further tightened to the smallest gap to be allowed in the work. Normally, this smallest gap is defined as the gap at all the spaces less than 0.005 in. (125 µm) and not all gaps completely closed. The 0.005 in. (125 µm) gage is refused at all spaces, but a visible gap exists in at least one space. The bolts in this test and in the actual installation should not be installed to a no visible gap condition. The load in the bolt becomes indeterminant when no gap exists. Failure of the bolt due to over tightening may occur when the bolt is tightened beyond complete crushing of the DTI.
7. Remove the bolt from the calibrator and turn the nut on the threads of the bolt by hand. The nut should be able to be turned on the complete length of the threads, excluding the thread run-out. If the nut is unable to go the full thread length, the load required for the minimum gap in Step 6 is too large. The test must be repeated with a larger minimum gap, for example, one space that will accept a 0.005 in. (125 µm) feeler gage to establish the smallest gap allowed in the work for the fastener rotational capacity lot allowed in the work.
8. Short Bolts - Bolts from R-C lots too short to fit in the tension measuring device shall be tested by tightening to the minimum gap in Step 6 and checked in accordance with Step 7. The DTI used with the short bolt should be checked in accordance with Steps 1 through 5 using a longer bolt in the tension measuring device.

602.18-Plate Cut Edges.

(a) Edge Planing.

Sheared edges of plate more than 5/8 in. (16 mm) in thickness and carrying calculated stress shall be planed to a depth of 1/4 in. (6 mm). Re-entrant corners shall be filleted to a minimum radius of 3/4 in. (19 mm) before cutting.

(b) Visual Inspection and Repair of Plate Cut Edges.

Visual inspection and repair of plate cut edges shall be in accordance with Article 3.2.3 of the AASHTO/AWS "Bridge Welding Code," D1.5, current edition..

602.19-Welds. All work shall be done in accordance with the AASHTO/AWS "Bridge Welding Code," D1.5, current edition. Where conflicts occur, these Specifications shall govern.

All full penetration welds in webs and flanges shall be ground flush.

The following are revisions to the AASHTO/AWS Bridge Welding Code:

Add the following sentence to Article 6.1.1.1:

After fabrication, Quality Control (QC) shall mark each piece (girders, beams, diaphragms, X-frames, bearings, etc.) with the fabricators logo and the CWI Number of the QC Inspector accepting the piece. These stamps will signify that Quality Control (QC) has inspected the piece and that it meets the requirements of the plans and specifications.

Delete Article 6.1.3.1(3).

Delete Article 6.1.3.2.

Delete the last sentence in Article 6.1.3.4 and substitute the following:

Only individuals qualified for NDT Level II may perform nondestructive testing.

Delete the period at the end of Article 6.6.1 and add the following:

and access to all records necessary to verify conformance to plans and specifications.

Delete Article 6.7.1 and substitute the following:

Complete penetration groove welds in main members, as identified in the contract documents shall be QC tested by nondestructive testing.

Radiographic and ultrasonic testing shall both be performed in accordance with the requirements of Section 6.7.1.2:

Delete the first sentence on Article 6.7.1.2 and substitute the following:

Radiographic and ultrasonic testing of welds shall be performed in accordance with the following requirements:

Add the following Article 6.17.5:

Each Ultrasonic Unit shall be certified for general operational performance at a minimum time interval of 12 months with a method approved by the instrument manufacturer.

602.20-Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the ANSI surface roughness requirements as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part I:

Steel Slabs	ANSI	2,000
Heavy plates in contact in shoes to be welded	ANSI	1,000
Milled ends of compression members, milled or round ends of stiffeners and fillers	ANSI	500
Bridge rollers and rockers	ANSI	250
Pins and pin holes	ANSI	125
Sliding bearings	ANSI	125

602.21-Abutting Joints. Abutting joints in compression members and girder flanges, and in tension members where so specified on the drawings, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/4 in. (6 mm).

602.22-End Connection Angles. Floor-beams, stringers and girders having end connection angles shall be built to exact length shown on the Plans measured between the heels of the connection angles, with a permissible tolerance of plus 0 in. (0 mm) to minus 1/16 in. (1.6 mm). Where continuity is to be required, end connections shall be faced. The thickness of the connection angles shall not be less than 3/8 in. (10 mm) or less than that shown on the detail drawings, after facing.

602.23-Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

602.24-Fabrication of Members. Unless otherwise shown on the Plans, steel plates for main members and splice plates for flanges and main tension members, not secondary members, shall be cut and fabricated so that the

primary direction of rolling is parallel to the direction of the main tensile and/or compressive stresses.

Fabricated members shall be true to line and free from twists, bends and open joints.

602.25-Web Plates. In built-up girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than 1/8 in. (3 mm) below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be 1/2 in. (13 mm) less in width than the distance back to back of flange angles. Splices of webs in girders without cover plates shall be sealed on top with silicone caulk prior to painting.

At web splices, the clearance between the ends of the web plates shall not exceed 3/8 in. (10 mm). The clearance at the top and bottom ends of the web splice plates shall not exceed 3/4 in. (19 mm).

602.26-Bent Plates. Un-welded, cold bent, load carrying, rolled steel plates shall conform to the following:

(a) They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic deck bridges may be bent in the direction of rolling if permitted by the Engineer.

(b) Bending shall be such that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in the following table:

THICKNESS IN INCHES (MILLIMETERS)

	Up to 13 (0.5)	Over 13 to 25 (0.5 to 1.0)	Over 25 to 38 (1.0 to 1.5)	Over 38 to 64 (1.5 to 2.5)	Over 64 to 100 (2.5 to) 4)
All grades of structural steel in this specification	2 t	2.5 t	3 t	3.5 t	4 t

Note: Low alloy steel in thickness over ½ in. (13 mm), may require hot bending for small radii.

Allowance for spring-back of ASTM A 709 Grade HPS 100W steels should be about 3 times that for structural carbon steel. For break press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1200°F (649° C), except for ASTM A 709 Grade HPS 100W steels. If ASTM A 709 Grade HPS 100W steel plates to be bent are heated to a temperature greater than 1125° F (607° C), they must be re-quenched and tempered in accordance with the producing mill's practice. Hot bent plates shall conform to requirement (a) above.

(c) Before bending, the corners of the plate shall be rounded to a radius of 1/16 in. (1.6 mm) throughout the portion of the plate at which the bending is to occur.

602.27-Fit of Stiffeners. End stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing (either milled, ground or, on weldable steel in compression areas of flanges, welded as shown on the Plans or specified) on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless shown or specified otherwise, fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 in.(6 mm) at each end.

602.28-Eyebars. Pin holes may be flame cut at least 2 in. (50 mm) smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together in the order that they will be placed on the pin and bored at both ends while so clamped. Eyebars shall be packed and match marked for shipment and erection. All identifying marks shall be stamped with steel stencils on the edge of one head of each member after fabrication is completed so as to be visible when the bars are nested in place on the structure. The eyebars shall be straight and free from twists and the pin holes shall be accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/16 in.(5 mm) to a ft.(m).

The edges of eyebars that lie between the transverse centerline of their pin holes shall be cut simultaneously with 2 mechanically operated torches abreast of each other, guided by a substantial template, in such a manner as to prevent distortion of the plates.

602.29-Annealing and Stress Relieving. Structural members which are indicated in the contract to be annealed or normalized shall have finished machining, boring and straightening done subsequent to heat treatment. Normalizing and annealing (full annealing) shall be as specified in ASTM E 44. The temperatures shall be maintained uniformly throughout the furnace during the heating and cooling so that the temperature at no two points on the member will differ by more than 100° F(56° C) at any one time.

Members of ASTM A709 Grade HPS 100W steels shall not be annealed or normalized and shall be stress relieved only with the approval of the Engineer.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instruments including recording pyrometers, shall be provided for determining at any time the temperatures of members in the furnace. The records of the treatment operation shall be available to and meet the approval of the Engineer. The holding temperature for stress relieving ASTM A709 Grade HPS 100W steels shall not exceed 1100° F (600° C).

Members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together shall be stress relieved in accordance

with the procedure of paragraph 3.9 of AWS D 1.1 when required by the Plans, Specifications or Special Provisions governing the Contract.

602.30-Pins and Rollers. Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than 9 in. (225 mm) in diameter shall be forged and annealed. Pins and rollers 9 in. (225 mm) or less in diameter may be either forged and annealed or cold-finished carbon steel shafting.

In pins larger than 9 in.(225 mm) in diameter, a hole not less than 2 in.(50 mm) in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling, and before being annealed.

602.31-Boring Pin Holes. Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The distance outside to outside of end holes in tension members and inside to inside of end holes in compression members shall not vary from that specified more than 1/32 in. (0.8 mm).

602.32-Pin Clearances. The diameter of the pin hole shall not exceed that of the pin by more than 1/50 in.(0.5 mm) for pins 5 in. (125 mm) or less in diameter or by 1/32 in. (0.8 mm) for larger pins.

602.33-Threads for Bolts and Pins. Threads for all bolts and pins for structural steel construction shall conform to the Unified Standard Series UNC-ANSI B 1.1, Class 2 A for external threads and Class 2 B for internal threads, except that pin ends having a diameter of 1-3/8 in. (35 mm) or more shall be threaded 6 threads to the in..

602.34-Pilot and Driving Nuts. Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

602.35-Identification of Steels During Fabrication.

(a) Identification by Contractor.

The Engineer shall be furnished with complete certified mill test reports showing chemical analysis and physical tests for each heat of steel for all members unless excepted by the Engineer. Each piece of steel to be fabricated shall be properly identified for the Engineer.

Shop drawings shall specifically identify each piece that is to be made of steel which is to be other than ASTM A709 Grade 36 steel. Pieces made of different grades of steel shall not be given the same assembling or erecting mark, even though they are of identical dimensions and detail.

The Contractor's system of assembly marking individual pieces, required to be made of steel other than ASTM A709 Grade 36 steel, and the issuance of cutting instructions to the shop (generally by cross-referencing of the assembly marks shown on the shop drawings with the corresponding item covered on the mill purchase order) shall be such as to maintain identity of the mill test report number.

The Contractor may furnish from stock, material that he can identify by heat number and mill test report.

Any excess material placed in stock for later use shall be marked with the mill test report number and shall be marked with its AASHTO M 160 (ASTM A 6) specification identification color code (see Table 602.35) if any, when separated from the full-size piece furnished by the supplier.

(b) Identification of Steels During Fabrication.

During fabrication, up to the point of assembling members, each piece of steel, other than ASTM A709 Grade 36 steel, shall show clearly and legibly its specification identification color code shown in Table 602.35.

Individually marked pieces of steel which 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, may be used without further color coding provided that the heat number or color code remains legible.

Pieces of steel, other than ASTM A709 Grade 36 steel, which are to be cut to smaller size pieces shall, before cutting, be legibly marked with the AASHTO M 160 (ASTM A 6) specification identification color code.

Individual pieces of steel, other than ASTM A709 Grade 36 steel, which are furnished in tagged lifts or bundles shall be marked with the AASHTO M 160 (ASTM A 6) specification identification color code immediately upon being removed from the bundle or lift.

Pieces of steel, other than ASTM A709 Grade 36 steel, which prior to assembling into members, will be subject to fabricating operations such as blast cleaning, galvanizing, heating for forming, or painting which might obliterate paint color code marking, shall be marked for grade by steel die stamping or by a substantial tag firmly attached.

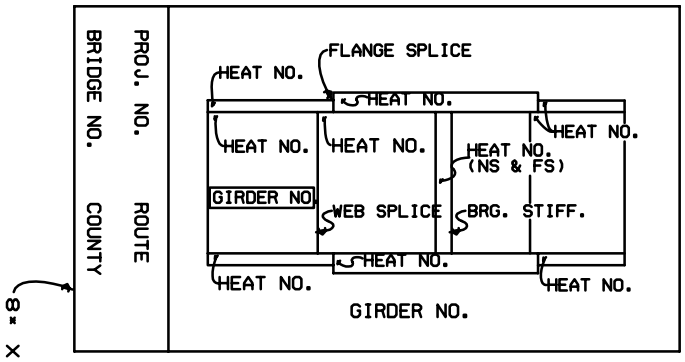
(c) Certification of Identification.

Upon request, the Contractor shall furnish an affidavit certifying that throughout the fabrication operation he has maintained the identification of steel in accordance with this specification.

602.36-Weighing of Members. In case it is specified that any part of the material is to be paid for by actual weight, finished work shall be weighed in the presence of the Inspector, if practicable. In such case, the Contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various parts.

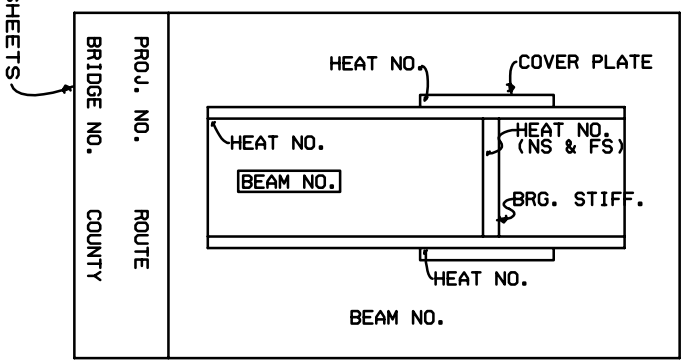
602.37-Full Size Tests. When full size tests of fabricated structural members or eye-bars are required by the Contract, the Plans or Specifications shall state the number and nature of the tests, the results to be attained and the measurements of strength, deformation or other performance that are to be made. The Contractor shall provide suitable facilities, material, supervision and labor necessary for making and recording the tests. The members tested in accordance with the contract shall he paid for in accordance with Subsection 602.50. The cost of testing, including equipment, handling, supervision, labor and incidentals for making the tests shall be included in the contract price for the fabrication or fabrication and erection of structural steel, whichever is the applicable item in the Contract, unless otherwise specified.

602.38-Marking and Shipping. Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished with erection marks shown thereon. Heat numbers shall be permanently stenciled on the main material so they will be identifiable in the field. The steel fabricator shall submit three sketches identifying these heat numbers on 8-1/2 x 11 in. (215 x 280 mm) sheets to the Inspecting Agency and to the Engineer.



EXAMPLE WELDED GIRDER

8" X 11 SHEETS



EXAMPLE ROLLED BEAM

In addition to the heat number shown, the fabricator shall identify all high strength steels regardless of where it is used.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements and erection diagrams as the Engineer may direct. The weights of the individual members shall be shown on the statements. Members weighing more than 3 metric ton (tons) shall have the weights marked thereon. Structural members shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed or otherwise damaged.

Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts and packages of bolts, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 135 kilograms (300 pounds). A list and description of the contained material shall be plainly marked on the outside of each shipping container.

CONSTRUCTION REQUIREMENTS-ERECTION

602.39-Erection. The Contractor shall provide the false-work and all tools, machinery, and appliances, including drift-pins and fitting-up bolts, necessary for the expeditious handling of the work, and shall erect the metalwork, remove the temporary construction, and do all work necessary to complete the structure as required by the Contract and in accordance with the Plans and these Specifications. If shown on the Plans or in the Special Provisions, the Contractor shall dismantle the old structure on the bridge site.

602.40-Handling and Storing Materials. Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the Contract is for erection only, the Contractor shall check the material turned over to him against the shipping lists and report promptly in writing any shortage or injury discovered. He shall be responsible for the loss of any material in his care, or for any damage caused to it after being received by him.

602.41-Falsework. The false-work shall be properly designed and substantially constructed and maintained to support the loads to which it will be subjected. The Contractor, if required, shall prepare and submit to the Engineer construction drawings for false-work, and working drawings for changes in any existing structure necessary for maintaining traffic, in accordance with Subsection 105.02, Working Drawings.

602.42-Method and Equipment. All contractors and subcontractors directly engaged in the erection of Structural Steel, precast prestressed or mild steel reinforced concrete bridge beams or girders over active highway traffic lanes, on any route, railroad or any stream deemed navigable to commercial or pleasure water craft, shall be required to submit an erection plan prepared by a Tennessee registered engineer. This plan shall include the following: the sequence of erection, the generalized location of all pick points and the contractor's plan to adequately stabilize the structure throughout the erection process. This plan shall be submitted to the Engineer at least 30 days prior to erection starting. At each stopping point in the erection sequence, a competent contractor‘s representative will inspect the beams to insure adequate stability.

No work shall be done until such approval by the Engineer has been obtained. The approval of the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in accordance with the Plans and Specifications.

602.43-Straightening Bent Material and Cambering.

(a) Straightening Bent Material.

The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, except that heat straightening of ASTM A 709 Grade HPS 100W or ASTM A 517 steel members shall be done only under rigidly controlled procedures, each application subject to the approval of the Engineer. In no case shall the maximum temperature of the ASTM A 709 Grade HPS 100W or ASTM A 517 steels exceed 1100° F (600° C), nor shall the temperature exceed 950° F (510° C) at the weld metal or within 6 in.(150 mm) of weld metal. Heat shall not be applied directly on weld metal. In all other steels, the temperature of the heated area shall not exceed 1200° F (649° C) (a dull red) as controlled by temperature indicating crayons, liquids, or bimetal thermometers.

Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture. Fractured material will be rejected.

(b) Cambering

Correction of errors in camber in welded beams and girders of ASTM A 709 Grade HPS 100W material shall be done only under rigidly controlled procedures, each application subject to approval of the Engineer.

602.44-Misfits. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Inspector and his approval of the method of correction obtained. The correction shall be made in his presence. The Contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.

602.45-Assembling. The parts shall be accurately assembled as shown on the working drawings and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members will not be permitted. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully connected with permanent fasteners

and all other truss connections pinned and erection bolted. Splices of butt joints of compression members and railing shall not be permanently fastened until the span has been swung. Splices and field connections shall have one-half of the holes filled with erection bolts and cylindrical erection pins (half erection bolts and half pins) before placing permanent fasteners. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the permanent fasteners and cylindrical erection pins shall be 1/32 in.(0.8 mm) larger.

602.46-Pin Connections. Pilot and driving nuts shall be used in driving pins. They shall be furnished by the Contractor without charge. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed tight and the threads burred at the face of the nut with a pointed tool.

602.47-Setting Shoes and Bearings. Shoes and bearing plates shall not be placed on bridge seat bearing areas that are improperly finished, deformed, or irregular. They shall be set level in exact position and shall have full and even bearing. Unless otherwise specified, the shoes and bearing plates may be set by any of the following methods:

(a) Sheet Lead of 1/8 in.(3 mm) Thickness.

(b) A preformed fabric pad composed of multiple layers of 8 ounce(225 gram) duck impregnated and bound with high quality natural rubber or of equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be such as to produce a thickness of 1/8 in.(3 mm) after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 psi (69 MPa) without detrimental reduction in thickness or extension.

(c) Elastomeric Bearing Pads.

(d) Grouted Bearing Plate.

No load shall be placed on them until the grout has set for at least 96 hours, adequate provisions being made to keep the grout well moistened during this period. The grout shall consist of one part Portland cement to one part of mortar sand.

Unless otherwise indicated on the plans or conditionally approved by the Engineer, all anchor bolts shall be cast into the masonry. The bolts shall be set accurately, and fixed by completely filling the holes with grout meeting the requirements of Subsection 918.21. The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of erection. The nuts on anchor bolts at the

expansion ends of spans shall be adjusted to permit the free movement of the span.

602.48-Painting. Unless otherwise specified on the Plans or in the Contract, shop and field painting shall be in accordance with the requirements of Section 603, Painting. Special attention is directed to Subsection 603.06, Schedule of Painting.

Rollers, when not painted, shall be greased with hard grease that will readily adhere to the metal in cold and hot weather. The ends of rollers shall be painted with the same kind and type of paint as the rest of the structure.

COMPENSATION

602.49-Method of Measurement. Metal in a structure will be measured for payment by the unit, lump sum, when the item is designated "Steel Structures" and by the pound (kilogram) when the item is designated "Structural Steel." The weight for "Structural Steel" will be computed on the following bases:

(a) Unit Weights, lbs per Cu. Ft.(kgs per m^3).

Materials	**Lbs. per Cu. Ft. (Kgs. per Cubic Meter)**
Aluminum, cast or wrought	173.0 (2771)
Bronze	536.0 (8586)
Copper-Alloy	536.0 (8586)
Copper-Sheet	558.0 (8938)
Iron, cast	445.0 (7128)
Iron, malleable	470.0 (7529)
Iron, wrought	487.0 (7801)
Lead, sheet	707.0 (11325)
Steel, rolled, cast, copper bearing, silicon, nickel and stainless	490.0 (7849)
Zinc	450.0 (7208)

(b) Shapes and Plates.

The weight of rolled shapes, and of plates up to and including 36 in.(900 mm) in width, will be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawing, deducting for cuts, and open holes.

The weights of plates wider than 36 in.(900 mm) will be computed on the basis of their dimensions as shown on the approved shop drawings, deducting for cuts and holes. To this will be added one-half of the "Permissible Variation in Thickness and Weight," as tabulated in ASTM Designation A 6, "General Requirements for Delivery of Rolled Steel Plates, Shapes and Bars for Structural Use."

(c) Castings.

The weight of castings will be computed from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight will be added 5 per cent allowance for fillets and overrun. Scale weights may be substituted for computed weights of castings or of small complex parts for which accurate computations of weight would be difficult.

(d) High Strength Bolts.

The weight of heads, nuts, single washers and threaded stick-through of all high tensile strength shop bolts shall be included on the basis of the following weights:

Diameter of Bolt Inches	**Weight per 100 bolts, pounds**
1/2	19.7
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1-1/8	165.1
1-1/4	212.0
1-3/8	280.0
1-1/2	340.0

(e) Welds.

The weight of shop and field fillet welds will be based on the following:

Size of Weld, Inches	**Pounds per Linear Foot**
1/4	0.20
5/16	0.25
3/8	0.35
1/2	0.55
5/8	0.80
3/4	1.10
7/8	1.50
1	2.00

(f) Shear Connectors.

The weights of shapes for shear connectors will be computed on the basis of their nominal weights per ft. (m) as shown on the approved shop drawings.

The weights of spirals for shear connectors will be computed on the basis of the weights per ft.(m) as shown on the approved shop drawings.

The weight of stud bar shear connectors will be based on the following:

Weight of Stud Bars in Pounds

Meter of Shank	Weight per Inch of Shank	Weight of Head
3/4 in.	0.125	0.174
7/8 in.	0.170	0.210
1 in.	0.223	0.250

(g) Miscellaneous.

The weight of temporary erection bolts, shop and field paint, boxes, crates, and other containers used for shipping, and materials used for supporting members during transportation and erection, will not be included.

(h) Other Items.

The quantities of other contract items that enter into the completed and accepted structure will be measured for payment in the manner prescribed for the items involved.

602.50-Basis of Payment. Payment will be made on a unit price per pound (kilogram) or on a lump sum basis, as required by the terms of the Contract. No payment will be made for materials used in standard tests, unless otherwise indicated on the Plans or in the Special Provisions.

Full size fabricated structural members or eye-bars which are tested in accordance with the Specifications, when such tests are indicated on the Plans or in the Special Provisions, will be paid for at the same rate as for comparable members in the structure. Members that fail to meet the contract requirements and members that are rejected as the result of tests, will not be paid for.

The cost of drilling anchor bolt holes, shall be included in the various pay items of the Contract and no further payment will be made therefor.

(a) Structural Steel-- Pound (Per Kilogram).

Under Contracts containing an item for Structural Steel, all metal parts, other than metal reinforcement for concrete and metal piling, such as anchor bolts and nuts, shoes, rockers, rollers, bearing and slab plates, pins and nuts, expansion dams, weld metal, bolts embedded in concrete, cradles and brackets, etc. shall be considered as structural steel, unless otherwise stipulated. All structural steel will be paid for at the contract unit price per pound (kilogram) for Structural Steel, complete in place and accepted.

(b) Steel Structures--Lump Sum.

When the bid schedule calls for a lump sum price for Steel Structures, the item will be paid for at the contract lump sum price, complete in place and accepted.

The estimate of the weight for steel structures shown on the Plans is approximate only, and no guarantee is made that it is the correct weight to be furnished. No adjustment in the contract price will be made if the weight furnished is more or less than the estimated weight.

If changes in the work are ordered by the Engineer, which vary the weight of steel to be furnished, the lump sum payment will be adjusted as follows:

The value per pound (kilogram) of the increase or decrease in the weight of structural steel involved in the change will be determined by dividing the contract lump sum amount by the weight of steel in the original structure(s). The adjusted contract lump sum payment will be the contract lump sum amount, plus or minus the value of the steel so determined involved in the change, and no additional compensation will be made on account of said change.

SECTION 603-PAINTING

SECTION 603-PAINTING

603.01-Description. This work shall consist of preparing the surface, applying the paint, furnishing protection from paint spatter and disfigurement, and final cleanup, all in conformity with these Specifications. The type, color, and number of coats of paint shall be as designated in **Subsection 603.06** and as shown on the plans.

All contractors or subcontractors involved in field surface preparation or coating application shall be certified according to the Society for Protective Coatings(SSPC) Contractors Certification Program(PCCP).

Contractors or subcontractors performing field coating application shall be certified according to SSPC-QP1 – Field Painting.

Contractors and subcontractors performing field surface preparation of existing structures shall be certified according to SSPC-QP2 – Field Removal of Hazardous Coatings.

All contractors and subcontractors that perform field surface preparation or field coating application shall be certified to the requirements of SSPC-QP1 or QP2 as stated above prior to contract award, and shall remain certified while accomplishing any surface preparation or coating application. The painting contractors and painting subcontractors must remain so certified for the duration of the project. If a contractor's or subcontractor's certification expires or is suspended, the contractor shall not be allowed to perform any work until the certification is reissued or reinstated. Requests for extension of time for any delay in the completion of the project due to an inactive certification, will not be considered and liquidated damages may apply. The contractor shall supply a copy of their certification to the Engineer before beginning work and shall notify the Engineer of any change in certification status.

MATERIALS

603.02-Materials. Materials shall conform to the requirements of Section 910. All paint or paints unless otherwise stipulated shall be manufactured and prepared to comply with the applicable specifications including those included by reference.

EQUIPMENT

603.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on hand and approved before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

603.04-Clearing and Removing Obstructions. Trees, limbs, bushes, grass, and other items that will damage or prevent satisfactory painting shall be cut or cleared away. All obstructions or other items that will prevent the proper application of paint shall be removed and replaced as directed. Care shall be exercised in removing the obstructions so as not to damage their

usefulness when replaced. Any items damaged by the Contractor shall be replaced at the Contractor's expense.

603.05-Preparation of Surfaces.

(1) New Structures

All surfaces of metal shall be prepared to a condition equivalent to SSPC-SP10 (Near White Blast Clean). All surfaces shall be free of oil, dirt, dust or any other contaminant that will affect the adherence of the paint, whether the paint is applied in the shop or the field.

The fabricated steel shall be prepared to have a surface profile of 1. mils(25 µm) minimum and 2.5 mils(64 µm) maximum prior to application of the shop coat. The surface profile obtained on the prepared surface will be verified using ASTM D 4417, Method A, B or C.

(2) Existing Structures

Surfaces of metal to be painted shall be prepared by the method or combination of methods designated on the Plans, in accordance with these specifications. All surfaces to be painted shall be thoroughly cleaned to remove all loose and flaking existing coatings, chalking, rust, loose mill scale, oil or grease and other foreign substances.

Unless otherwise specified, any of the following methods may be used to clean the metal:

(a) Hand or Power Tool Cleaning.

Rust, scale, and dirt shall be thoroughly removed by approved methods of hand cleaning, power tools, or any combination of these methods. Hand cleaning may include the use of metal brushes, scrapers, chisels, hammers, or other effective means. Power tools may include wire brushes, impact tools, grinders, sanders, or any approved combination of these methods. Bristle or wood fiber brushes shall be used for removing loose dust. Oil and grease shall be removed by means of solvent cleaning in accordance with SSPC-SP1. Solvents shall be safe and biodegradable.

(b) Blast Cleaning.

Any of the following blast cleaning methods may be used:

Dry abrasive blasting, using compressed air blast nozzles and dry abrasive;

Wet or water vapor abrasive blasting, using compressed air blast nozzles and water and abrasive;

Grit blasting, using compressed air blast nozzles and grit made of crushed cast iron, malleable iron, steel, or other metals;

Shot-blasting, using centrifugal wheels and cast iron and malleable iron, or steel pellets.

Other approved methods.

The surface, if dry blasted, shall be brushed with clean brushes made of hair, bristle, or fiber, or blown off with compressed air (from which detrimental oil and water have been removed), or cleaned by vacuum, for the purpose of removing any traces of blast products from the surface, and also for the removal of abrasive from pockets and corners.

The surface, if wet abrasive blasted, shall be cleaned by rinsing with fresh water to which sufficient corrosion inhibitor has been added to prevent rusting, or with fresh water followed immediately by an inhibitive treatment. This cleansing shall be supplemented by brushing if necessary, to remove any residue.

The compressed air used for nozzle blasting shall be free of detrimental amounts of water or oil. Adequate separators and traps shall be provided.

Blast cleaning operations shall be done in such a manner that no damage is done to partially or entirely completed portions of the work.

The blast-cleaned surface shall be examined for any traces of oil, grease, or smudges deposited in the cleaning operations. If present, they shall be removed by an approved method. The cleaning shall be approved by the Engineer prior to painting.

The appearance of the surface after blast cleaning shall correspond with the pictorial standards A SP-10, B SP-10, C SP-10 or D SP-10 of SSPC-VIS 1-89 (The Society for Protective Coatings Visual Standard for Abrasive Blast Cleaned Steel).

(c) Water Washing.

A high pressure water wash shall remove all chalk, loose coatings and other contaminants. High pressure water wash is defined as using pressure from 3,000 to 4,000 psi (20.7 to 27.6 MPa) at 8 to 10 gallons (30 to 38 liters) per minute.

603.06-Schedule of Painting.

(a) New Structures

Unless otherwise indicated, all structural steel and other exposed metal shall be painted by the following paint systems:

SYSTEM A-INORGANIC ZINC

Paint System	Specification	Min. Dry Film Thickness	Max. Dry Film Thickness
1. Primer (shop coat)	Inorganic Zinc Silicate Paint, Subsection 910.03	2.5 mils (65 µm)	5.0 mils (125µm)
2. Intermediate Tie Coat	Subsection 910.03 As modified below	2.0 mils (50 µm)	5.0 mils (125µm)
3. Finish Coat (color coat)	Urethane Finish, Subsection 910.03 (color shall match color specified on the Plans)	2.0 mils (50 µm)	5.0 mils (125µm)

Only the primer shall be applied in the fabrication shop. The intermediate tie coat and finish coat shall be field applied. To insure compatibility between coats, all paint applied primer, intermediate tie coat and finish coat) shall be supplied by the same manufacturer.

(b) Existing Structures

All metal surfaces of existing structures shall be painted with one of the following systems or System A specified above, unless otherwise noted on the plans. To insure compatibility between coats, all paint applied (spot primer, primer and finish coat) shall be supplied by the same manufacturer.

SYSTEM B

Paint System	Specification	Min. Dry Film Thickness	Max. Dry Film Thickness
1. Spot Primer	Epoxy Mastic*	2.0 mils (50 µm)	5.0 mils (125µm)
2. Primer	Epoxy Mastic*	3.0 mils (75 µm)	5.0 mils (125µm)
3. Finish Coat (color coat)	Urethane Finish, **Subsection 910.03** (color shall match color specified on the Plans)	2.0 mils (50 µm)	5.0 mils (125µm)

SYSTEM C

Paint System	Specification	Min. Dry Film Thickness	Max. Dry Film Thickness
1. Spot Primer	Universal*	2.0 mils (50 µm)	5.0 mils (125µm)
2. Primer	Universal*	3.0 mils (75 µm)	5.0 mils (125µm)
3. Finish Coat (color coat)	Urethane Finish, **Subsection 910.03** (color shall match color specified on the Plans)	2.0 mils (50 µm)	5.0 mils (125µm)

603.07-Weather Conditions. Paint shall not be applied when the either the ambient or steel surface temperature exceeds 38° C(100° F) or is below 40° F (4° C), unless otherwise approved by the Engineer in writing. Paint shall not be applied to steel which is at a temperature that will cause blistering or porosity, or otherwise be detrimental to the life of the paint. Paint shall not be applied when the relative humidity exceeds 85 percent. Paint shall not be applied during rain, snow, fog or misty conditions or when the steel surface temperature is less than 5° F(3° C) above the dew point.

*Material to be on Qualified Products List maintained by the Division of Materials and Tests

603.08-Storing of Paint. When paint is allowed to remain in storage for a considerable length of time, the containers shall be turned end for end at least once a week. Paint that has been in storage longer than six months shall be re-inspected prior to approval for use.

603.09-Mixing Paint. Paint shall be thoroughly mixed before applying and the pigments shall be kept in uniform suspension during application. Mixing shall be by mechanical methods, except that hand mixing will be permitted for containers less than 5 gal.(18.9 liters) in size. When special paint is specified, it shall be mixed according to the manufacturer's recommendation.

603.10-Application of Paint.

(a) General.

The manufacturer's current printed instructions for applying the paint system specified shall be submitted to the Engineer for approval. The instructions, as approved shall be followed by the Contractor unless otherwise directed by the Engineer.

Paint shall be applied by brushing, spraying or a combination of these methods. Daubers or sheepskins may be used when no other method is practicable for proper application in places' of difficult access. Dipping, roller coating, or flow coating shall be used only when specifically authorized.

To the maximum extent practical, each coat of paint shall be applied as a continuous film of uniform thickness free of pores. Any thin spots or areas missed in the application shall be repainted and permitted to dry before the next coat of paint is applied.

Each coat of paint shall be in a proper state of cure or dryness before the application of the succeeding coat.

(b) Spray Application.

Spray application of paint, whether air spray, airless spray, hot air spray or hot airless spray, shall be in accordance with the following:

The equipment used shall be suitable for the intended purpose, shall be capable of properly atomizing the paint to be applied, and shall be equipped with suitable pressure regulators and gages. The equipment shall be maintained in proper working condition. Spray equipment shall be kept clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film. Any solvents left in the equipment shall be completely removed before using.

Air Spray - The air caps, nozzles and needles shall be those recommended by the manufacturers of the material being sprayed and the equipment being used.

Traps or separators shall be provided to remove oil and condensed water from the air. The traps or separators shall be of adequate size and shall be drained periodically during

operations. The air from the spray gun impinging against a clean surface shall show no sign of condensed water or oil. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to properly atomize the paint, but not so high as to cause excessive fogging of paint, excessive evaporation of solvent or loss by over-spray.

Airless Spray - Fluid tips shall be of proper orifice and fan angle, and the fluid control gun of proper construction, as recommended by the manufacturer of the material being sprayed and the equipment being used. Fluid tips shall be of the safety type with shields.

The air pressure to the paint pump shall be adjusted so that the paint pressure to the gun is proper for optimum spraying effectiveness. This pressure shall be sufficiently high to properly atomize the paint. Pressures considerably higher than are necessary to properly atomize the paint should not be used.

Spraying equipment shall be kept clean and shall utilize proper filters in the high pressure line so that dirt, dry paint, and other foreign materials are not deposited in the paint film. Any solvent left in the equipment shall be completely removed before applying paint.

Airless paint spray equipment shall always be provided with an electric ground wire in the high-pressure line between the gun and the pumping equipment. Further, the pumping equipment shall be suitably grounded to avoid the build-up of any electrostatic charge on the gun.

(c) Brush Application.

Brushes shall be of a style and quality that will enable proper application of paint. Round or oval brushes are generally considered most suitable for bolts, irregular surfaces and rough or pitted steel. Wide, flat brushes are suitable for large flat areas, but they should not have a width over 5 in.(125 mm). Length of the bristles should be equal to or exceed the brush width.

The brushing shall be done so that a smooth coat, as nearly uniform in thickness as possible, is obtained. Brushing of subsequent coats should be in a direction perpendicular to that of the previous coat. Typically brushed coats are thinner than sprayed coats and additional brushed coats may be needed to achieve the proper film thickness. Paint shall be worked into all crevices and corners. Surfaces not accessible to brushes shall be painted by spray, daubers or sheepskins. All runs or sags shall be brushed out.

(d) Roller Application.

Roller application may be used on flat or slightly curved surfaces and shall be in accordance with the recommendations of the paint manufacturer and roller manufacturer. Paint rollers shall be of a style and quality that will enable proper application of paint having the continuity and thickness required in Section 6.7 and 6.8 of SSPC-PA 1.

Roller application should not be used on irregular surfaces such as bolts, crevices, welds, corners or edges, unless otherwise specified. When permitted, however, the paint applied by roller on these irregular surfaces shall be subsequently brushed out to form a continuos and unbroken film.

603.11-Shop Painting. Unless otherwise specified, steelwork shall be given one coat of primer paint after it has been accepted by the inspector and before it is shipped from the plant. The shop coat of paint shall have a dry film thickness as specified under **Subsection 603.06** for the paint system being supplied.

Surfaces not in contact, but inaccessible after assembly shall be painted with three coats of shop paint. The shop contact surfaces and field contact surfaces within friction type joints shall be free of oil, paint, lacquer, galvanizing, or rust inhibitor. Other field contact surfaces shall receive a shop coat of paint, except main splices for chords of trusses and large girder splices involving multiple thicknesses of material where a shop coat of paint would make erection difficult.

Structural steel that is to be welded shall not be painted before welding is complete. If it is to be welded only in the fabricating shop and subsequently erected by bolting, it shall receive one coat of paint after shop welding is finished. Unless a zinc primer is used, steel shall not be shop painted in the area where field welding will be performed.

Machine finished surfaces for sliding contact shall be coated as soon as practicable after being accepted and before removal from the shop, with an approved lubricant.

Erection marks for the field identification of members and weight marks shall be painted upon surface areas previously painted with the shop coat. Material shall not be loaded for shipment until it is thoroughly dry, and in any case, not less than 24 hours after the paint has been applied.

Bolted faying surfaces shall be designed for a Class B surface. The Contractor shall insure the faying surfaces are prepared to provide a slip coefficient at least equal to that required for a Class B surface. The Contractor shall provide a certification that the paint used will provide the required resistance at the proposed thickness.

Painted steel shall not be moved or handled until sufficient cure time has elapsed to ensure no damage is done to the fresh coating. The steel shall be insulated from the binding chains by softeners approved by the Engineer. Hooks and slings used to hoist steel shall be padded. Diaphragms and similar pieces shall be spaced in such a way that no rubbing will occur during shipment that may damage the coatings. The steel shall be stored on pallets at the job site, or by other means approved by the Engineer, so that it does no rest on the dirt or so that components do not fall or rest on each other.

603.12-Field Painting. The intermediate coat and finish coat for steel structures shall be field applied, after erection is complete, except as noted in **Subsection 603.11**. Before painting operations begin the Contractor shall: (1) obtain the Engineers approval of a containment system designed to prevent release of drippings and/or over-spray into the environment and (2) develop a contingency plan for cleanup of any inadvertent spills of paint as indicated below:

The Contractor shall submit a copy of the contingency plan to the Engineer, together with a list of the equipment and personnel that will carry out the plan.

Before beginning painting, the Contractor shall have on the job site, and approved, the personnel, equipment and material necessary to contain both spillage and over-spray. The following items, as a minimum, shall be kept at the project site: (1) 55 gal.(200 liter) drum of sand, (2) Biodegradable cleaners and degreasers and (3) Boom skimmer collector and boat with motor for over water work.

The Contractor shall limit and contain over-spray by following prudent application procedures in accordance with the specifications, taking into account the ambient climatic conditions. Drop-cloths, screens, etc. shall be used to prevent contamination of the soil, adjacent properties or any streams or ponded surface water.

The Contractor shall immediately clean up any spill or over-spray and concurrently report the occurrence to the Tennessee Department of Environment and Conservation (TDEC) and the Engineer. Also, the Tennessee Emergency management Agency (TEMA) will be notified where deemed appropriate.

A copy of the Contractor's contingency plan, including emergency phone numbers, shall be prominently displayed at the job site.

Each field coat of paint shall have a dry film thickness as specified under **Subsection 603.06** for the paint system being applied. Where measurement of the dry film thickness may become difficult or dangerous, wet film measurement may be authorized. In such cases, the Engineer will predetermine and notify the Contractor of the required wet film thickness, for each type of paint, to comply with the dry film thickness specified.

Areas of each coat which have dry film thickness over the maximum specified or which have runs and sags, shall be sanded to remove the excessive thickness. Areas of the finish coat shall be touched up after sanding to provide a uniform appearance.

Metal that has been shop coated shall be touched up with the same type of paint as the shop coat. This touch-up shall include cleaning and painting of field connections, welds, and all damaged or defective paint and rusted areas. The Contractor may, at his option, apply an overall coat of primer in place of touch-up or spot painting.

Surfaces(other than contact surfaces) which are accessible before erection, but which will not be accessible after erection, shall receive all field coats of paint before erection. Only shop primer shall be applied to surfaces that will be in contact with concrete.

If concreting or other operations damage any paint, the surface shall be cleaned and repainted. All cement or concrete spatter and drippings shall be removed before any paint is applied.

When traffic produces an objectionable amount of dust, the Contractor shall, at his own expense, allay the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before the paint is applied.

603.13-Repainting of Existing Steel Structures. All metal surfaces to be repainted shall be cleaned and prepared in accordance with **Subsection 603.05(b)**, unless otherwise specified, and repainted with the paint system shown on the plans. Application of paint shall be as specified above. Unless otherwise specified on the Plans, the following special precautions must be taken in the removal, containment and disposal of the surface preparation waste and paint removal media.

a. General

Prior to commencing any surface preparation, the Contractor shall take soil and water samples at the bridge site. The samples shall be analyzed by EPA Test Method 1311, Toxicity Characteristic Leaching Procedure (TCLP), to determine existing metal and organic content.

All waste debris shall be contained in an enclosed system utilizing air moving equipment capable of creating a negative pressure inside the enclosure to prevent release of any debris or dust into the environment, with the following exception: equipment capable of creating a negative pressure will not be required when surface preparation is performed using high pressure water or when paint removal is confined to localized surface areas such as bearings, beam ends, etc. and where removal of the paint is accomplished by a containment means, approved by the Engineer, that precludes the release of removal waste into the environment. Surface preparation shall not be performed when weather conditions, as determined by the Engineer, preclude effective containment of all waste debris and dust.

When a high pressure water wash is specified, the Contractor shall perform a preliminary wash test on a representative area 50 s.f.(5 m^2) of the structural steel which to be cleaned and painted, in order to collect a minimum of two samples of used wash water. The samples shall be taken in the presence of a TDOT representative and analyzed for metal and organic content using the TCLP test method. If samples do not exceed threshold values for a characteristic waste, containment shall consist of screens and/or water permeable tarps. These screens or tarps shall be placed around the work area in a manner to contain all paint chips or other solid wastes generated by the water wash operations. If samples exceed threshold values for a characteristic waste, containment shall utilize water impermeable material capable of containing all waste including the wash water.

The Contractor shall be responsible for obtaining all permits required for performance of the work, with copies supplied to the Engineer prior to commencement of the work.

b. Containment

Prior to commencing surface preparation at each bridge, the Contractor shall submit the design drawings of the containment system for surface preparations to the Engineer for review. The submittal shall include:

1. An analysis of the load that will be added to the existing structure by the containment system and waste materials. The load analysis shall assure that the system will not induce a load on the bridge that will create an overstress condition nor otherwise affect the structural integrity of the bridge. The analysis shall be prepared and sealed by a Civil Engineer licensed by the State of Tennessee. The containment system or equipment shall not encroach upon the minimum bridge clearances shown on the plans, unless otherwise approved by the Engineer.

   The review and acceptance of the load analysis by the Engineer shall in no way relieve the Contractor of any responsibility for structural safety of the containment system.

2. A work phase diagram describing how the debris shall be contained and collected during surface preparation operations, including material specifications for containment structures (frame, supports, enclosure sheeting, etc.) and type of blast media. The containment system must be properly maintained while work is in progress and shall not deviate from the approved working drawings without prior approval of the Engineer. Public access to all rigging, scaffolding and containment systems must be denied at all times.

3. The Contractor shall submit, for review, a contingency plan for environmental cleanup of a containment system failure or spill which releases surface preparation debris into the environment. A copy of the contingency plan and all materials and equipment required to implement the cleanup shall be maintained at the job site at all times during surface preparation and containment operations.

   In the event of a containment system failure or spill, the Contractor shall immediately notify the Tennessee Department of Environment and Conservation (TDEC). The Contractor shall also suspend all operations except those attendant to implementation of the contingency plan for cleanup. Surface preparation operations shall not resume until modifications have been made to correct the cause of failure or spill.

4. The location and type of temporary storage area for contaminated debris pending its final disposition.

c. Storage and Disposal

All waste collected in the containment system shall be placed in approved containers and hauled daily, or as directed, to the storage area which must be secure from spillage and migration of the waste into the environment. The containers shall be tagged with the bridge number, contract number, Contractor's name, contents and the date noted thereon. The storage area must provide protection from vandalism and unauthorized access by the general public and shall be approved by the Engineer.

The Contractor shall collect a representative, composite sample for each 10 c.y.(m^3), or portion thereof, of all waste as it is generated. All samples shall be analyzed, by an approved independent testing laboratory retained by the Contractor, for metals and organic content using Method 1311 Toxicity Characteristic Leaching Procedure (TCLP) as specified in Appendix 2 of 40 CFR 261.

The TCLP test report for each composite sample shall show the percentage of the toxic metals and their respective threshold values. Waste not exceeding the threshold for a characteristic waste may be disposed of as an industrial waste in any landfill permitted to handle this material. All waste that exceeds the threshold for a characteristic waste shall be handled as a hazardous waste. The Contractor shall be responsible for complying with all hazardous waste rules and regulations of the EPA and the Tennessee Department of Environment and Conservation (TDEC).

No waste, that is determined to be hazardous, shall be stored at the temporary site more than 90 days after the date of generation. All hazardous waste must be transported by a permitted transporter and must be disposed of in an authorized hazardous waste facility. As the co-generator of the waste, the Contractor shall sign any manifest and other required documents.

A copy of all test reports, transportation manifests and confirmation of disposal shall be supplied to the Engineer by the Contractor prior to acceptance of the project.

d. Worker and Public Safety

All personnel involved in the generation and handling of the waste shall be trained in accordance with EPA/Occupational Safety and Health Administration (OSHA) directives. Also, the Contractor shall comply fully with 29 CFR 1926.62 for worker and public safety protection. The Contractor shall furnish adequate respiratory protection and protective clothing to all exposed workers, including Department employees when their inspection duties subject them to exposure. The protection provided shall meet OSHA requirements.

The Contractor shall contain all waste generated by surface preparation so as to not cause a hazard to the public.

After metal surfaces have been cleaned and prepared, existing steel structures shall be painted in accordance with **Subsection 603.06** or as otherwise specified.

603.14-Protection of Traffic. The Contractor shall take every precaution to protect the environment and the traveling public, both vehicular and pedestrian, from injury or damage during the progress of painting. These precautions may include, but are not limited to erecting suitable coverings, protective screens, warning signs and barricades. The Contractor will be directly and solely responsible for any injury and/or damage incurred and hereby agrees to hold the Department and its employees harmless therefrom.

603.15-Protection of Structures and Surfaces. The Contractor shall take every precaution to protect all portions of the structure against disfigurement by splatter, splashes, smirches, etc., of paint or paint materials. Any surface, or surfaces, damaged by splatter, splashes, smirches, etc., shall be thoroughly cleaned and restored to the original condition at the Contractor's expense.

603.16-Final Cleanup. Final cleanup shall be performed in accordance with the requirements of **Subsection 104.11** of these Specifications.

COMPENSATION

603.17-Method of Measurement. Unless otherwise indicated, Painting Steel Structures will not be measured and paid for as a separate item but will be included in the price bid for structural steel.

When the Contract provides for payment for Painting Steel Structures on a lump sum basis, measurement for payment for painting a structure or structures, as indicated on the Plans, will be considered as one unit.

Repainting Existing Steel Structures will be measured for payment on a lump sum basis for each unit. The repainting of a structure or structures as indicated on the Plans will be considered as one unit.

The Containment and Disposal of Waste will be measured for payment on a lump sum basis for each unit. The containment and disposal of surface preparation wastes for a structure or structures as indicated on the Plans will be considered one unit.

When the Proposal does not include pay items for containment and disposal of waste, such work shall be performed and the cost thereof shall be included in the prices bid for other items of construction.

603.18-Basis of Payment. Unless otherwise indicated, Painting Steel Structures will not be paid for directly, but will be considered a necessary and incidental part of the work, and the costs thereof shall be included in the unit price bid for other items of work.

When the Contract specifies payment for Painting Steel Structures, payment will be made at the Contract unit price(Lump Sum) for each unit measured as specified above, for Painting Steel Structures, complete in place, which payment shall be full compensation for preparing the surface

and furnishing and applying the paint all in accordance with these Specifications.

Repainting Existing Steel Structures, measured as specified above, will be paid for at the contract unit price(Lump Sum) for each unit, complete in place, which payment shall be full compensation for obtaining all permits, all surface preparation including removal of paint and furnishing and applying the paint, all in accordance with these Specifications.

Containment and Disposal of Waste as specified above, will be paid for at the Contract unit price(Lump Sum) for each unit, complete in place, which payment shall be full compensation for obtaining all permits, all fees and costs thereof, containment of surface preparation waste, furnishing containers and placing waste therein, testing, transporting and disposal of all surface preparation waste, all in accordance with these specifications.

Any fines incurred by the State as a result of the Contractor's operation shall be deducted from monies due to the Contractor.

SECTION 604-CONCRETE STRUCTURES

SECTION 604-CONCRETE STRUCTURES

604.01-Description. This work shall consist of the construction of all structures or parts of structures composed of Portland cement concrete, whether plain, reinforced, or a combination of both. Concrete structures shall be constructed of Class A Concrete, unless otherwise specified. They shall be constructed on prepared foundations, at the locations indicated or directed, in reasonably close conformity to the dimensions, lines and grades shown on the Plans or as directed by the Engineer, and in accordance with these Specifications.

The concrete used in this construction shall be composed of a mixture or mixtures of Portland cement, aggregates, air-entraining agents, water, and chemical additives when approved, combined by the methods herein stipulated and in the proportions specified for the particular class of concrete designated.

Parts of a structure, or structures, indicated to be constructed with materials other than Portland cement concrete and concrete reinforcement steel, shall be constructed in accordance with the provisions set out in the Section of these Specifications covering the particular type of construction.

MATERIALS

604.02-Materials. Materials used in this construction shall meet the requirements of the following sections or Subsections of Division III, Materials, of these Specifications.

Material	Section or Subsection
Water	**918.01**
Portland cement[1]	**901.01**
Fine Aggregate, (all Classes of concrete)	**903.01**
Coarse Aggregate	
For Class A Concrete: Size No. 57	**903.03**
For Class D Concrete: Size No. 57	**903.03**
For Class P Concrete: Size No. 57 or 67	**903.03**
For Class L Concrete	**903.19**
Fly Ash	**918.31**
Ground Granulated Blast Furnace Slag	**918.32**
Cement Concrete Curing Materials	**913**
Air-Entraining Admixtures	**918.09**
Steel Bar Reinforcement	**907.01**
Welded Steel Wire Fabric	**907.03**
Waterstops	**918.11**

[1]Type I, Type I-SM or Type I cement with either fly ash and/or ground granulated blast furnace slag as a partial cement replacement shall be used unless otherwise specified or permitted. When Type I cement with either fly ash and/or ground granulated blast furnace slag as a partial cement replacement is used, the requirements of **Subsection 604.03** shall apply.

Joint Filler, Preformed Type	**905.01**
Structural Steel	**908.01**
Applied Texture Finish	**918.30**
Steel Castings	**908.05**
Elastomeric Bearing Pads	**908.12**
Bronze Bearing Plates, Plain	**908.09**
Bronze Bearing Plates, Self-Lubricating	**908.10**
Paints	**910**
Chemical Additives for Concrete[1]	**918.09**
Gray Iron Castings	**908.07**
Permanent Steel Bridge Deck Forms	**908.03**
Precast Prestressed Bridge Deck Panels	**918.29**
Precast Concrete Box Culverts	**914.08**

Fly ash or ground granulated blast furnace slag of different classes or sources used as a partial replacement for Portland cement in concrete mixes will not be permitted. Fly ash or ground granulated blast furnace slag shall only be permitted as a partial cement replacement in Type I Portland cement.

Both fly ash and ground granulated blast furnace slag may be used as a partial cement replacement on the same project as specified in **Subsection 604.03**. When Type I-SM cement is used on a project, neither fly ash nor ground granulated blast furnace slag, as partial cement replacement will be permitted.

Portland cement concrete with fly ash as a partial cement replacement shall not be produced until the concrete supplier furnishes the following information to the Engineer:

1. Copies of the results of all tests performed by the fly ash producer within the previous 30 days, on shipments to the concrete supplier showing:
   Fineness (percent retained on the No. 325(45μm) sieve)
   LOI (loss on ignition)
   Specific gravity
   Soundness (autoclave expansion)
   Moisture content
   Pozzuolanic activity, 7 day cement

2. A notarized certification from the fly ash producer stating that the fly ash meets the Departments specifications.

Portland cement concrete with ground granulated blast furnace slag as a partial cement replacement shall not be produced until the concrete supplier furnishes the following information to the Engineer:

[1] The use of chemical additives will be permitted only when approved by the Department and the proportions are fixed by the Engineer. No reduction in the normal cement content of the concrete mix will he made when the use of chemical additives is permitted.

1. Copies of the results of all tests performed by the ground granulated blast furnace slag producer within the previous 30 days on shipments to the concrete supplier showing:

   Fineness (percent retained on the No. 325(45μm) sieve.
   Air content of slag mortar
   Individual sample slag activity index (percent)
   Average of last five consecutive samples slag activity index (percent)
   Specific gravity
   Sulfide sulfur(s) (percent)
   Sulfate ion reported as SO_3 (percent)
   Total alkalies ($Na_2O+0.658K_2O$)
   Compressive strength (28 day)

2. A notarized certification from the ground granulated blast furnace slag producer stating that the slag meets the Departments specifications.

Unless otherwise indicated on the plans, the Contractor may substitute precast reinforced box sections meeting the requirements of AASHTO M-1433 for all fill heights for cast in place concrete box sections. The Contractor is only required to notify the project engineer and the Division of Structures that he intends to utilize sections fabricated to the appropriate AASHTO Materials Specifications or the other pre-approved sections contained in the Division of Structures Standard Drawings for Precast Boxes. Should he elect to construct precast boxes of a different design, the Contractor shall submit shop drawings of the proposed precast box section and design calculations to the Structures Division for approval prior to construction. As a minimum, the shop drawings shall include a plan and elevation view of the box culvert showing all precast sections, a typical precast box section showing dimensions and reinforcing, and notes and details required for construction. After securing the necessary approval, the Contractor shall furnish the Structures Division a permanent, 100 μm(4 mil) mylar reproducible of the design for their file. The Contractor will be paid for the precast box based on the price bid for the quantity of the items in the cast in place structure it replaces. The precast reinforced box sections shall be manufactured in accordance with Departmental procedures

604.03-Classification, Proportioning and Quality Assurance of Concrete.

(a) Classification and Proportioning and Quality Assurance

Min. 28 Day Comp.Strength PSI (MPa)	Min. kg (lbs.) Cement per C.Y. (C.M..)	Maximum Water/Cem. lb/lb (kg/kg)	Air Content % (Design± production tolerance)	Slump in. (mm)
	CLASS A CONCRETE			
3,000 (20.7)	564 (335)	0.45	6 ± 2	3 ± 1[1] (75 ± 25)
	CLASS D CONCRETE[2&3]			
4,000 (27.6)	620 (368)	0.40	6[3]	8 max.[4] (200 max.)
	CLASS L CONCRETE[5&3]			
4,000 (27.6)	620 (368)	0.40	6[3]	8 max.[4] (200 max.)
	CLASS S (SEAL) CONCRETE[6]			
3,000 (20.7)	682 (405)	0.47	6 ± 2	6±1 (150 ± 50)

The proportioning of the concrete shall be based on a predetermined minimum cement content, and the water-cement ratio shall not exceed the maximum shown in the above table. Below this limit, the quantity of water shall be adjusted to meet the slump requirements. The fine aggregate shall not exceed 44% by volume calculation of the total aggregate.

[1] For slip forming, the slump shall range from 0 to 3 inches.
[2] Class D concrete shall be used in all bridge decks except box and slab type structures unless otherwise noted on the plans.
[3] Class D and Class L concrete shall be designed at 6% air content, acceptance range for pumping is 6.0-8.5%, acceptance range for other placement methods is 5.0-8.5%. Sampling will be at the truck chute.
[4] The slump before the addition of the HRWRA shall be 3 in. max.
[5] The unit weight of air dried Class L Concrete (lightweight concrete) shall not exceed 115 lbs./c.f (185 kgs/0.1 m^2) as determined by ASTM C 567.
[6] The Use of Fly Ash as a cement replacement will be allowed in Class S (Seal) concrete.

Chemical Admixtures shall be included in the concrete mixture as specified in the following table based on the ambient air temperature and expected weather conditions.

Class of Concrete	Temperature less than 85°F (30°C) and falling	Temperature 85°F (30°C) or greater and rising
A	Type A or F	Type D or G or A and B
D	Type F	Type F and B or G
L	Type F	Type F and B or G
S	Type D or G or A and B	Type D or G or A and B

If a Type F or G high range water reducer is used, then the allowable slump shall be maximum of 8 in. (200 mm), but the mixture shall not have a slump greater than 3 in. (75 mm) before the high range admixture is added.

Admixtures to be incorporated into the concrete shall all be from the same manufacturer, shall be compatible, and shall be incorporated into the concrete in accordance with the manufacturer's recommendations.

The fine aggregate in all Class L Concrete shall be natural sand conforming to the requirements of **Subsection 903.01**.

Fine aggregate manufactured from limestone or other polishing aggregates will not be permitted in concrete to be used as a riding surface in traffic lanes.

The Contractor shall submit the proposed concrete design to the Engineer for approval. The design shall be determined using saturated surface dry aggregate weights and shall be determined by the use of trial batches meeting the requirements of these specifications. The concrete design shall be prepared by a TDOT certified Class 3 concrete technician or approved independent testing laboratory under the direction of a registered civil Engineer licensed by the STATE OF TENNESSEE. The concrete plant technician or the civil Engineer shall certify that the information contained on the design is correct and is the result of information gained from the trial batches. The concrete design shall produce an average compressive strength to indicate that the specified 28 day strength can be obtained in the field. All strength determinations shall be made on equipment meeting the requirements of and in the manner prescribed by AASHTO T 22. Trial batches for design shall be built no more than 90 days prior to the design submittal. All cost of concrete design, preparation and submittal shall be the responsibility of the Contractor.

The proposed concrete design submittal shall contain as a minimum, the following:

Source of all aggregates
Brand and type of cement
Source and class of fly ash (if used)
Source and grade of ground granulated blast furnace slag (if used)
Specific gravity of cement
Specific gravity of the fly ash (if used)
Specific gravity of the ground granulated blast furnace slag (if used)
Admixtures (if used)
Gradations of aggregates
Specific gravity of aggregates (saturated surface dry)
Air content (if air entrainment is used)
Percentage of fine aggregate of the total aggregate (by volume)
Slump
Weight per c.y.(m^3)
Yield
Temperature of plastic concrete
Water/cement ratio lb/lb (kg/kg)
14 day compressive strength (minimum of 3-6 in.x 12 in.(150 mm x 300 mm) cylinders
28 day compressive strength (minimum of 3x-6 in.x 12 in. (150mm x 300mm) cylinders
Weight of each material required to produce a c.y.(m^3) of concrete

In lieu of the above mix design submittal, the Contractor may submit for approval an existing design approved by the Department within the current calendar year. The approval of this concrete design submittal will not relieve the Contractor of the responsibility of providing concrete meeting the requirements of these specifications. A temporary mix design may be issued if the 7 day compressive strengths exceed the required 28 day strengths.

If materials from sources other than those shown on the approved concrete design are to be used, the Contractor must submit and obtain approval of a concrete design showing these sources. No concrete shall be placed with materials that are not shown on an approved concrete design.

In addition to the option to use Type I-SM cement, the contractor may have the option to replace a portion of Type I cement in Portland cement concrete, up to a maximum specified herein, with fly ash and/or ground granulated blast furnace slag. It is the Contractors responsibility, if he chooses to use fly ash and/or ground granulated blast furnace slag as a partial cement replacement, to provide Portland cement concrete of the design strengths specified in all applicable special provisions, on the plans, or in the standard specifications. Type I-SM cement or Type I cement with fly ash or ground granulated blast furnace slag as a partial cement replacement will not be used in concrete when high early strength is specified. When the Contractor elects to replace a portion of Type I cement with fly ash or ground granulated blast furnace slag, the following

requirements must be verified prior to producing any Portland cement concrete:

1. Fly ash or ground granulated blast furnace slag shall be stored in silos separate from each other and separate from the Type I cement.
2. The fly ash or ground granulated blast furnace slag is to be added to the concrete by methods and equipment approved by the Engineer, capable of uniformly distributing the materials throughout the mix.
3. The fly ash or ground granulated blast furnace slag may be weighed cumulatively in the weigh hopper with the cement, provided the cement is added first. The temperature of the fly ash or the ground granulated blast furnace slag is not to exceed 160° F(71° C) at the time of introduction to the mix.

Design of Portland cement concrete with Type I cement modified by the addition of fly ash and/or ground granulated blast furnace slag. The following table indicates that maximum cement replacement rates(by weight) and minimum substitution ratios(by weight) for the type of modifier specified:

Modifier	**Cement Replacement Rate**(Maximum)% (by weight)	**Minimum Modifier Cement Substitution Rates** (by weight)
Ground Granulated Blast Furnace Slag (grade 100 or 120)	35.0	1:1
Class F Fly Ash	20.0	1:1
Class C Fly Ash	25.0	1:1

Ternary cementitious mixtures (mixtures with Portland cement, ggbfs, and fly ash) will be allowed for Class A Concrete provided that the minimum Portland cement content is 50%. The maximum amount of fly ash substitution in a ternary blend will be 20%. Substitution rates will be at a 1:1 ratio.

The Contractor shall submit a mix design with fly ash or ground granulated blast furnace slag as a partial replacement for Type I Portland cement in Portland cement concrete for the Department's review and approval together with the following information, as a minimum, furnished by an approved independent testing laboratory:

1. Certified results of compressive strength test at ages 7, 14 and 28 days conducted in accordance with ASTM C 39.
2. Test for slump, entrained air content unit weight and yield conducted in accordance with C-138, C-143, C-173 and C-231 as applicable.

Any request for a change in source of materials or admixtures from the original mix design must be made in writing to the Regional Materials and Tests Engineer explaining the necessity for the change and must be accompanied by a new mix design in accordance with the above provisions. No concrete will be allowed to be placed until the new design is approved.

(b) Quality Control and Acceptance of Concrete

It shall be the responsibility of the Contractor to determine and measure the batch quantities of all ingredients (including all water and any specified or approved admixtures) for all concrete produced for the project and to mix, deliver and place the concrete so that the concrete meets the requirements of these specifications. The minimum size of a batch shall be 2.5 c.y. (2.0 m^3). The Contractor shall have a TDOT Class 2 or higher certified technician at the concrete plant during all batching operations with the primary responsibility of process control, which includes all sampling, testing and inspection of the aggregate and concrete.

The Contractor shall have a TDOT or ACI certified Class 1 or higher technician for all sampling, testing and inspection for process control of the concrete at the placement site. A technician shall be present at each placement site during all concrete placement. The technician at both the plant and job site shall be authorized to promptly correct any deficiencies in quality control within approved design parameters. All necessary equipment required for process control shall be furnished by the Contractor and shall be at the plant and at the placement site at all times during concrete and placement.

Process control shall include, but not be limited to, the following test and inspections:

1. Test to determine aggregate gradations (AASHTO T 27 with AASHTO T 11 when required).
2. Frequent inspections of the stockpile to ascertain that stockpiles are being maintained in an uncontaminated and un-segregated manner. A current aggregate quality report shall be kept at the plant.
3. Calibration of weighing systems, water meters and admixture dispensing systems prior to starting production.
4. Assurance of accurate weighing of the aggregates and cement, the proper metering of water and admixtures and the quality of water.
5. Assurance that mixing equipment is in proper working condition and the proper mixing speeds and revolutions are controlled as required by the specifications and the Materials and Tests Circular Letter File book.
6. Adjustment of mix proportions due to moisture content of both coarse and fine aggregates (moisture determination to be in accordance with AASHTO T 255).
7. Slump (AASHTO T 119) and Air Test (AASHTO T 152 - AASHTO T 196 required for concrete containing light weight aggregate).

8. Yield test (AASHTO T 121) (When yield varies more than ±2% from that shown on the design. All batching operations shall cease until the problem has been identified and corrected or a new concrete design has been obtained.
9. All cylinders, including 28 day acceptance test cylinders, for compression tests in accordance with AASHTO T 22, except those required for independent assurance sampling and testing.
10. Tests for concrete and ambient air temperatures.
11. A report furnished daily to the Engineer showing all pertinent information (Date, Contract and Project, Item number(s), batch weights, moisture corrections, admixtures, slump, air content, temperatures, etc.). A sample daily report will be given to the Contractor as an example.
12. A concrete delivery ticket must accompany each load to the placement site. The ticket shall at a minimum include the following:

    Date
    Contract number
    County
    Class of concrete
    Concrete design number
    Number of cubic yards
    Load number
    Truck number
    Maximum water allowed by design
    Total water added at the plant
    Maximum water allowed to be added on the project
    Actual water added on project
    Number of revolutions at mixing speed at plant
    Number of revolutions at mixing speed at project
    Time loaded
    Time discharged
    Actual and target batch weights of each component including each aggregate, chemical admixture and cementitious material used.

The Contractor shall develop for approval of the Engineer and maintain at the plant written procedures for sampling, testing and inspection of the concrete. The Contractor shall keep a record of all tests and inspections performed at the plant site and placement site and this documentation, together with a certification by the Contractor that the concrete incorporated in the work meets the requirements of the specifications, shall be delivered to the Engineer upon completion of the project for inclusion in the project records. Records shall be kept current and shall be made available to the Engineer for review at any time.

It shall be the responsibility of the Contractor to properly make, cure and transport all 28 day acceptance cylinders in accordance with AASHTO T 23 to the Central Laboratory in Nashville for testing. However, the Department will furnish transportation for the cylinders to the Central

Laboratory if the Contractor requests, providing the Contractor delivers the cylinders to the Regional Laboratory or other designated pickup sites established by the Regional Materials Engineer. All early break cylinders (7-14 day, etc.) must be delivered to the Regional laboratory or other established satellite laboratories for tests.

All quality control sampling and testing and acceptance sampling and testing performed by the Contractor, shall be monitored by a Department technician. All independent assurance sampling and testing shall be performed by the Department. All sampling and testing for acceptance and independent assurance results shall be at the frequencies established in TDOT Procedures. The time and location for obtaining all acceptance and assurance samples will be determined by the Department.

An approved concrete design is required for non-critical items involving small quantities of concrete but these non-critical items may be accepted at a reduced testing frequency in accordance with TDOT Procedures. This is to be used for sidewalks, curbs and gutters, building foundations, slope paving, ditch paving, guardrail anchorages, small culvert headwalls 30 in. (750 mm) diameter or less, fence posts, catch basins, manhole bases and inlets, small sign bases and steel strain pole footings.

A qualified plant technician shall be at the ready-mix plant during all batching operations. A field technician is not required to be at the placement site during all small quantity placing operations but is required to perform one complete set of tests during the life of the project. A delivery ticket must accompany each load delivered to the job site.

Pre-approved, pre-packaged concrete mixtures may be used for the applications listed above provided the quantity does not exceed 2 c.y.(1.5 m^3) per day. No design will be required.

Batch weights shall be corrected to compensate for any surface moisture on the aggregate at the time of use. The Contractor may elect to withhold some of the water from the mix at the plant. If a portion of the water is withheld at the plant, additional water may be added at the work site provided the design water/cement ratio of the mix is not exceeded. When the addition of water to the mix is made in the field, 30 additional revolutions at mixing speed are required.

(c) <u>High Early Strength</u>

When high early strength concrete is required, in the plans for structural or pavement repairs, or other type work, the use of Type I or Type III cement will be optional with the Contractor. If Type I cement is used, a minimum cement content of 714 lbs/c.y. (424 kgs/m^3) will be required. If Type III cement is used, a minimum cement content of 620 lbs./c.y.(368 kgs/m^3) will be required. High early strength concrete, meeting these requirements, may be substituted at the option of the Contractor for Class A or Class P concrete when approved in writing by the Engineer.

When the Contractor elects to use high early strength concrete, the source and gradation of fine and coarse aggregates shall be the same as that specified for the concrete for which the high early strength concrete is substituted. No additional compensation will be made if the Contractor

elects to substitute high early strength concrete for Class A or Class P concrete. The unit price for the class of concrete for which the substitution is made shall be full compensation for the concrete.

Any request for a change in source of materials or admixtures from the original mix design must be made in writing to the Regional Materials and Tests Engineer explaining the necessity for the change and must be accompanied by a new mix design in accordance with the above provisions. The Contractor shall place no concrete until the new design is approved.

EQUIPMENT

604.04-Equipment. Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. Equipment shall be on hand sufficiently ahead of the start of construction operations to be examined and approved. The equipment and construction processes shall be of sufficient capacity to accomplish the maximum continuous concrete placement, as governed by the construction joints shown on the Plans or as directed by the Engineer.

The requirements for batching plants shall be as prescribed in **Subsection 501.04**, paragraph (a), except that when approved by the Engineer, the requirement for storage compartments in addition to weigh bins, for fine and coarse aggregates may be waived, provided the batching tolerances specified in **Subsection 501.09** are maintained.

The requirement for mixers shall be as prescribed in **Subsection 501.04**, paragraph (b), except that the stipulation requiring the boom-and-bucket attachment to the mixer will be waived.

Ample and satisfactory equipment for conveying concrete from the mixer to final position in the forms shall be provided. Closed chutes or pipes shall be used when concrete is to be dumped or dropped for a distance greater than 5 ft.(1.5 m). Where steep slopes are required, the chutes shall be equipped with baffle boards or shall be in short lengths that will enable the direction of movement to be reversed.

Vibrators shall be of an approved type and design, and shall operate under load at the rate as recommended by the manufacturer and approved by the Engineer.

Concrete for items of construction set out in **Subsection 604.12**, may be mixed in a mobile volumetric continuous mixing plant.

The mobile mixing plant shall be designed to accurately batch aggregates and cement by volume based on weight. The mixing shall be by a continuous auger and/or paddles. The mobile unit shall be capable of producing a uniform concrete mix meeting all requirements of the specifications.

The mobile mixer shall be capable of carrying in separate compartments all the necessary ingredients needed for the concrete mix and shall be equipped with calibrated proportional devices for each material.

Each unit shall have attached thereto a metal plate on which is marked the discharge speed and weight calibrated constant of the machine.

Adequate standard volume measures, scales, and weights shall be available for checking accuracy of proportioning mechanism.

The proportioning controls shall be so constructed that they may be set and secured for different materials and mixes.

A calibrated chart for the individual unit must be furnished when required by the Engineer.

The calibration and gate settings for the design to be used shall be performed according to the manufacturer's recommendations, by the producer or factory representative, in the presence of the Engineer or Inspector.

This mobile mixer shall be equipped with separate bins and gate openings for each type of material. The storage bin for cement shall be waterproof. The aggregate bins shall be covered with tarpaulins or by other approved methods when required.

A satisfactory method of setting the dosage for admixtures must be furnished and if admixtures other than air-entraining agents are used, they shall be added in the manner and in the dosage recommended by the manufacturer.

When concrete is placed by pumping, the use of aluminum conduit will not be permitted.

No concrete for bridge decks or slabs above grade shall be poured prior to the Contractor verifying the availability and operability of all necessary equipment, including finishing machines, continuous water source or portable tanks, water distribution equipment, 2 work bridges, vibrators, sprayers, 12 ft. (3.65 m) straightedge and appropriate backup items.

The contractor shall provide at every concrete deck pour a portable, cold fogger capable of changing humidity and cooling air above fresh concrete. The fogger will be designed to provide a VMD(volume mean diameter) of 15, a maximum throw distance of 60 ft. (18 m), and an area of 600 s.f. (55 m^2).

CONSTRUCTION REQUIREMENTS

604.05-Forms.

(a) Construction.

Forms shall be mortar-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other stresses incidental to the construction operations, including vibration. Forms shall be so constructed and maintained as to prevent the opening of joints due to shrinkage of the lumber.

The forms shall be built true to line and grade and shall be held in place by means of studs or uprights, and waling, which shall be sufficiently and substantially braced and tied.

All forms and studding shall be cut off and capped with not less than a 2 x 4 in.(50 x 100 mm) piece.

All exposed edges shall be chamfered with 3/4 in.(19 mm) material, unless otherwise specified. All chamfer strips shall be straight, of uniform width, and dressed.

Wood devices of any kind used to separate forms shall be removed before placing concrete within 4 in.(100 mm) of such devices.

(b) Form Lumber.

Form lumber for all exposed concrete surfaces shall be dressed at least on 1 side and 2 edges, and shall be so constructed as to produce mortar-tight joints and smooth, even concrete surfaces.

Plywood forms, or forms face-lined with plywood, masonite, or other approved similar material may be used, provided the plywood forms and form linings are substantial, of uniform thickness, and are mortar-tight when in position.

(c) Metal Ties.

Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 1 in.(25 mm) from the face without injury to the concrete. In case wire ties are permitted, the wires shall be cut back at least 1/4 in.(6 mm) from the surface of the concrete, and the surface left sound, smooth, even, and uniform in color.

(d) Walls.

Sufficient openings shall be provided at intervals along the bottom of wall forms to permit thorough cleaning prior to concrete placement. Such openings shall be closed before placing concrete in the forms.

(e) Surface Treatment.

Prior to placing reinforcement, all forms shall be treated to prevent the adherence of concrete. Forms not provided with a special treatment shall be treated with an approved oil. Any material that will adhere to or discolor the concrete shall not be used.

(f) Metal Forms.

The specifications for forms, as regards design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse and oiling, apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt heads shall be countersunk on the face forming the concrete surface. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms that do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter.

(g) Permanent Steel Bridge Deck Forms

Bridge deck forms for concrete deck slabs of bridges may be constructed using permanent steel forms. Permanent steel bridge deck forms shall not be used for the overhang portions of the slab.

The following criteria shall govern the design of permanent steel bridge deck form:

1. The steel forms shall be designed on the basis of dead load of form, reinforcement and plastic concrete plus 50 psf(2.4 kPa) for construction loads. The unit working stress in the steel sheet shall be not more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 36,000 psi(248 MPa).
2. Deflection under the weight of the forms, the plastic concrete and reinforcement shall not exceed 1/180 of the form span or 1/2 in.(13 mm) whichever is less, but in no case shall this loading be less than 120 psf(5.8 kPa) total. The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits. Laminations may be used to satisfy design criteria.
3. If the design span of the form sheets is less than the clear distance between top girder flanges minus 2 in.(50 mm), the design for the support system must accompany the shop drawings.
4. Physical design properties shall be computed in accordance with requirements of the American Iron and Steel Institute Specification for the Design of Cold Formed Steel Structural Members, latest published edition.
5. All reinforcement, both transverse and longitudinal in the bottom mat, shall have a minimum concrete cover of 1 in.(25 mm).
6. The plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete deck shall be maintained.
7. Permanent steel bridge deck form shall not be considered as lateral bracing for compression flanges of supporting structural members.
8. Permanent steel bridge deck forms shall not be used in panels where open longitudinal deck joints are located between stringers.
9. Fabricators shop and erection drawings shall be submitted to the Engineer of Structures for approval. These plans shall indicate the grade of steel, the physical and section properties for all permanent steel bridge deck form sheets and a clear indication of the method of attachment of the forms and form supports to the main structural members. However, the review of shop drawings by the Engineer of Structures will be for approval of general details of forms and attachments. As this forming system is not an integral load-carrying member of the completed slab, no review of the design will be made by the Engineer of Structures. The sole responsibility for assuring the safe design of the metal decking system and its installation remains that of the contractor.

10. Form sheets shall not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 in.(25 mm) at each end.
11. Form supports shall be placed in direct contact with the flange of either the stringers or floor beams. All attachments shall be made by bolts, clips or other approved means. Welding of form supports to main structural members will not be permitted.
12. Any permanently exposed form metal where the galvanized coating has been damaged shall be thoroughly cleaned, wire brushed and painted with 2 coats of zinc oxide-zinc dust primer, Federal Specification TT-P-641d, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds need not be touched up.
13. Transverse construction joints shall be located at the bottom of a flute and 1/4 in.(6 mm) weep holes shall be field drilled at not more than 12 in.(300 mm) on center along the line of the joint.
14. Particular emphasis should be placed on proper vibration of the concrete to avoid honeycomb and voids at construction joints, expansion joints, valleys and ends of form sheets. Pouring sequences, procedures and mixes shall be approved by the Engineer. Calcium chloride or any other admixture containing chloride salts shall not be used in the concrete placed on permanent steel bridge deck forms.
15. After the deck concrete has been in place for a minimum period of 2 days, the concrete shall be tested for soundness and bonding of the forms by sounding with a hammer. If areas of doubtful soundness are disclosed by this procedure, the Contractor will be required to remove the forms from such areas for visual inspection after the pour has attained adequate strength.
16. Where sections of the forms are removed, the Contractor will not be required to replace the forms, but the adjacent metal forms and supports shall be repaired to present a neat appearance and assure their satisfactory retention. All unsatisfactory concrete shall be removed or repaired as directed by the Engineer. Any damage to the concrete and/or reinforcing steel caused by the inspection process, shall be repaired by the Contractor at no cost to the Department.
17. As permanent steel deck forms are not a structural component of the bridge or deck system, the determination of the structural adequacy of the deck forms to support the wet concrete and specified construction load allowance is the responsibility of the Contractor. It is also his responsibility to verify that the deck system meets all the requirements set forth in this section.

18. No over runs in deck concrete, attributable to deflections or distortions in the deck form, will be paid for, but are considered incidental to the forming system.

(h) Special Forming Systems

Precast concrete deck panels shall be in accordance with the Plans.

When precast bridge deck panels are used, the bottom reinforcing mat in the cast in place bridge deck is eliminated; therefore it is not possible to make all of the ties needed to maintain the rigidity of the reinforcing mat, deck form and girder system. To enhance the stability of this system during construction, additional reinforcing, ties, temporary erection diaphragms and permanent diaphragms shall be required as specified on the plans and as indicated below. The cost associated with these requirements shall be included in the unit price of items bid .

1. The strands projecting from the ends of deck panels shall be tied to the upper mat of reinforcing steel at 2 ft. (600 mm) maximum spacing. The upper mat shall be tied to projecting shear reinforcement or stud shear connectors at maximum 2 ft .(600 mm) spacing along the beam.
2. For precast, prestressed I beams and Bulb-Tee beams, additional permanent diaphragms or additional temporary erection diaphragms as shown on the Plans shall be constructed between all girders at substructures and at intermediate points such that the spacing between diaphragms does not exceed that indicated on the plans.
3. For precast prestressed box beams, additional permanent diaphragms or additional temporary erection diaphragms as shown on the Plans shall be constructed between all girders at substructures and at intermediate points such that the spacing between diaphragms does not exceed that shown on the plans.
4. For prestressed I beams and box beams, integral abutment backwalls and support diaphragms at alternate substructures may be poured prior to constructing the bridge deck. If poured prior to the deck pour, the support diaphragm at the pier must be poured level with the top of the support brackets for the deck panels so that the bituminous fiberboard is continuous across the support diaphragm. Support diaphragms constructed prior to placement of the bridge deck may be constructed using Class A Concrete (3,000 psi (20.7 MPa)) with payment made under the item for Class A Concrete (Bridges). The remaining diaphragms at substructures shall be poured concurrently with the bridge deck. Temporary erection diaphragms as shown on the Plans will be required at the ends of girders where the end diaphragms are to be poured concurrently with the bridge

deck. The Contractor may also submit alternate temporary diaphragm details to the Engineer for approval.

5. For prestressed Bulb-Tee beams, all support diaphragms except the bottom 12 in. (300 mm) must be poured concurrently with the bridge deck. Integral abutment backwalls shall not be poured until at least half of the slab in the end span has been poured or the backwall may be poured concurrently with the deck slab. A minimum of the top 12 in. (300 mm) of the abutment backwall must be poured concurrently with the slab. Temporary erection diaphragms as shown on the Plans will be required at the ends of girders. The Contractor may also submit alternate temporary diaphragm details to the Engineer for approval. The contractor is responsible for supporting the beams to prevent damage due to twisting or overturning during all phases of construction.
6. Form supports, for precast bridge deck panels shall be placed in direct contact with the flange of the girders or beams. All attachments shall be made by bolts, clips or other approved means. Welding of form supports to main structural members will not be permitted.

When the Contractor wishes to utilize a special forming system not specifically authorized in this specification, he shall submit his design and calculations to the Engineer of Structures for review and approval.

(i) Global Stability of Exterior Girders during Slab Overhang Pours:

The Contractor shall be responsible to assure the stability of the exterior girder(s) against twisting, overturning, or web buckling during slab pouring operations. This may require supplemental bracing. When the width of the slab overhang exceeds the depth of the exterior girder, details and design calculations for the cantilever support (including deflections caused by the mechanical screed) shall be submitted to the Engineer for approval.

(j) Other Considerations:

If the deck slab thickness is increased more than 1-1/2 in.(38 mm) due to the use of permanent deck forms or precast deck panels, the Contractor will be required to redesign the girders for the entire change in thickness. All costs incidental to the increased depth of slab thickness and girder redesign if required, shall be borne by the Contractor.

All bridge beams and girders must be erected and the grade of the roadway established on the bridge before forming is started for the bridge deck, unless otherwise noted on the Plans or approved by the Engineer.

604.06-Falsework. The falsework used to support the forms and concrete for concrete structures shall be supported on sills resting on rigid foundations composed of solid rock, piles driven until the bearing capacity of each pile is sufficient to support the load to which it will be subjected, or earth borne footings as hereinafter provided.

Earth borne footings will be permitted only when, in the opinion of the Engineer, the soil can adequately support the superimposed loads and the following conditions are met:

1. Spread footings will only be permitted on stable ground, capable of supporting the superimposed load.
2. The site is graded and so maintained to prohibit ponding of water, or erosion of soil in the proximity of the spread footings.
3. The falsework system shall be designed and constructed to preclude exceeding the bearing capacity of the soil, but in no case shall exceed 3,000 psf(145 kPa).
4. The footings shall be designed and constructed to carry the superimposed loads.
5. All footings shall be constructed on a level plane.

The bearing value of piles shall be calculated according to the formulas given in **Subsection 606.14**.

The falsework shall be designed and constructed to support the required loading without distortion or settlement of the forms.

The Contractor shall place "tell-tales" for observation of the amount of falsework settlement at locations designated by the Engineer.

The Engineer may require the Contractor to submit detailed falsework plans, together with a soils report, design calculations or any other information necessary for a thorough review. The Contractor is totally responsible for the design and construction of the falsework system and shall repair, or remove and replace, as directed and at his expense, any concrete, other material or portions of the structure which are damaged or destroyed due to failure of the falsework.

Plans for falsework and formwork for cast in place structures over pedestrian or vehicular traffic shall be prepared by a Tennessee Licensed Professional Engineer.

Prior to placing any superstructure concrete, the Contractor shall furnish to the Project Engineer a certification to the effect as follows:

CERTIFICATION

I hereby certify that the plans for falsework and formwork on (Structure Identification) _____ have been prepared by me in accordance with accepted structural engineering practice. I further certify that said falsework has been erected in full compliance with said plans.

_____, P.E.

Tennessee License Number _____

604.07-Camber. Structures of any type or size shall be constructed to a permanent camber only when shown on the Plans. Sufficient camber shall be provided in the falsework and forms for each span to allow for the tightening of joints in the forms and supporting falsework.

604.08-Reinforcement. All reinforcement shall consist of deformed steel bars meeting the requirements of ASTM A 615M grade 400 (ASTM A 615 grade 60), unless otherwise indicated or directed. Standard CRSI hook details shall apply unless otherwise noted. Reinforcing steel designated with the suffix E, shall be epoxy coated in accordance with **Subsection 907.01**. Deformed steel bars shall have a net area at all sections equivalent to that of plain round or square bars of the corresponding nominal size.

Steel wire fabric may be furnished in rolls or sheets.

Reinforcing steel shall be stored above the ground surface upon platforms, skids or other supports located without the scope of the active construction operations; and shall be protected at all times from injury and damage. All brush and weeds shall be removed from the area immediately prior to storing reinforcing steel thereon.

Reinforcing steel, where indicated, shall be accurately bent, without heating, to the forms and dimensions, indicated on the Plans. Unless otherwise indicated, all bends shall be in one plane. Uncoated bars of 3/4 in.(19 mm) or less which have only hooks or a single bend may be bent in the field, provided satisfactory equipment for proper and accurate work is used, and provided the bending is accomplished true to form and dimensions without damage to the bars. All other bending shall be done in the shop before shipment.

Substitution of bars of different sizes from those indicated on the Plans may only be made with the written permission of the Engineer. If substitution is permitted, the following shall apply:

1. The total area of steel in any 1 ft(m) in each direction shall not be reduced.
2. For cast in place concrete the clear distance between parallel bars in a layer shall not be less than 1.5 bar diameters, 1.5 times the maximum size of the coarse aggregate, nor 1 1/2 in.(38 mm).
3. Where positive or negative reinforcement is placed in 2 or more layers, bars in the upper layers shall be placed directly above those in the bottom layer with the clear distance between layers not less than 1 in.(25 mm).
4. Clear distance limitation between bars shall also apply to the clear distance between a contact lap splice and adjacent splices or bars. Groups of parallel reinforcing bars bundled in contact to act as a unit shall be limited to 4 in any 1 bundle. Bars larger than #11(35 mm) shall be limited to 2 in any 1 bundle in beams. Bundled bars shall be located within stirrups or ties. Individual bars in a bundle cut off within the span of a member shall terminate at different points with at least 40 bar diameters stagger. Where spacing limitations are based on bar diameter, a unit of bundled bars shall

be treated as a single bar of a diameter derived from the equivalent total area.

5. In walls and slabs, the primary flexural reinforcement shall not be spaced farther apart than 1.5 times the wall or slab thickness, or 18 in.(450 mm).

All reinforcement shall be furnished in the full length shown on the plans, unless otherwise approved in writing by the Engineer. Temperature reinforcement may be spliced at no additional compensation. Splicing may occur once per bar in the end sections of box and slab type culverts that are on a skew other than 90° and in box and slab type culverts that require no contraction joints due to their length. Temperature reinforcement in end sections of 90° skewed structures and in interior sections of all box and slab type culverts will be furnished in the full length required, with no splices. No splices shall be made, unless indicated on the Plans or authorized by the Engineer of Structures. Splices of tension reinforcement at points of maximum stress will not be allowed. The members at all splices shall be rigidly clamped by means of at least two approved metal clips located approximately 3 in.(75 mm) from the ends of the bars and bolted around them, or securely wired in a manner satisfactory to the Engineer.

Steel shapes shall be spliced only as indicated on the Plans.

Steel fabric shall be spliced by overlapping of the sheets by not less than 12 in.(300 mm); by matching at least three transverse members, and by securely wiring the overlapped sections in a manner satisfactory to the Engineer.

Before being placed, all reinforcing steel shall be thoroughly cleaned of mill scale, rust, dirt, paint, oil, or other foreign substances or coating of any character that will reduce the bond. If reinforcement which has been placed becomes dirty, rusty, or spattered with mortar that dries before concrete is placed around it, such reinforcement, or part affected, shall be thoroughly cleaned before being covered with concrete.

Reinforcement shall be accurately placed and firmly held in position as indicated on the Plans or as directed by the Engineer. Uncoated steel bars shall be securely fastened together with metal clips or wire at each intersection. Uncoated steel bars shall be fastened with coated wire ties or coated clips. Where spacing is less than 1 ft (300 mm) in each direction, then alternate intersections shall be fastened. All reinforcing steel shall be securely spaced from the forms and between adjacent reinforcement by means of approved metal spacers, concrete blocks or other approved devices or methods, except metal spacers only will be permitted in slabs of bridges and top slabs of box type structures. Where possible, all spacer devices shall be so arranged that their use cannot be detected in the completed structure. Concrete spacer blocks shall be made in the same proportions as that in the concrete mixture and shall be rectangular in shape with uniform surfaces and shall not have a dimension greater than the depth required for proper spacing from the forms or between adjacent reinforcement. The use of gravel, brick, or wooden blocks is prohibited.

All the reinforcing steel in a section of a concrete pour shall be accurately and securely placed and the placement approved by the Engineer

before any concrete is deposited in the section. Care shall be taken to not disturb the spacers during placement of the concrete.

All dimensions relating to the spacing or cover of reinforcing bars are to the centers of the bars or the clear distance respectively, unless otherwise indicated. Tolerances for placement shall be ±1/2 in.(13 mm) for spacing and -1/8 in.(3 mm) or +3/8 in.(10 mm) for cover.

604.09-Drainage and Weep Holes. Drainage openings and weep holes shall be constructed using materials in the manner, and at the locations shown on the Plans or established by the Engineer. Ports or vents for equalizing hydrostatic pressure, when required, shall be placed as directed.

Where structures are to be backfilled, weep holes or openings shall be protected by placing a wire basket 1 by 1 by 1 ft. (300 x 300 x 300 mm), filled with coarse aggregate, size 7, 8, 57, 67, 68, or 78, immediately over or behind the holes or openings, as directed by the Engineer. After all finished grading is complete, weep holes shall be cleaned of all dirt and debris and verified to be free draining.

604.10-Placing Pipes, Conduits, Anchors, Casting, and other Appurtenances. Pipes, conduits, anchors, castings, bolts, plates, grillages, and other appurtenances which are necessary or desirable to be placed in the concrete of a structure, whether indicated on the Plans or not, shall be placed by the Contractor during construction, as directed by the Engineer. Unless otherwise stipulated, pipes and conduits will be delivered to the Contractor at the site of the structure by the Department or by other parties for whose use the pipes and conduits are intended.

No compensation will be allowed for placing such pipes, conduits, and other appurtenances, except that no deductions will be made for the volume of concrete displaced by those items.

604.11-Handling, Measuring, and Batching Materials.

A. Major Structures

The requirements for handling, measuring, and batching materials to be incorporated in structural concrete shall be as prescribed in **Subsection 501.09.**

When lightweight aggregates are used, the aggregates shall be uniformly pre-saturated by sprinkling and allowed to drain. At time of use, the aggregates shall be in a saturated surface dry condition to minimize water absorption.

When concrete is being placed during hot weather, appropriate measures shall be taken to reduce the hazards of increased rate of cement hydration and high concrete temperatures.

The temperature of the concrete at point of discharge shall not exceed 90° F(32° C).

The Contractor shall take any or all, but not limited to, the following precautions to reduce the temperature of the concrete:

1. Sprinkle coarse aggregate stockpiles in a manner so as to distribute the water evenly and to prevent a variation of moisture within the stockpile.
2. Use crushed or chipped ice as a portion of the mixing water, or use water cooled by refrigeration or other means. If ice is used it shall be substituted on a lb. for lb. (kg. for kg.) basis for water and completely melted before the concrete is discharged from the mixer.
3. The Contractor may employ other means which he may have at his disposal if approved by the Engineer.

Unless otherwise specified in the contract, additives or admixtures shall be used when approved by the engineer, based on receipt of a revised mix design..

Unless specifically provided in the contract, the furnishing and use of approved additives or admixtures and the other precautions necessary to provide satisfactory concrete and concrete products will be considered incidental to the furnishing and placement of the concrete and any additional costs and risks shall be borne by the Contractor.

Different types of cement shall not be mixed, nor shall they be used alternately. Where it is necessary for the color of the concrete to be uniform, only those cements that will produce similar color in concrete may be used alternately.

B. Minor Structures

In the following items of construction, a mobile volumetric continuous mixing concrete plant meeting the requirements of **Subsection 604.04** may be substituted for method described in **Subsection 501.09**.

Section 611	Manholes, catchbasins, inlets, and pipe end walls
Section 701	Cement concrete sidewalks, riveways and median pavement
Section 702	Cement concrete curb, gutter, and combined curb and gutter
Section 703	Cement concrete ditch paving
Section 705	Guard rail
Section 707	Fences
Section 709	Rip-rap slope paving
Section 713	Highway signing
Section 714	Roadway and Structure lighting

604.12-Limitations of Mixing. When mixing of concrete is completed during non-daylight hours an adequate and approved artificial lighting system shall be provided and operated.

Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40° F(4° C), and not resumed

until an ascending air temperature in the shade and away from artificial heat reaches 35° F(2° C).

When concreting at temperatures above 35° F(2° C), the aggregates or water shall be heated or cooled if necessary prior to being placed in the mixer so that the temperature of the resultant mixture will be not less than 50° F(10° C) nor more than 90° F(32° C) at the time of placement. If heating is required, the apparatus used shall heat the mass uniformly and shall be so arranged as to preclude the possible occurrence of overheated areas which might injure the concrete. No frozen aggregates shall be used in the concrete.

When concreting is authorized at temperatures 35° F(2° C) or less, the Engineer will require the water or the aggregates or both to be heated to not less than 70° F(21° C) nor more than 150° F(65° C). The temperature of the mixed, heated concrete shall be not less than 60° F(15° C) nor more than 90° F(32° C) at the time of placing on the road.

604.13-Mixing Concrete. The requirements for mixing concrete shall be as prescribed in **Subsection 501.10** for major structures. However, when the concrete is mixed and transported in truck mixers, the time elapsing from when the water is added to the mix until the concrete is deposited in place at the site of the work shall not exceed 90 minutes. When the ambient air temperature exceeds 90° F(32° C), the elapsed time above shall be reduced to 60 minutes for concrete placed in bridge decks. Retempering concrete by adding water or by other means will not be permitted; however, a portion of the mixing water or chemical admixtures may be withheld from transit mixers and added at the work site if all requirements of the approved mix design are met. In the event water or chemical admixtures are added at the placement site, the concrete shall be mixed a minimum of 30 revolutions at mixing speed after additions are made. Concrete that is not within the specified slump limits, air content limits, temperature limits or time limits at time of placement shall not be used.

For items of construction specified in **Subsection 604.12(b),** concrete mixing may be performed by mobile volumetric measuring and mixing equipment as prescribed in **Subsection 604.04** of these Specifications.

When concrete placed in the items of construction specified in **Subsection 604.12(b)** does not exceed 25 c.y.(20 m^3) per day, it may be accepted on the basis of field testing for air, slump, and occasional strength tests with only random plant inspections as deemed necessary by the Engineer for control.

When this basis of acceptance is used, the ready-mix plant furnishing the concrete shall have been inspected and approved for use as provided in **Subsection 604.04**. In addition, the delivery ticket accompanying each load of concrete shall show the class of concrete, the quantity of cement, aggregates, water, and additives used in the batch, and the time of batching. Materials used in the concrete shall be tested and approved.

604.14-Consistency of Concrete. The slump of the concrete when measured in accordance with AASHTO T 119 shall conform to the requirements of **Subsection 604.03**.

604.15-Compressive Strength Tests of Concrete. The Engineer will determine concrete strength by tests made during the progress of work and these tests will be used to determine the strength of the concrete for acceptance and pay purposes. The frequency of testing shall be as specified in the sampling and testing schedule of Departmental Standard Operating Procedures.

The frequency of testing for compressive strength to determine when forms may be removed, or when a structure may be put into service, shall be as requested by the Contractor or as deemed necessary by the Engineer.

The methods used in making and curing test specimens shall be in accordance with AASHTO T 23, unless otherwise specified or directed. The specimens shall be tested for compressive strength in accordance with the provisions of AASHTO T 22. The necessary concrete for making test specimens and adequate curing and storage facilities shall be furnished by the Contractor without additional compensation.

All acceptance cylinders for testing 28-day strength as specified in **Subsection 604.03** must be delivered by the contractor to the Central Lab in Nashville or may be delivered to the regional lab or other agreed pick-up point if arrangements are made in advance with the Regional Materials Engineer. Concrete cylinders submitted for testing beyond 28 days must comply with the following strength requirements:

Class of Concrete	**Less than 31 days**	**31 to42 days**	**43 days or more**
A, S	3,000 psi (20,700 kPa)	3,300 psi (22,700 kPa)	3,500 psi (24,100 kPa)
D, L	4,000 psi (27,600 kPa)	4,400 psi (30,300 kPa)	4,600 psi (31,700 kPa)

In addition, concrete cylinders submitted for testing beyond 56 days, will not be accepted. Acceptance for payment will be based on cores provided by the contractor at his expense. These cores shall be required to meet the strength requirements of the above chart for 43 days or more.

Concrete meeting the required strengths as specified in **Subsection 604.03** for their respective class, but failing to meet the requirements shown above will be accepted at reduced cost in accordance with the table specified in **Subsection 604.31.**

If the acceptance cylinders fail to meet the specified strengths, the Contractor may elect to drill core samples from the hardened concrete as verification of the strength of the concrete in lieu of the concrete cylinders, the costs of obtaining the cores and repairing the core holes shall be borne by the Contractor. The coring shall be completed in accordance TDOT Procedures.

If the acceptance cylinders fail to meet the specified strengths, the Contractor may elect to drill core samples from the hardened concrete as verification of the strength of the concrete in lieu of the concrete cylinders. The costs of obtaining the cores and repairing the core holes shall be borne by the Contractor. The cores shall be obtained in accordance with the TDOT Standard Operating Procedure.

The average compressive strength of the two cores taken to represent the low test cylinders will be considered to be the acceptance strength of the in-place concrete provided that the cores are obtained and tested within 42 days after the placing of the concrete. If, however, the Contractor fails to obtain the cores in a timely fashion so they can be tested within 42 days, the cores shall meet the strength requirements shown in the table above for 43 days or more. Concrete meeting the required strengths as specified in **Subsection 604.03** for the respective class, but failing to meet the requirements shown above will be accepted at reduced cost in accordance with the table specified in **Subsection 604.31**. This will serve as verification of the strength of the concrete in lieu of the concrete cylinders.

All concrete used must be tested for acceptance. In place concrete that is represented by acceptance cylinders that have been lost, damaged, or destroyed, must be formally accepted by methods determined by the Department. These methods may include coring or non-destructive type testing.

604.16-Placing Concrete.

(a) General

Concrete shall not be placed until forms and reinforcing steel have been checked and approved. The forms shall be clean of all debris and kept wet immediately before concrete is placed. The method and sequence of placing concrete shall be approved by the Engineer. Unless otherwise permitted, all concrete shall be placed in daylight, and the placing of concrete in any portion of the structure shall not be started unless it can be entirely completed in daylight. When the placing of concrete is permitted during other than daylight hours, an adequate and approved artificial lighting system shall be provided and operated.

All concrete shall be thoroughly worked during the placing by means of tools of approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets, or honeycomb.

If the forms show bulging or settlement while concrete is being placed, the placing shall be stopped until correction has been made.

T-beam girders, slabs, arch rings, and all horizontal sections, except curbs and sidewalks, shall be constructed monolithically and continuously, unless otherwise permitted.

Curbs and sidewalks shall be constructed after the bridge deck is completed, unless otherwise indicated on the Plans.

After initial set and prior to final set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement. Piles shall not be driven closer than 20 ft.(6 m) to footings that are less than 7 days old nor to foundations supporting concrete that is less than 7 days old.

Unless otherwise specified, prior to placing a bridge deck overlay of Class D or Class L concrete, the surface to be covered shall be machine scarified to a minimum depth of 1 in.(25 mm). In areas inaccessible to machine scarifying, and in areas of spalling, where steel reinforcement is exposed, deteriorated concrete shall be removed by using hand tools or other methods approved by the Engineer. After scarifying, the deck shall be cleaned of all deleterious material, and traffic shall not be permitted on the scarified deck.

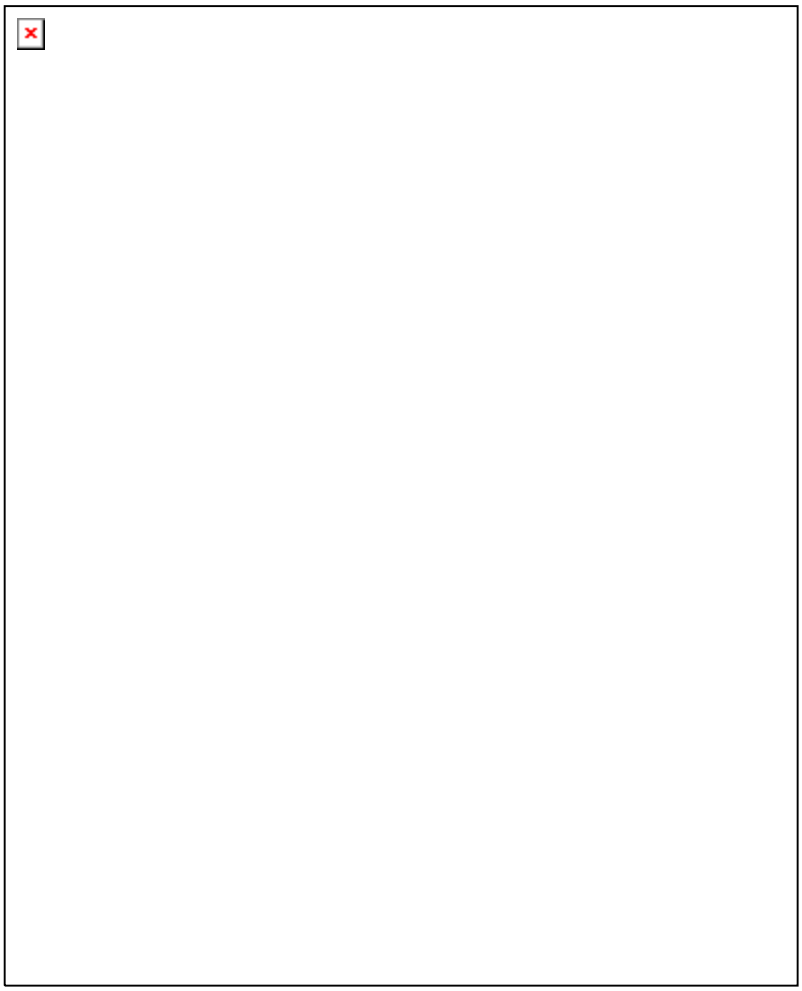
The Contractor shall exercise care to avoid contaminating the surface of the bridge deck after scarification. Any contaminants on the deck shall be removed to the satisfaction of the Engineer prior to placement of the concrete overlay.

These additional requirements shall apply to concrete bridge decks when the rate of moisture evaporation may be excessive as determined by the Engineer.

No concrete deck pour shall commence until the mandatory Bridge Deck Construction Pre-pour Meeting is conducted and all pertinent considerations covered by the Pre-pour Check List are resolved.

The concrete shall be protected to prevent rapid drying as a result of high temperature, low humidity, high winds or combinations thereof. No concrete shall be placed when the rate of moisture evaporation from the freshly placed concrete exceeds 0.2 lb/ft²/hr as determined by Figure 2.1.5, American Concrete Institute Publication "ACI 305R." The Contractor shall provide the Engineer appropriate measuring devices meeting industry standards to establish the temperature of both the concrete and ambient air, relative humidity and wind velocity adjacent to the surface of the concrete.

If data collected during the 24 hours prior to the pour, or predictions from the National Weather Service indicate that the moisture evaporation rate of 0.2 lb/ft²/hr may be exceeded, then the Contractor shall act to limit concrete placement to hours when the evaporation rate is less than 0.2 lbs./ft.²/hr. An exception to this requirement would be that the Contractor demonstrates to the satisfaction of the Engineer prior to the pour that protection can be provided, or other actions taken, to maintain an acceptable moisture evaporation rate. Placement of bridge deck concrete shall be scheduled accordingly. Notwithstanding all precautions, if during placement of the concrete the evaporation rate of 0.2 lbs./ft.²/hr is exceeded, the Contractor shall forthwith terminate the pour, as directed by the Engineer.



If data collected during the 24 hours prior to the pour, or predictions from the National Weather Service indicate that the moisture evaporation rate of 0.2 lb/ft²/hr may be exceeded, then the Contractor shall act to limit concrete placement to hours when the evaporation rate is less than 0.2 lbs./ft.²/hr. An exception to this requirement would be that the Contractor demonstrates to the satisfaction of the Engineer prior to the pour that protection can be provided, or other actions taken, to maintain an acceptable moisture evaporation rate. Placement of bridge deck concrete shall be scheduled accordingly. Notwithstanding all precautions, if during placement of the concrete the evaporation rate of 0.2

lbs./ft.²/hr is exceeded, the Contractor shall forthwith terminate the pour, as directed by the Engineer.

Plans for nighttime operations, including adequate lighting, shall be acceptable to the Engineer.

It may be necessary to apply a very light fog spray during the placement and finishing operations. If a light fog is needed, it shall be applied by a hydro- pressure sprayer, capable of providing water pressures greater than 3,000 psi(20,700 kPa), at a minimum rate of 4.0 gal./min. (3.3 ltrs/min), and very fine droplets of water using the appropriate nozzle treatment...

Immediately before the concrete is placed, the forms and reinforcing steel shall be cooled to 90° F (32° C) or less by using a fine spray of water, leaving no puddles or pockets of water. Trucks shall be sprinkled or kept in the shade when not being unloaded so as to contribute to reducing the temperature of the concrete.

One of the 4 following methods shall be utilized at the discharge point when concrete is pumped:

(1) A metal loop consisting of four 90 degree elbows shall be placed in the line just before the rubber discharge hose.
(2) A minimum of 10 ft.(3 m) of line lying horizontally just prior to the discharge point.
(3) A rubber discharge hose configured into a “j” shape or loop, either of which prevents a loss in the pressure of the discharge line.
(4) A rubber discharge hose, 10 ft. (3 m) in length, that reduces in diameter from 5 to 4 in. (125 to 100 mm) over its length.

The air content shall meet **Subsection 604.03** requirements at the point of delivery to the pump.

Closed chutes or pipes shall be used when concrete is to be dumped or dropped for a distance greater than 5 ft. (1.5 m). Where steep slopes are required, the chutes shall be equipped with baffle boards or shall be short lengths that will enable the direction of movement to be reversed.

(b) Railings and Curbing.

When constructing curb, careful attention shall be given to the installation of railing steel or anchoring devices.

Concrete railings shall not be constructed on any structure until the falsework has been struck.

(c) Chutes and Troughs.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.

All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with

water after each run. The water used for flushing shall be discharged clear of the concrete already in place.

Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and around the reinforcement without displacing the bars.

(d) Vibrating.

Unless otherwise directed, the concrete shall be compacted with suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position. The vibration at any point shall be of sufficient duration to accomplish compaction, but shall not be prolonged to the point that segregation occurs.

At least 1 additional stand-by vibrating unit shall be available for all individual pours in excess of 10 c.y.(m^3).

(e) Joints.

Featheredge construction joints will not be permitted. Transverse or longitudinal joints through spans will not be permitted, except where specified.

Placement of bridge deck concrete between specified transverse construction joints shall be continuous unless otherwise approved in writing by the Engineer. When the Contractor fails to maintain a rate of placement of 20 ft. (8 m) per hour in the longitudinal direction as specified in **Subsection 604.23** or placement is interrupted unduly in the judgment of the Engineer because of failure or repositioning of equipment or any other cause, the Engineer may direct that all placement be stopped and a transverse construction joint be formed in the deck as provided for in the Plans or as directed by the Engineer.

Layers completing a day's work or placed just prior to temporarily discontinuing operations shall be cleaned of all laitance or other objectionable material as soon as the surface has become sufficiently firm to retain its form.

In the construction of box culverts 6 ft.(1.8 m) or less in height, the side walls and top slab may be constructed as a monolith. When this method of construction is used, any necessary construction joints shall be vertical and at right angles to the axis of the culvert.

In the construction of box culverts more than 6 ft.(1.8 m) in height, the concrete in the walls shall be placed and allowed to set at least four hours before the top slab is constructed. In this case,

appropriate keys shall be left in the side walls for anchoring the top slabs.

Unless otherwise specified on the Plans, transverse contraction joints in box culverts shall be plain butt joints and longitudinal reinforcement shall not extend across the joint. Contraction joints shall be spaced at intervals of 30 to 40 ft.(9 to 12 m). The location of joints shall be predetermined, and when practicable, shall be placed at changes in the box section. These joints will be located parallel to the main reinforcing steel in the slab and not necessarily perpendicular to the axis of the box or slab type culverts.

604.17-Bonding Construction Joints. Where dowels, reinforcing bars, or other adequate ties are not indicated on the Plans, keys of a directed size shall be made by constructing projections above the concrete and monolithically with the concrete.

In resuming work, the forms shall be drawn tightly against the face of the concrete. The entire surface of the concrete to be bonded shall be cleaned thoroughly, and roughened with a steel tool. The surface shall be soaked with clean water, after which concreting may proceed.

604.18-Depositing Concrete Under Water. No concrete, except for cofferdam seals, shall be deposited under water. The work required under **Subsection 204.10**, Foundation Preparation, shall be performed prior to placing concrete foundation seals. It is necessary to inspect foundations for seal concrete. The Contractor shall furnish an experienced diver equipped with a diving suit, two-way telephonic and other appurtenant equipment necessary for performing underwater inspections.

Concrete for seals shall be placed only in still water, and the cofferdams or cribs shall meet the requirements stipulated in **Subsection 204.09**. The method of depositing shall be regulated to maintain the surface of the concrete as nearly horizontal as practicable throughout the operation. The concrete shall be carefully placed in a compact mass in its final position by means of a tremie, unless otherwise approved by the Engineer. The concrete shall not be disturbed after being deposited, and shall not be exposed to the action of water before final setting. The Contractor will be required to obtain cores for each seal footing. However, the inspection and coring of the seal footing will be waived provided the seal footing is founded on piles and such encased piling projects above the seal footing and embeds into the structural footing a minimum length as shown on the Plans. The Contractor shall obtain 4 cores, size N, as described by the Diamond Core Drill Association, or larger, representing 80% of the depth of the seal footing as directed by the Engineer unless otherwise noted on the Plans. Should the cores or other inspection indicate an inferior seal, corrective measures when required will be at the Contractor's expense. Unless otherwise noted, all costs for coring the seal will be included in the cost of other items bid.

All concrete deposited under water shall be mixed in the proportions designated for Class S concrete. No additional compensation will be allowed for the additional cement. The consistency of the concrete shall be

carefully regulated and controlled, and special care shall be exercised to prevent segregation of material during placement. The placement shall be continuous until the work is completed.

The tremie shall consist of a metal tube and suitable hopper of sufficient strength to withstand the stresses to which it is subjected. The tube shall have a minimum inside diameter of not less than 10 in.(250 mm), and shall be constructed in sections having flanged couplings fitted with gaskets. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and to permit the tremie being rapidly lowered when necessary to reduce or stop the flow of concrete. The lower or discharge end of the tremie shall be equipped with a suitable valve or device which shall be tightly closed while the tremie is being charged and lowered into position and which can be fully opened in the lower position. The discharge end shall be sealed until the tube is filled with concrete to prevent water from entering. The tremie shall not be raised to the extent that the discharge end is out of the deposited concrete. After removal of cofferdam sheeting, the Contractor will be required to furnish an underwater diver and camera to perform a tactile inspection of the concrete seal exposed faces and provide a video to document the condition of the exposed seal footing surfaces.

604.19-Removal of Forms and Falsework. Forms for ornamental work, railings, parapets, columns, and vertical surfaces that do not carry loads may be removed in from 12 to 48 hours, unless otherwise directed by the Engineer. In cold, damp, or freezing weather, all vertical forms shall remain in place until the concrete has set sufficiently to withstand damage when the forms are removed. In removing forms, care shall be exercised not to mar the surface of the concrete nor to subject it to any undue pressure.

Projecting wires or other metal devices used for holding forms in place, and which pass through the body of the concrete shall be removed or cut as specified in **Subsection 604.05(c),** and the holes or depressions thus made, and all other holes, depressions, small voids, etc., which show upon the removal of the forms, shall be filled with cement mortar mixed in the same proportions as that which was used in the body of the concrete which is being repaired.

Falsework and supports under concrete in structures may be released and removed when representative specimens of the concrete, cured by the methods and in the manner the concrete which the test specimens represent is cured, attain a compressive strength of 3,000 psi(20.7 MPa). In addition to the above requirements, the concrete shall have been placed a minimum of 7 days not counting days of 24 hours each in which the temperature falls below 40° F(4° C) or 21 calendar days, whichever occurs first. After the above conditions have been met, the Contractor may proceed with the placement of further concrete pours or erection of precast or fabricated members. Other loadings will be allowed as prescribed in **Subsection 604.28**.

For continuous concrete girder or slab units, the falsework and supports may not be released or removed from any span in the continuous unit until the concrete in all spans has been placed a sufficient length of time to meet

all requirements for the removal of falsework and supports as set forth above.

604.20-Defective Concrete. Upon discovery, any defective concrete shall be removed and replaced. If the surface of the concrete is bulged, uneven or has honeycombing which cannot be repaired satisfactorily, the entire section or unit shall be removed and replaced. The extent of the removal shall be as determined by the Engineer.

Concrete having an acceptance compressive strength less than the minimum specified shall be removed, disposed of, and replaced by the Contractor at no expense to the Department, unless specifically authorized by the Engineer, in writing, to be included in the permanent work. The removal and disposition shall be in such a manner as not to damage any existing construction or other facilities and property.

The Engineer may at his discretion allow concrete, which fails to meet the strength specified, to be included in the permanent construction, provided the durability is good; but the payment for this concrete will be made at a reduced price to compensate the Department for reduced strength. The bid price for concrete failing to meet the specified strength, yet considered structurally adequate for inclusion in the permanent construction, shall be adjusted downward in accordance with **Subsection 604.31**. Any downward adjustment in bid price due to low strength concrete will be based on the acceptance compressive strength of record of the concrete determined in accordance with **Subsection 604.16**.

604.21-Finishing Concrete Surfaces. Unless otherwise authorized, the surface of the concrete shall be finished immediately after form removal.

All concrete surfaces shall be given a Class I finish. The following surfaces of all structures shall be given a Class II or Applied Texture Finish: roadway face and top of curbs, vertical outside face of curb overhang or sidewalks slab, bottom surface of slab overhang, bridge railings, barrier railings, all vertical surfaces of the superstructure of dual bridges exposed to view from either structure and all surfaces of retaining walls, wing walls, and end walls, which are visible from passing vehicles.

All surfaces of structures over a highway or another structure exposed to general view shall be given a Class II or Applied Texture Finish. Such surfaces, in addition to these set out above, will usually include all parapets, copings, columns, piers, bents, sides and ends of caps, the outside of all fascia beams, the ends of arch rings, outer surfaces of spandrel walls, the exposed surfaces of wing walls and the faces of abutments. If additional surfaces are to receive a Class II or Applied Texture Finish other than those already indicated, these surfaces will be shown on the Plans. If an Applied Texture Finish is used, the color of the finish shall be similar to mountain gray, **Federal Specification No. 36440**, **Federal Color Standard 594b**, except that the inside face and the top of the parapet or rail shall be white, **Federal Specification No. 37886**. A color sample shall be submitted to the Engineer for approval.

A combination of the Class II and Applied Texture Finish will not be permitted. If an Applied Texture Finish is called for on the Plans, a Class II finish cannot be used.

Other finish classes may be specified by the Plans for designated surfaces.

(a) **Class 1, Ordinary Surface Finish**

Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces which are to be exposed or waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the Class of the concrete being finished. Mortar used in pointing shall not be more than 30 minutes old. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

All surfaces which cannot be repaired to the satisfaction of the Engineer shall be rubbed as specified for a Class II finish.

(b) **Class 2, Rubbed Finish**.

After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing to thoroughly set. Surfaces to be finished shall be rubbed with a wetted wooden block or a medium coarse carborundum stone. The carborundum stone shall not be used until the concrete has hardened to the state where the sand will grind, rather than ravel or roll. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place. A brush finish or painting with grout will not be permitted.

After all concrete above the surface being finished has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder, and objectionable marks.

(c) **Class 3, Float Finish**.

This finish, for unformed surfaces, except slab surfaces for pavements or bases, shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface.

Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating-tool of wood, canvas, or cork. Before the finish has set, the surface cement film shall be removed with a fine brush in order to have a finegrained, smooth but sanded texture.

(d) **Applied Texture Finish**.

Surface preparation prior to the textured finish shall include a Class 1 Ordinary Surface Finish in accordance with **Subsection 604.22(a)**. The concrete shall be in place a minimum of 28 days to allow for ample cure time and weathering of curing compounds prior to application of the textured finish. All surfaces shall be pressure washed just prior to application. Surfaces to be coated shall be free from efflorescence, flaking, coating, rust, dirt, oil and other foreign substances. Coatings shall be applied only to surfaces that are free of surface moisture as determined by sight and touch. Surfaces that are not to receive a Coated Finish are to be shielded and masked. Cracks over 1/8 in.(3 mm) wide are to be veed out and filled with an approved product from the TDOT QPL 13-E.

The surface preparation shall be approved by the Engineer immediately prior to the beginning of the work.

The textured finish shall be applied in 2 separate, distinct coats. Each coat shall be applied at a rate of 1 gallon per 45 (±5) s.f.(0.9 ±0.1 liter per m^2). The textured finish shall be applied with rollers or brushes so as to provide a consistent and uniform coverage. As an alternative, the Contractor may elect to spray the textured finish if he furnishes a containment system meeting the approval of the Engineer. Regardless of the method of application, drippings and/or overspray from the texturing process shall be prohibited or otherwise contained in a manner that will not contaminate the environment.

A color sample shall be submitted to the Engineer for approval.

604.22-Finishing Slab Surfaces for Pavements or Bases. Bridge floors or top slabs of structures serving as finished pavements or bases shall be finished by approved mechanical finishing machines. In extreme cases where mechanical finishing machines cannot be used, such as narrow width due to phase construction, hand finishing or other methods may be permitted by the Engineer.

Mechanical finishing machines shall be approved power driven machines, traveling on rails adjusted to conform to the profile of the roadway. The machines shall be equipped with oscillating or vibrating transverse or longitudinal screeds that may be adjusted to conform to the profile or the required cross section of the roadway. The screed shall have sufficient strength to retain their shape after adjustment. The finishing

machine shall go over each area of the bridge floor as many times as it is required to obtain the required profile and cross section.

When longitudinal screeds are used, the following restrictions shall apply:

a. The span length of the slab section to be poured is 70 ft.(20 m) or less.
b. Sufficient concrete shall be placed ahead of the strike-off to fully load the beam or girder prior to strike-off.
c. The rate of placement shall be controlled to assure that the concrete will not take its initial set before the entire placement is complete.
d. The slab to be poured is in a tangent section.
e. The Contractor will be responsible for any damage to the Structure relating to the use of this method. Any changes to the sequence of construction, as noted in the plans, will not be permitted, unless requested by the Contractor and approved in writing by the Engineer.

When the hand method is used, the bridge floors or slabs shall be struck off with a screed which is parallel to the centerline of the roadway resting on bulkheads or screed strips cut or set to the required cross section of the roadway. This screed shall be so constructed as to have sufficient strength to retain its shape and that the cutting edge may be adjusted to conform to the profile of the roadway. Screeds shall be of sufficient length to finish the full length of spans 40 ft.(12 m) or less in length. Spans over 40 ft.(12 m) in length shall be finished in two or more sections, but no section shall be less than 20 ft.(6 m) in length. Screed strips or headers shall be accurately set to the specified grades, checked, and adjusted as necessary prior to the final screeding operation. The screed shall be worked back and forth over the surface until the proper profile and cross section is obtained.

The Contractor shall maintain a minimum rate of placement of 20 ft.(6 m) of deck per hour when concrete is placed in a longitudinal direction.

For bases, the surface shall be finished by grooving lightly with a wire broom at an angle of 60° with the centerline. All strokes shall begin at the center and end at the edge.

The surface of bridge approach slabs, bridge decks and top slabs of other structures serving as roadway pavements shall be finished and textured by Method (c) below, except Method (a) or (b) may be employed where specified on the Plans and/or where the design speed of the roadway on which the structure is located is less than 40 mph(64 kph).

(a) The surface shall be finished by dragging a seamless strip of damp burlap over the full width of the surface. The burlap drag shall consist of sufficient layers of burlap to slightly groove the surface and shall be moved forward with a minimum bow of the lead edge. The drag shall be kept damp, clean and free of particles of hardened concrete. A light broom or brush herringbone finish that leaves a texture similar to that obtained by the burlap drag may be used when permitted by the Engineer.

(b) The surface shall be finished with a burlap drag as noted in (a) above. Then at an appropriate time during the stiffening of the concrete, transverse grooves shall be formed in the surface so that in the hardened concrete the grooves will be between 0.09 and 0.13 in.(2 to 3 mm) in width; between 0.12 and 0.19 in.(3 to 5 mm) in depth; and spaced at random intervals between 0.3 and 1.0 in.(8 to 25 mm). The grooves shall be relatively smooth and uniform, and shall be formed without tearing the surface, and without bringing pieces of coarse aggregate to the surface, and shall be formed to drain transversely.

(c) The surface shall be finished with a burlap drag as noted in (a) above. Then after the concrete has been allowed to cure in accordance with **Subsection 604.23** of these specifications, and hardened sufficiently to support the necessary equipment, the surface shall be grooved transversely using a mechanical saw device that will leave grooves 0.125 in.(3 mm) wide, 0.125 in.(3 mm) deep, and randomly spaced from 0.75 to 1.125 in.(20 to 30 mm) apart center to center. Any corrective grinding for smoothness shall take place prior to transverse grinding, otherwise it will be necessary to re-groove.

The Contractor shall establish positive means for removal of grooving residue as specified in **Subsection 604.28**.

The grooves formed by method (b) or (c) above shall terminate approximately 12 in.(300 mm) from curbs, parapets, barrier walls and other vertical walls.

All cost for finishing and texturing shall be included in the unit price bid on the concrete being placed. As soon as the surface has set sufficiently to withstand damage when walking on it, and not later than the morning following the placing of the concrete, it shall be straightedged with the 12 foot(3.6 m) straightedge and all variations exceeding 1/8 in.(3 mm) shall be plainly marked. The Contractor shall correct and seal such variations in the same manner as specified in **Subsection 604.28**.

604.23-Curing Concrete. All concrete surfaces, except those surfaces, protected by forms that remain in place 7 days or longer as required under the provisions of **Subsection 604.20**, Removal of Forms, shall be cured as specified below. All curing materials shall meet the requirements of **Section 913** of these specifications. Curing shall begin on unformed surfaces immediately after the water sheen disappears and the surface finish is applied and on formed surfaces immediately after removal of forms.

When the temperature is expected to fall below 35° F(2° C), the concrete shall be protected in accordance with the provisions of **Subsection 604.25**.

Curing by both the Membrane-Forming Compound Method and the Water Method with burlap shall be required for bridge decks and for the top slabs of other structures located above the roadway subgrade elevation. New burlap shall be used for each pour, except burlap may be reused on the

same project provided it is undamaged and deemed acceptable by the Engineer. All other concrete surfaces may be cured by either of the following methods:

(a) **Membrane-Forming Compound Method**.

All surfaces shall be given the required surface finish and kept moist prior to application of the curing compound. The burlap drag finish on bridge decks and on the top slabs of other structures which also serve as the roadway surface shall be applied as soon as practicable after screeding the surface and then shall be immediately followed by application of the membrane curing compound.

The rate of application of curing compound shall be as recommended by the manufacturer. The curing compound shall be applied under pressure. Hand sprays shall only be used in areas that are inaccessible to pressure equipment. At the time of application of the curing compound the concrete shall be thoroughly moist but without surface water.

At the time of use, the compound shall be in a thoroughly mixed condition with the pigment or dye uniformly dispersed throughout the vehicle. If the application of the compound results in a streaked or blotchy appearance, corrective action shall be taken at once to obtain a well dispersed mixture of uniform appearance. Concrete surfaces not protected by burlap curing covers shall be protected by other means against marring for a period of 5 days from the date of application. Any membrane coating marred within the 5 day period on an otherwise unprotected surface shall be replaced at once.

(b) **Water Method**.

After application of the curing compound to bridge decks and to other top slabs located above subgrade elevation, damp burlap, or other sheet type materials meeting the performance requirements of AASHTO M-171 and approved by the Department shall be applied from a work bridge as soon as possible taking care not to mar the surface of the deck.. All other concrete slabs shall be covered immediately with materials suitable for use with the water cure. Upon placement, the protective cover shall be immediately wet with a misty spray and kept thoroughly wet with a continuously fed soaker hose system for 120 hours.

All surfaces other than slabs shall be protected from the sun and shall be kept wet for a period at least 72 hours from the beginning of the initial curing period. Curbs, walls, handrails and other surfaces requiring a Class II finish may have the covering temporarily removed for finishing, but the covering shall be restored as soon as possible.

604.24-Protection of Concrete in Cold Weather. If, after the concrete has been placed, it is expected that the ambient temperature will drop below 35° F(2° C), the Contractor shall provide insulation blankets sufficient canvas and framework, or other types of housing, to enclose and protect the

structure in such a way that the air surrounding the fresh concrete can be maintained at a temperature of not less than 45° F(7° C), and the surface temperature of the concrete shall not exceed 80° F(27° C). The above conditions shall be maintained for a period of 120 hours after the concrete is placed. The Contractor shall furnish a maximum-minimum thermometer to the Engineer for the purpose of temperature documentation.

604.25-Painting Metals. The exposed surfaces of all metals which are not lubricated or which do not have a bituminous coating shall be painted, unless otherwise indicated or directed. Painting shall conform to the requirements of **Section 603**.

The surface of metals having a bituminous coating shall be cleaned and treated with 2 coats of bitumen so as to present a smooth finished surface, tough, and tenacious when cold and not tacky when warm, nor with any tendency to scale off.

Exposed surfaces, as used above, shall include the inside of cast iron drainpipes or weep holes.

604.26-Waterproofing and Waterstops. Waterproofing where indicated on the Plans or directed by the Engineer, shall be performed in accordance with the requirements of **Section 605** of these Specifications.

Waterstops, as specified, shall be installed in accordance with the details shown on the Plans and in conformity with the requirements of these Specifications.

Waterstops shall be installed in continuous strips without splices, except that splices will be permitted at changes in direction when necessary to avoid buckling or distortion of the web or flange. All splices of waterstops shall be performed in accordance with the manufacturer's recommendations and in the case of polyvinylchloride waterstops, the heat used shall be sufficient to melt but not char the plastic.

Adequate provisions shall be made to support the waterstops during the progress of work and to insure their proper embedment in the concrete. The concrete shall be thoroughly worked in the vicinity of the joints to insure maximum density and imperviousness. Forms shall be so designed that they can be removed without damaging the waterstops. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstops from mechanical damage.

604.27-Rideability of New or Resurfaced Bridge Decks and Roadway Approaches On all highway sections with a design speed greater than 40 mph(64 kph), the following rideability provisions shall apply to new or resurfaced bridge decks and roadway approaches, except that testing with the Rainhart Profilograph or high speed road profiling equipment need not be made on bridges with approaches posted for a lower speed due to roadway alignment.

Bridge decks resurfaced with bituminous material shall meet the respective rideability requirements for the bituminous material.

All asphalt paving in each 300 foot(100 m) approach area shall be set to grade by the use of string lines. All concrete paving in each 300 foot(100 m) approach area shall be set to grade by using string lines or side

forms set to grade. The Contractor shall be responsible for the final adjustment of the string lines in the approach area.

All expansion joints shall be fabricated and installed in accordance with the applicable specifications, standard drawings and approved shop drawings. The recess for the expansion device shall be formed to the proper dimensions to permit the expansion device to be placed.

Expansion joint installation shall be delayed and the joint temporarily bridged to facilitate a smooth operation of the road profiling and planing equipment across the joint. The expansion device shall be installed using the proper tools and equipment including grade beams in order to insure that it is set properly with respect to the roadway surface.

After the bridge decks, approach slabs and roadway pavement tie-ins are completed, they shall be subjected to smoothness tests using the Rainhart Profilograph or high speed road profiler output converted to a profile index in each wheel path beginning and ending 300 ft.(100 m) past each end of the bridge unless a shorter distance is specified by the Engineer or indicated on the plans. Where the roadway approaches to the bridge are not paved with hot mix asphalt or Portland cement concrete under this contract, smoothness testing shall be performed only on the bridge deck and approach slabs. It shall be the Contractor's responsibility to schedule profile testing at least 7 days prior to need. The Contractor shall insure that the area to be tested has been cleaned and cleared of all obstructions. Wheel paths shall be located 3 ft.(90 cm) each side of the centerline of each traffic lane.

Each lane for the length of the bridge and approaches (maximum 300 ft. (100 m) beyond each end of the bridge) shall be considered one lot. Using a 0.1 in. (2.5 mm) blanking band, the pavement roughness index for each lot shall not exceed the maximum allowable Pavement Roughness Index values as specified in the following table:

PAVEMENT ROUGHNESS INDEX

Bridge Profile Index

Lot Distance Ft (m)	**Profile Index Values** in./mile (mm/km.)
100 to 200 (30 to 60)	19.5 (310)
201 to 300 (61 to 90)	18.5 (290)
301 to 400 (91 to 120)	18.0 (285)
401 to 600 (121 to 180)	17.5 (275)
601 to 800 (181 to 240)	17.0 (270)
801 to 1000 (241 to 300)	16.5 (260)
1001 to 1500 (301 to 450)	16.0 (250)
1501 to 2000 (451 to 600)	15.5 (245)
2001 to 3000 (601 to 900)	15.0 (235)
3001 to 4000 (900 to 1200)	14.5 (230)
Over 4001 (over 1201)	14.0 (220)

In addition, pavement roughness index, using a 0.1 in.(2.5 mm) blanking band, shall not exceed 0.4 in.(10 mm) for any 25 ft.(7.6 m) section per each wheel path. All roadway and bridge deck surfaces shall be further tested with a 12 ft.(3.6 m) straightedge and shall meet the requirements of **Subsections 407.18, 501.17** and **604.23** as applicable.

For each lot that the pavement roughness index exceeds maximum allowable value as specified in the above table, the lot area shall be

corrected by a method approved by the Engineer. For each 100 ft.(30 m) section of wheel-path that the pavement roughness index exceeds 0.4 in.(10 mm) but is less than 0.5 in.(13 mm), the Contractor may elect to correct the deficiencies or forfeit the sum of $500.00 per 100 ft.(30 m) section as liquidated damages. Pavement roughness indexes exceeding those described above or areas failing the straightedge requirements shall be corrected by a method approved by the Engineer.

The grinding equipment shall be a power driven, self-propelled machine that is specifically designed to smooth and texture Portland cement Concrete surfaces using diamond blades. The effective wheel-base of the machine shall not be less than 12 ft.(3.6 m). The equipment shall be of a size that will cut or plane at least 3 ft.(900 mm) wide. The equipment shall be capable of grinding the surface without causing spalls at cracks, joints, or other locations. Small grinding equipment will not be allowed except for very small areas and only with the approval of the Engineer.

Asphalt milling or cold planing machines will not be permitted to perform grinding work on Portland cement concrete bridge deck surfaces. Grinding of Portland cement concrete bridge deck surfaces will not be permitted within 1-1/2 in.(38 mm) of reinforcing steel.

All corrective action on bridge decks, where practicable, shall precede the installation of expansion devices and final surface grooving. All surfaces that are ground shall be sealed with an approved penetrating sealant listed on the Department's QPL.

The Contractor shall establish positive means for removal of grinding and/or grooving residue. Solid residue shall be removed from pavement surfaces before being blown by traffic action or wind. Residue will not be permitted to flow across lanes used by public traffic or into gutters or drainage facilities. Residue shall be disposed of in a manner that will prevent residue, whether in solid or slurry form, from reaching any waterway in a concentrated state.

Residue may be continuously discharged on adjacent roadway slopes or ditches if the Engineer determines that there is sufficient vegetative cover to adequately filter the residue. However, if the Engineer determines that there is <u>not</u> sufficient vegetative cover on the adjacent roadway slopes and ditches to adequately filter the residue, then the residue shall be collected in approved storage tanks and deposited in settling basins, spread over flat vegetated areas, or filtered by other means approved by the Engineer.

All surfaces that are corrected shall be retested with the profile testing equipment to insure that the pavement roughness index does not exceed the minimum requirements. Correction by grinding of bridge decks and approach slabs, removal of pavement tie-ins, resurfacing, and any other corrective action, including the application of sealants, shall be the responsibility of the Contractor at no additional cost to the Department.

604.28-Loading and Opening to Traffic. No traffic, heavy equipment, storage of materials, or other loading will be allowed on a structure or any part thereof, except as noted in **Subsection 604.19**, until all forms and falsework have been removed per **Subsection 604.19** and 10 calendar days have elapsed thereafter.

604.29-Final Cleanup. Final cleanup shall be performed in accordance with the requirements of **Subsection 104.11**.

COMPENSATION

604.30-Method of Measurement Concrete for concrete structures, unless otherwise stipulated, will be measured for payment by the c.y.(m^3). The volume will be computed from the dimensions indicated on the Plans or ordered in writing by the Engineer except for the concrete fillet above fabricated bridge girders. This fillet, as shown on the Contract Plans, is intended as a means to allow for adjustment due to the imprecise methods of predicting camber development of structural members. At the time of construction, the fillet actually utilized to compensate for grade changes due to camber development, super-elevation or other factors beyond the Contractor's control will be field measured for payment by profiling of the bridge members.

No allowance will be made for furnishing the material and the construction of drainage openings and weep holes as indicated or as directed, provided such openings are 6 in.(150 mm) in diameter or less, except that no deduction will be made for such openings in the computation of concrete quantities. Allowance will be made for other openings as indicated.

No allowance will be made for additional cement used in depositing concrete under water; for use of chemical additives, for fillers, sealers, and tar paper used in expansion joints; for dowels or other materials used in bonding construction joints; for waterstops; and for painting metals.

Unless directed by the Engineer, no allowance will be made for concrete placed below the foundation elevation shown on the Plans. When approved by the Engineer, concrete used for leveling structure footings shall be measured by the c.y.(m^3) by the average end area method or other approved methods.

The hydro-blasting of the bridge deck, prior to placing a bridge deck overlay, will be measured for payment by the s.y.(m^2).

Structure Excavation, Foundation Preparation and Backfill will be measured and paid for in accordance with the provisions of **Section 204,** except when the Plans indicate that no payment will be made for excavation and foundation preparation, then no measurement of excavation will be made, and the costs involved shall be included in the unit prices bid for other items of construction.

When, under the provisions of **Subsection 204.10(a),** Foundation Preparation, the Contractor is permitted to place a foundation seal that is not included in the Plans, the costs of furnishing the concrete and placing the seal shall be entirely at the expense of the Contractor, unless the following requirements and conditions are complied with prior to placing the foundation seal:

1. Cofferdams in which seals are requested shall have been constructed in strict compliance with all of the provisions of **Subsection 204.09**, Protection of Excavation.

2. After investigation, the Engineer determines that conditions have been encountered which make it impracticable to de-water the foundation before placing the footing.
3. The Contractor requests and receives approval for the construction of the seal in writing.
4. The Department and the Contractor execute a Supplemental Agreement to establish a unit price per c.y.(m^3) and the method of measurement for the concrete to be used in the seal.

When the above conditions have been complied with, measurement and payment for the Concrete Foundation Seal will be in accordance with the terms of the Supplemental Agreement.

Unless otherwise indicated, deductions will be made for the volume of concrete displaced by the pile heads.

No additional compensation will be made for high early strength concrete substituted by the Contractor for other classes of concrete.

Reinforcement used in concrete structures, unless otherwise stipulated, will be measured and computed for payment by the pound(kilograms).

The weight for payment of steel bar reinforcement will be computed from the dimensions indicated on the Plans or ordered in writing by the Engineer and from the following table:

Bar Designation No. English (Metric)	**Mass, Lbs./Ft. (kgs/m)**
3 (10)	0.376 (0.560)
4 (13)	0.668 (0.994)
5 (16)	1.043 (1.552)
6 (19)	1.502 (2.235)
7 (22)	2.044 (3.042)
8 (25)	2.670 (3.973)
9 (29)	3.400 (5.060)
10 (32)	4.303 (6.404)
11 (36)	5.313 (7.907)

SPECIAL LARGE SIZE BARS

Bar Designation No. English (Metric)	Lbs./Ft. (Mass, kgs/m)
14S (43)	7.650 (11.380)
18S (57)	13.600 (20.240)

Metric Bar numbers are soft metric bar designations approximating the nominal diameter of the bars in mm. The English bar numbers designate the number of 1/8 of an inch increments in the nominal diameter of the bars. The nominal diameter of a deformed bar is equivalent to the diameter of a plain bar having the same weight per ft.(m) as the deformed bar.

No allowance will be made for any device for splicing, clamping, tying, or positioning the reinforcement.

Applied Texture Finish will be measured by the s.y.(m^2) of concrete surface treated. The surface area will be determined in accordance with the provisions of **Section 109**, Measurement and Payment.

604.31-Basis of Payment. The accepted quantities will be paid for at the respective contract unit price per c.y.(m^3) for Class A Concrete, Class D Concrete, Class L Concrete and Class S Concrete; per lb.(kg) for Steel Bar Reinforcement and Epoxy Coated Reinforcing Steel; and per s.y.(m^2) for Scarifying bridge deck surface and Applied Texture Finish; complete in place.

The concrete fillet above fabricated bridge girders will be paid as bridge deck concrete with the quantities based on the fillet required for a conventional deck forming system. Increases in the aforementioned fillet depth to solely accommodate the Contractor's chosen deck forming system (e.g. precast deck panels) will not to be measured and paid for directly. All costs of this increase will be included in other items bid.

The accepted quantities of leveling concrete shall be paid for at 40% of the price bid for the concrete that is to go into the footing.

Any deduction in monies due to the Contractor for failure to comply with the surface rideability requirements set forth in **Subsection 604.28** shall be make on a lump sum basis.

When field conditions result in the construction of a different type of box culvert or box bridge from that established on the Plans (box type to slab type or vice versa) the respective bid price per c.y.(m^2) for Class A concrete shall be increased by 15% for constructing a slab type in lieu of box type and decreased by 13% for constructing box type in lieu of slab type. No adjustment of Steel Bar Reinforcement unit bid price is to be made for the change in box culvert or box bridge type.

Where concrete does not meet the specified strength but is allowed to be included in the permanent construction as set out in **Subsection 604.21**,

Defective Concrete, or when tardy acceptance cylinders and/or cores fail to meet the strengths specified in **Subsection 604.16**, then the following table will be used for adjusting the bid price.

PERCENT BELOW SPECIFIED STRENGTH	PERCENT OF BID PRICE TO BE PAID*
0.1 – 3.3	95
3.4 – 6.7	90
6.8 – 10.0	80
10.1 – 13.3	70
13.4 – 16.7	60
16.8 – 20.0	50
20.1 – 23.3 `	45
23.4 – 26.7	40
26.8 – 30.0	35
30.1 – 33.3	30
> 33.3	25

*Payment to be based on unit price of item as bid, i.e., volume [c.y.(m^3)], length [ft.(m)], each, or other designated bid units. Payment of the above listed percentages includes cost of incidental items such as reinforcing steel when included in the price bid for the Item.

SECTION 605-WATERPROOFING

SECTION 605-WATERPROOFING

605.01-Description. This work shall consist of the application of waterproofing materials to Portland cement concrete masonry surfaces at the locations indicated on the Plans, in accordance with these Specifications and as directed by the Engineer.

MATERIALS

605.02-Materials. Materials used in this construction shall meet the following requirements, in addition to the general requirements of these Specifications:

Material	Section
Waterproofing Materials	**906**

605.03-Classification. Waterproofing will be classified and paid for under the following designations:

Class 1

Waterproofing Class 1 shall consist of a primer applied cold, followed by 4 applications of asphalt sealer applied hot, and 3 layers of bituminized fabric. The primer for asphalt sealer shall also be asphalt. The bitumen for the sealer, including the bitumen in the fabric, shall be all asphalt, as indicated on the Plans, and shall be of the type specified or indicated.

Class 2

Waterproofing Class 2 shall consist of a prime coat of asphalt applied cold, 4 seal coats of asphalt applied hot, with 3 layers of asphalt saturated fabric, and a protection course of asphalt plank. The type of asphalt for seal coats shall be as specified on the Plans or otherwise directed by the Engineer.

EQUIPMENT

605.04-Equipment. The equipment required for the satisfactory performance of this construction shall be on the project and approved by the Engineer before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

605.05-Preparation of Surface. Before any surfaces are waterproofed, they shall be given a Class 1 finish, in accordance with the provisions of **Subsection 604.22**. Immediately prior to applying the primer, the surface of the concrete shall be thoroughly cleaned of all dust or other objectionable material. The surface of the concrete shall be dry at the time the primer is applied.

Joints which are essentially open or are free construction joints, but that are not designed to provide for expansion, shall be first caulked and then filled flush with the surface, as specified.

605.06-Application.

Class 1

Waterproofing shall be applied only in dry weather and when the ambient temperature is above 40° F (4° C. Concrete surfaces shall have cured 10 days for Portland cement concrete and seven days for high-early-strength concrete.

Surfaces which waterproofing is to be applied upon shall be thoroughly dry and free from frost.

Waterproofing shall begin at the lower part of the surface and continue upward, if on inclined or vertical surfaces; and on horizontal surfaces, it shall begin at one end, unless otherwise directed by the Engineer, and continue through to the other end.

All bitumen, except primer coats, shall be mopped or brushed on the surface to be waterproofed. Spraying will be permitted for primer coats.

Mopping shall be so thorough that the surface will be completely covered, and where applied on fabric, it shall so completely cover each layer that the weave will be concealed and the layers of the fabric entirely separated.

Primer shall be uniformly spread over the surface at the rate of not less than 0.2 gal./s.y. (0.9 liter/m^2), and shall be allowed to cure thoroughly before the subsequent coats of hot bitumen are applied.

The hot bitumen coats and coating between fabric shall be applied uniformly. Not less than 0.25 gal./s.y.(1.1 liter/m^2) shall be used in each coating or between layers of fabric on horizontal surfaces and not less than 0.30 gal./s.y. (1.4 liter/m^2) on vertical surfaces.

All waterproofing material shall be carried continuously across expansion joints.

Bitumen to be applied hot shall be stirred or otherwise agitated to secure uniform heating and to avoid local overheating.

All surfaces that have been waterproofed with bituminous materials shall be thoroughly cured before backfilling or other material is placed against them.

The application temperatures for hot bitumen shall be between 250° F (120° C) and 325° F(165° C).

At the place of beginning waterproofing, and upon the prime coat, a section 2 in.(50 mm) wider than the strip of fabric to be applied and for the full length of the section shall be covered with hot bitumen and the strip of fabric shall be rolled or pressed thereon while the bitumen is hot. Upon 2 in.(50 mm) of this strip of fabric and an area of the adjoining surface equal to 2 in. (50 mm) more in width than a strip of fabric shall be applied a coating of hot bitumen, and a strip of fabric, full width, shall be rolled or pressed thereon, as required for the first strip. Thereafter, full widths of fabric shall be laid as specified for the

first strip, and in such manner that each strip will lap the preceding strip by 2 in.(50 mm). Side laps shall be not less than 2 in.(50 mm) and end laps not less than 12 in.(300 mm).

The second and third layers of fabric shall be applied in the same manner as the first layer of fabric, but the laps of the layers shall not come directly over the laps of either of the other layers. The third layer of fabric shall be completely covered with a coat of hot bitumen.

When placing upon vertical or inclined surfaces, the bitumen between two layers of fabric shall be allowed to cool before placing the next layer of fabric.

When placing upon horizontal surfaces, one layer may be applied immediately following the preceding layer, but care shall be taken not to disturb the preceding layer.

Each strip of fabric shall be laid without folds or creases, and all air bubbles and pockets shall be eliminated.

Class 2

The asphaltic materials and asphalt saturated fabric for Class 2 waterproofing shall be placed as prescribed above for Class I Waterproofing.

After the final coating of bitumen is applied to the fabric, and while it is hot, the asphalt plank shall be placed upon the bitumen and tightly laid, with the end joints broken in each layer of plank. After the planks are laid, all open cracks shall be filled with hot asphalt and the outer surface of the planks shall be given an application of hot asphalt.

The finished surface shall be smooth and true to line and grade.

605.07-Edges. At the edge of any surface, or where any surface is punctured by drains, pipes, openings, etc., suitable provisions shall be made to prevent water from getting between the waterproofing and the surface waterproofed. All flashings at curbs and against girders, spandrels, walls, etc, shall be constructed with separate sheets lapping the main sheets not less than 12 in.(300 mm).

605.08-Protection and Patching. Care shall be taken to prevent injury or damage to the materials applied in waterproofing. Any damage that occurs shall be repaired by patching. Patches shall extend at least 12 in.(300 mm) beyond the outermost portion damaged, and each succeeding layer shall extend at least 3 in.(75 mm) beyond the preceding layer.

Asphalt planks which become damaged shall be removed and relaid or replaced as directed by the Engineer.

605.09-Final Cleanup. Final cleanup shall be performed in accordance with **Subsection 104.11**.

COMPENSATION

605.10-Method of Measurement. Waterproofing of the various classes will be measured for payment by the s.y.(m^2). The area will be obtained from surface measurements of the area completed and accepted.

No deduction for areas not waterproofed of 9 s.f.(1 m^2) or less within the waterproofing area will be made.

605.11-Basis of Payment. Accepted quantities of waterproofing will be paid for at the contract unit price per s.y.(m^2), complete in place, for each of the Classes listed below that is called for in the Bid Schedule.

SECTION 606-PILING

SECTION 606-PILING

606.01-Description. This work shall consist of piling furnished and driven or placed in accordance with these Specifications and in reasonably close conformity with the Plans or as directed by the Engineer. The work shall include the furnishing and driving of test piling and production piling and making load tests, when specified on the Plans or included in the Contract.

606.02-Classification. Piling will be classified by the following designations: Steel "H" Piling, 8, 10, 12, and 14 in. (200, 250, 300 and 350 mm); Steel Pipe piling as designated on the Contract Plans; Timber Piling (Untreated), Sizes 1 and 2; Timber Piling (Treated), Sizes 1 and 2; Precast Prestressed Concrete Piling, 14, 16 and 18 in. (350, 400 and 450 mm); and Cast in Place Concrete Piling.

The Plans will indicate the designation and size of piling to be used in the construction.

MATERIALS

606.03-Materials. Materials used in this construction shall meet the following requirements, in addition to the general requirements of these Specifications:

Material	Subsection
Steel Piles	**908.15**
Timber Piles	**911.03**
Materials for Concrete	**604.02**
Reinforcement for Concrete Piles	**907.01**
Pre-stressing Reinforcement Steel and Anchorages	**907.04**
Steel Shells	**908.16**
Steel Pipes	**908.17**
Paint	**910.02**

EQUIPMENT

606.04-Equipment.

General.

All equipment required for handling and driving steel piling, timber piling, precast concrete piling, steel shells or steel pipe shall be on the project and approved by the Engineer before work will be permitted to begin.

Pile driving equipment shall include leads that are straight and constructed in such a manner as to afford freedom of movement to the hammer. The leads shall be held in position by guys or braces to insure support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary, unless otherwise approved by the Engineer.

All equipment and tools required for the manufacture of concrete for piles, whether precast or cast in place, shall conform to the requirements of **Subsection 604.04** and shall be approved by the Engineer before work will be permitted to begin.

Forms for precast concrete piles shall conform to the applicable requirements of **Subsection 604.05** or **Subsection 614.05**.

The plant and equipment furnished for steam and air driven hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The boiler or tank shall be equipped with an accurate pressure gauge. A gauge shall also be installed which will accurately measure the pressure at the hammer intake, unless another approved method is provided to furnish the data necessary for the determination of energy delivered by the hammer.

Diesel hammers shall be operated with a wide open throttle when blows are being counted for determination of average penetration to use in the safe load formula, except that in the case of diesel hammers with enclosed rams, the throttle settings shall be just short of the settings that would cause nonstriking parts of the hammer to rise off the piles as the ram piston travels upward.

Diesel hammers which have an enclosed ram shall be equipped with an accurate gauge and charts which will evaluate the equivalent energy actually being produced under any driving condition.

If the size or type of hammer used is found to be unsatisfactory, it shall be replaced with another size or type of hammer or other corrective measures shall be used as required to produce satisfactory results.

(a) Hammers for Timber Piles.

Timber piles shall be driven with an approved steam, air, diesel or gravity hammer.

1. Steam, air, or diesel hammers shall develop an energy of not less than 6,000 ft-lbs (8,135 Nm) per blow.
2. Gravity hammers shall weigh not less than 2,000 lbs (900 kgs) and not less than the weight of the driving head and pile. The height of fall shall be so regulated as to avoid injury to the pile and in no case shall exceed 20 ft (6 m).

(b) Hammers for Steel Piles

All steel type piles shall be driven with an approved steam, air or diesel hammer. Gravity hammers will be permitted only when requested by the Contractor and approved in writing by the Engineer. If approved, the requirements for the gravity hammer shall be as noted in No. 3 below.

1. Steam, air or diesel driven hammers shall:

(a) Develop at least 7,000 ft-lbs (9,500 Nm) of energy.

(b) Except as provided in paragraph 2.(b) below, develop an energy per blow in ft lbs. (Nm) of not less than 30(200) multiplied by R, where R is the required minimum bearing resistance of the pile in tons (kN).
(c) Have a gross energy in ft lbs. (Nm) of not less than 2.5(7.5) times the weight of the pile in lbs(kgs).

2. The additional following requirements apply to diesel driven pile hammers:

(a) Hammers which do not restrict the rebound of the ram shall have a ram weighing at least 2,000 lbs(900 kgs).
(b) Hammers which have an enclosed ram shall have a rated equivalent energy in foot-pounds- (Nm) of not less than 250(30) multiplied by R, where R is the required minimum bearing resistance of the pile in tons(kN).

3. When approved by the Engineer, gravity hammers may be used to drive steel piling provided that:

(a) The weight of the pile is no more than the weight of the hammer.
(b) The steel piling will be driven to refusal on rock, and the overburden is relatively free of boulders.
(c) The hammer shall weigh at least 3,000 lbs(1,350 kgs) and not more than 5,000 lbs(2,250 kgs). The height of fall shall be so regulated as to obtain a minimum energy per blow of 12,000 ft-lbs(16,250 Nm). The height of fall shall not exceed 10 ft(3 m), and shall be so regulated as to avoid damage to the pile.

(c) Hammers for Precast Concrete Piles

Precast concrete piles shall be driven with a steam, air or diesel hammer which shall develop an energy per blow in ft-lbs (Newton-meters) at each full stroke of the piston of not less than 12,000 ft-lbs(16,250 Nm) and not less than 3(1) times the weight in lbs(kgs) of the pile being driven. The maximum hammer energy shall be limited such that no damage occurs to the pile during driving.

The following further requirements also apply to diesel powered pile hammers:

(1) Hammers which do not restrict the rebound of the ram shall have a ram weighing:

(a) Not less than 2,750 lbs(1250 kgs) and
(b) not less than 1/4 the weight of the pile.

(2) Hammers which have an enclosed ram shall have a rated equivalent energy of not less than 15,000 ft-lbs(20,350 Nm) per blow.

(d) Hammers for Steel Shells or Steel Pipe.

Hammers used in driving steel shells or steel pipe for cast in place piles shall meet the requirements stipulated in **Subsection 606.04(c)**, Hammers for Precast Concrete Piles.

CONSTRUCTION REQUIREMENTS

606.05-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, Structure Excavation, Foundation Preparation and Backfill and Embankment Construction shall be performed in accordance with the requirements of **Sections 201, 202, 203**, **204**, and **205**, respectively. In areas where piles are to be driven and excavation or embankment construction is to be performed, the excavation or embankment shall be completed before the driving of piles begins.

606.06-Precast Concrete Piles. Precast concrete piles shall be constructed in accordance with the details shown on the Plans and the provisions of these Specifications. They shall be constructed of either air-entrained or non-air-entrained Class P concrete in accordance with the provisions of **Subsection 615.09**. The Contractor shall submit to the Department for approval a concrete design, indicating the proportions, the source or brand of all materials and the type of cement to be used. However, in no case will the cement content be less than 658 lbs per c.y.(390 kgs per m^3) of concrete. The concrete shall be prepared and placed in accordance with the applicable requirements of **Section 604** with the revisions and additions stipulated herein.

The reinforcement shall be assembled and placed as detailed on the Plans.

Stressing of cables for precast prestressed concrete piles shall be in accordance with the requirements of **Subsection 615.07** and **615.08**.

Piles shall be cast in a horizontal position. Casting in tiers will not be permitted. The concrete shall be placed continuously in each pile and shall be consolidated by mechanical vibration and spading. Special care shall be exercised to avoid horizontal or diagonal cleavage planes, and to see that the reinforcement is properly embedded in the concrete and not displaced. The forms shall be overfilled, the surplus concrete screeded off, and the top surface finished to a uniform, even texture similar to that produced by the forms.

Side forms may be removed as soon as their removal will not cause distortion to the hardened concrete. As soon as the forms are removed, surface irregularities shall be repaired, and unless otherwise specified, the piles shall be given a Class 1 finish in accordance with the requirements of **Subsection 604.22**.

Curing of the precast concrete piles shall be by the "Water Method" as prescribed in **Subsection 604.24**, or by steam curing in accordance with the provisions of **Subsection 615.11**.

No piles shall be moved from the bottom supporting forms, nor shall the stressing force on prestressed piles be released until the concrete has attained a compressive strength of not less than 3,500 psi(24.1 MPa), as evidenced by test specimens made and cured in the same manner as the piles.

The concrete in precast and precast prestressed piles shall have developed a compressive strength of at least 5,000 psi(34.5 MPa) and reached a minimum age of seven days before the piles are driven.

Test specimens shall be made, cured, and tested in accordance with the provisions of **Subsection 615.09**.

When concrete piles are handled or hauled, they shall be supported at the points shown on the Plans, or if not so shown, they shall be supported at the quarter points and the final inspection as to condition will be made after delivery to the site.

606.07-Cast in Place Concrete Piles.

(a) General.

Cast in place concrete piles shall be of the design shown on the Plans. They shall consist of concrete cast in drilled holes or in steel shells or pipes driven to the required bearing. Concrete shall be Class A, conforming to the requirements of **Section 604**. All water shall be removed from the inside of the drilled holes or the steel shells or pipes before the concrete is placed.

(b) Drilled Holes.

All holes for concrete cast in place piles shall be dry drilled to the tip elevations shown on the Plans. All holes will be examined for straightness and any hole on visual inspection from the top showing less than 1/2 of the diameter of the hole at the bottom will be rejected. Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is placed.

All loose material at the bottom of the hole after drilling operations have been completed shall be removed before placing concrete.

The use of water for drilling operations or for any other purpose where it may enter the hole will not be permitted. All necessary action shall be taken to prevent surface water from entering the hole.

(c) Casing.

Casing, if used in drilling operations, shall be removed from the hole as concrete is placed. The bottom of the casing shall be maintained not more than 5 ft(1.5 m) nor less than 1 ft(300 mm)

below the top of the concrete during withdrawal and placing operations, unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided by hammering or otherwise vibrating the casting.

(d) Steel Shells and Pipes.

The inside of shells and pipes shall be inspected in accordance with the provisions of **Subsection 606.15** and cleaned of all loose material before concrete is placed. The concrete shall be placed in one continuous operation from tip to cutoff elevation and shall be carried on in such a manner as to avoid segregation. The concrete in the upper 25 ft(7.5 m) of shell or pipe piles shall be consolidated by the use of vibrators.

No shell or pipe shall be filled with concrete until all adjacent shells, pipes, or piles within a radius of 5 ft.(1.5 m) or 4 1/2 times the average pile diameter, whichever is greater, have been driven to the required resistance.

After a shell or pipe has been filled with concrete, no shell, pipe, or pile shall be driven within 20 ft.(6 m) thereof until at least seven days have elapsed.

606.08-Test Piles. When called for in the Bid Schedule, the Contractor shall furnish and drive test piles of the dimensions, at the locations, and to the minimum tip elevations, shown on the Plans or as designated by the Engineer.

When approved by the Engineer, test piles to be load tested may be driven through the existing overburden, without excavating to the bottom of the footing elevation and by predrilling when required by the Engineer, provided that the additional length of test pile necessary to obtain the requirements specified below, shall be furnished at no additional cost to the project.

Before driving any other test or foundation piles, the ground at each test pile shall be excavated to the elevation of the bottom of the footing.

Test piles to be load tested shall be driven full length or to the specified bearing indicated on the Plans as determined by the applicable specification equation in **Subsection 606.14**; whichever occurs first. All other test piles shall be driven full length or to 1.5 times the specified bearing indicated on the Plans, whichever occurs first. However, the tip elevation for all piles shall be either a minimum of 10 ft(3 m) below ground elevation or the minimum tip elevation when specified on the Plans. If the test pile has been driven to 1.5 times the specified bearing but has not reached the minimum tip elevation, the test pile shall continue to be driven until the required penetration is obtained or practical refusal occurs, whichever occurs first. When the required pile penetration cannot be achieved by driving without exceeding practical pile refusal, other penetration aids such as jetting or preformed pile holes shall be used. Practical refusal shall be defined as 15 blows per in.(25 mm) for 2 consecutive in. (50 consecutive mm) of driving or when 2 times the minimum required bearing is achieved based on the last 6 in.(150 mm) of driving. Pile driving equipment shall be capable of

driving to 1.5 times the specified bearings indicated on the Plans at a driving rate not to exceed 15 blows per in.(25 mm). A load test shall be performed on one or more of the test piles as indicated on the Plans or as designated by the Engineer. From driving logs for test piles and hold-down piles, load tests and other available subsoil information, the Engineer will determine the number and length of piles to be used and the minimum required bearing.

The Engineer may require a test pile to be left in place for use, cut off, spliced, or removed.

Load tests shall consist of a test load accomplished by loading weights on a platform or by jacking against hold-down piles with suitable apparatus for accurately measuring the test load and the pile settlement under each increment of load. The pile load test apparatus for applying loads and measuring movement shall meet the requirements of ASTM D 1143. The load shall be applied so as not to exert any undue bending stresses or damage to the pile in any way. The loading and calibration system shall be capable of applying and recording loads up to 200% of the pile bearing values shown on the contract drawings. Materials used in performing load tests shall remain the property of the Contractor. Unless specified otherwise on the Plans, a minimum waiting period of 3 days shall elapse between installing the load test pile and commencing the test.

Load tests may be added, deleted or repeated as directed by the Engineer. Each load test performed in accordance with this Subsection shall be paid for at the unit price bid for load tests, except that a load test repeated for any given test pile from the same setup will be paid for at one-half the unit price bid for load tests.

The number of load tests and test piles shown on the Plans is based on the assumption that all tests piles are to be driven with the same pile driver as was used for the load test pile. Should the Contractor elect to drive some test piles with a different pile driver, he must furnish the necessary additional load tests at no additional cost to the project.

After the Engineer establishes the number and length of piles to be used, the regular piles may be driven with a different pile driver from that used for driving test piles provided the Engineer of Structures is notified prior to establishing pile lengths and the pile driver conforms to the requirements of the standard specification.

Prior to driving a pile to be load tested, the Contractor shall submit to the Engineer written details outlining his method of applying, measuring and recording test loads and shall include therewith sufficient sketches to fully illustrate the method, procedure and arrangements proposed. Calibration certificates from a laboratory approved by the Engineer for the jacks to be used in the tests shall be submitted to the Engineer. The certificates will not be acceptable if more than 6 months old.

The following are the 2 methods for performing pile load tests. The Contractor shall perform the quick load test unless directed otherwise on the Plans.

(a) Quick Load Test

The full test load shall be 200% of the pile load shown on the Plans. The load is applied in approximately equal increments of 10 to 20% of the pile load as shown on the Plans, and at intervals of 5 minutes throughout the load test. Readings of time, load and movement are taken and recorded immediately before and after the application of each load.

Load is applied until either a plunging failure occurs or the full test load is reached. Plunging failure occurs when continuous jacking is required to maintain the test load. After the final holding time, or immediately after plunging failure occurs, the applied load is removed in 5 approximately equal decrements with intervals of 5 minutes between decrements. Readings shall be taken after the removal of each decrement and 5 minutes after the complete removal of the test load.

(b) Maintained Load Test

The full test load shall be 150% of the pile load as shown on the Plans. It shall be applied in maximum increments of 25% of the pile load as shown on the Plans and will be applied at time intervals such that the rate of settlement does not exceed 0.12 in.(3 mm) per hour per load increment for a minimum interval of 2 hours. Readings of time, load and movement shall be taken and recorded immediately before and after the application of each load increment.

The failing load shall be defined as the minimum load that produces one of the following conditions:

(1) rate of settlement exceeding 0.12 in.(3 mm) per hour for a 2 hour period.
(2) settlement occurring during the last 12 hours of the full load test period.
(3) a permanent net settlement after rebound in excess of 1/4 in.(6 mm).

When failure occurs under condition 1, the applied load shall be decreased as necessary until the rate of settlement is within allowable limits in order to establish the failing load. A final reading shall be taken one hour after complete removal of the load. The failing load shall be accurately recorded and the full value of the unit price bid for load tests will be paid. The Engineer will decide to what extent, if any, the test pile will be considered as contributing to the support of the structure.

Should failure not occur due to condition 1, the load test shall be carried to completion with the full test load remaining on the pile for 48 hours and then removed in 6 equal increments at 1 hour intervals with readings taken after the removal of each increment and 1 hour after the complete removal of the test load.

The terminology in this Subsection is related to driven piles. However, it shall be applicable to cast in place piles if so designated on the contract drawings.

After the Contractor performs the load tests shown on the Plans, he may elect to substitute piling of a different material or configuration from that shown on the Plans provided they meet the minimum design standards and specifications and are approved by the Engineer. The required length of the substituted piling shall be determined by additional load test(s) at the Contractor's expense. The basis of payment for the piling shall be in accordance with **Section 606.22** except the total linear feet(meters) shall not exceed that established by load tests for the piles shown on the Plans.

When additional test piles that are load tested and deemed usable are made at plan location using the substituted material, payment will be made at the unit bid price for regular piling.

606.09-Calibration Tests. When diesel or other types of hammers requiring calibration are to be used, the hammers shall be calibrated by making load tests, as directed by the Engineer, even though no load tests are called for in the Bid Schedule, except that calibrations will not be required when the hammer is to be used only for driving piles to rock or a fixed tip elevation, or when the hammer is of a type and model that has previously been calibrated for similar type, size, and length of pile, and foundation material. Calibration data shall have been obtained from sources acceptable to the Engineer.

606.10-Order Lists for Piles. The Engineer will furnish the Contractor with an itemized list showing the number and length as determined by tests of all piles which will be required, complete in place. The Engineer will not prepare the list of piling for any portion of the foundation area until the required test data representative of that portion has been determined. The lengths given in the order list will be based on the lengths that are assumed to remain in the completed structure. The Contractor shall furnish the piles in accordance with the itemized list, except he shall, without added compensation, increase the lengths to provide for fresh heading and for such additional length as may be necessary to suit his method of operation.

If during driving of piling, conditions are encountered which require a change in lengths, said changes shall be made by cutting off if the pile is too long, by furnishing new piling, or by splicing in accordance with the provisions of **Subsection 606.16**, if the piling is too short.

No allowance will be made for delays occasioned by the procedure of determining the lengths of piles.

606.11-Storage and Handling. The method of storing and handling shall be such as to avoid injury to the piles. Steel piles shall be stored above ground and kept free of dirt and grease and, insofar as practicable, corrosion.

Hooks, dogs, pike poles, etc. shall not be used in handling timber piles and special care shall be taken to avoid breaking their surface.

Precast concrete piles shall be lifted by means of a suitable bridle or sling attached to the pile at points indicated on the Plans.

606.12-Driving Piles. All piles shall be driven at the locations shown on the Plans or as ordered in writing by the Engineer. They shall be driven

within an allowed variation as to direction of pile of not more than 1/4 in. per ft. (20 mm per m) of pile length, with a maximum variation at the head of the pile from the position shown on the Plans of not more than 3 in. (75 mm). Templates constructed of heavy timbers or steel, accurately positioned, securely held in place, and approved by the Engineer, shall be provided by the Contractor to insure proper positioning of each pile. When water jets are used, the number of jets and the nozzle volume and pressure shall be sufficient to erode the material adjacent to the piling freely. The pump shall have sufficient capacity to deliver at all times a pressure of at least 100 psi (690 kPa) at two 3/4 in. (19 mm) jet nozzles. Before the required penetration is reached, the jets shall be shut off and the piles driven by hammer to final penetration.

When preformed pile holes are used, they shall be constructed by drilling or driving and withdrawing a suitable punch or chisel at or near the locations of the piles. When preformed pile holes are oversized to the extent that the sides of a round pile or the corners of a square pile are not in contact with the soil, the Contractor at his expense shall restore lateral stability by filling the space between the pile and the sides of the hole with approved clean sand. Preformed holes must be terminated before the required penetration is reached, and the pile must be driven by hammer to the final tip elevation to seat the pile and secure the minimum required bearing.

Except when the pile head is fitted into a steel head block, every timber pile shall be provided with a metal collar or wire wrapping. The heads of all concrete piles and the heads of all other piles when the nature of the driving is such that piles may be unduly injured, shall be protected by caps of approved design, having a plywood cushion next to the pile head and fitting into a casting, which, in turn, supports a hammer cushion of man-made material (wire rope and other materials of limited durability should not be used). The actual thickness of the pile cushion used shall be sufficient to prevent damage to the pile during driving and shall be approved by the Engineer. A minimum initial dimension of 4 in. (100 mm) thick plywood pile cushion is required for concrete piles. The pile cushion should be replaced before excessive compression (more than 1/2 the original thickness), burning or charring takes place. During hard driving, several pile cushions may be necessary for a single pile. A new pile cushion should be used for each pile.

For special types of piling, driving heads, mandrels, or other devices in accordance with the manufacturer's recommendations shall be provided so that the pile may be driven without injury.

For steel piling, the heads shall be cut squarely and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer. When shown on the Plans, steel piles shall be capped with steel plates or other devices.

Full length piles shall be used where practicable. In exceptional circumstances, the splicing of piles may be permitted. The method of splicing shall be in accordance with the provisions of **Subsection 606.16**.

Production piles shall be installed full length, except that driving shall be terminated when practical refusal as defined in **Subsection 606.08** has been reached. If production piles do not achieve the minimum required

bearing when driven full length, the Engineer will determine if additional piling are required.

The tip elevation for all production piles shall be equal to or below the minimum pile tip elevation shown on the Plans. When the required pile penetration cannot be achieved by driving without exceeding practical refusal, other penetration aids such as jetting or preformed pile holes shall be used.

Piles raised during driving of other piles, or by any other cause, shall be driven down again at the Contractor's expense.

606.13-Bearing Value and Penetration. When load tests are called for in the Bid Schedule, the minimum number of hammer blows per unit of pile penetration needed to obtain the specified bearing value of piles will be determined by load tests prescribed in **Subsection 606.08** and **606.09**. In the absence of load tests, the safe bearing value shall be determined by the Engineer based on test pile data.

Each driven pile or shell shall have a minimum bearing value as shown on the Plans or as specified by the Engineer due to the results of the load test, or test pile data. Piles shall be driven with the same driving system (fuel setting, hammer cushion and pile cushion) as the test piles, or the pile that was load tested.

Piles used to penetrate a very soft upper stratum overlying a hard stratum shall penetrate the hard material a sufficient distance to fix the pile rigidly.

606.14-Determination of Bearing Value. The safe bearing value shall be determined by 1 of the following formulas

(a) $P = \frac{2WH}{S+1}$ for gravity hammers.

(b) $P = \frac{2WH}{S+0.1}$ for single acting steam or air hammers and diesel hammers with unrestricted rebound.

(c) $P = \frac{2H(W+Ap)}{S+.1}$ for double acting steam or air hammers.

(d) $P = \frac{2E}{S+0.1}$ for double acting steam or air hammers and diesel hammers having enclosed rams.

Where:

P = Safe load per pile in pounds;

W = Weight of the striking part of the hammer in pounds;
A = Area of piston in square inches;
p = Steam pressure in pounds per square inch at hammer;
H = Height of fall in feet for gravity, steam, and air hammers, and observed average height of fall, in feet, of blows used to determine penetration for diesel hammers with unrestricted rebound of ram;
S = Average penetration per blow in inches for the last 5 to 10 blows of a gravity hammer or the last 10 to 20 blows of a steam, air, or diesel hammer; and
E = Manufacturer's rating for ft.-lbs. of energy developed by double acting steam or air hammers, and 90% of the average equivalent energy in ft.-lbs., as determined by a gauge attached to the pile hammer and recorded during the period when the average penetration per blow is recorded for diesel hammers having enclosed rams. Hammers of this type shall be equipped with a gauge and applicable charts supplied which will evaluate the equivalent energy being produced under any driving condition.

Metric formulas:

(a) $P = \frac{1634WH}{S+25.4}$ for gravity hammers.

(b) $P = \frac{1634WH}{S+2.54}$ for single acting steam or air hammers and diesel hammers with unrestricted rebound.

P = Safe load per pile in Newtons (N).
W = Mass of the striking part of the hammer in kilograms (kgs.).
H = Height of fall in meters(m).
S = Average penetration per blows in millimeters (mm).

The above formulas are applicable only when:

1. The hammer has a free fall.
2. The head of the pile is free from broomed or crushed wood fiber or other serious impairment.
3. The penetration is at a reasonably quick and uniform rate.
4. There is no appreciable bounce after the blow.
5. The weight of pile is no more than the weight of hammer used, if hammer is of the gravity type.
6. A follower is not used.

The metric testing requirements for determination of bearing shall be as shown on the Plans.

If there is an appreciable bounce, twice the height of bounce shall be deducted from H to determine its value in the formula.

The bearing power, as determined by the appropriate formula in the foregoing list, will be considered effective only when it is less than the crushing strength of the pile.

Other recognized formulas for determining pile-bearing power may be used if fully detailed in the Special Provisions.

When the safe bearing value of any pile is found by test or computation to be less than the design load, longer piles or additional piles shall be driven as ordered in writing by the Engineer.

606.15-Inspection of Shells for Cast in Place Piling. After the shell has been driven, and the core withdrawn, the shell shall be inspected and approved before any concrete is placed. Shells that have been improperly driven, do not hold their proper form and dimensions, or are broken or otherwise defective, shall be removed and replaced.

606.16-Extensions and Splices.

(a) Steel and Timber Piles.

Full length steel or timber piles shall always be used where practicable, but if splices cannot be avoided, a method of splicing as detailed on the Plans shall be used. Spliced piles shall have a full, true, and even bearing at the joint. The splicing of timber piles in abutments will not be permitted.

(b) Precast Concrete Piles.

Extensions for precast concrete piles shall be made by cutting away the concrete at the end of the pile, leaving the reinforcement steel exposed for a length of 30 diameters.

Before cutting off a pile or building it up, it shall be securely braced to prevent any vibration during the cutting or building up. The final cut of the concrete shall be at right angles to the axis of the pile.

Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary forms shall be placed, care being taken to prevent leakage along the pile.

Just prior to placing concrete, the top of the pile shall be cleaned of all loose particles, thoroughly wetted, and covered with a thin coating of cement grout. The concrete shall be Class P or High early strength meeting the applicable requirements of **Section 604**, Concrete Structures and **Subsection 615.09**.

Buildups for precast prestressed concrete piling shall be constructed as detailed on the Plans and reinforcement similar to that used for precast concrete piling, Size 1, will be required.

Removal of forms shall be performed in accordance with the provisions of **Subsection 604.20**. After the forms have been removed, the concrete shall be given the required finish.

Caps to be supported by built-up precast concrete piles shall not be constructed until test specimens representing the concrete in the buildups attain a compressive strength of at least 3,000 psi (20.7 MPa).

606.17-Cutoffs and Treatment of Pile Heads. The tops of all piles shall be driven or cut to a true plane at the elevation shown on the Plans, or established by the Engineer.

Timber piles which support timber caps shall be sawed to the plane of the superimposed cap and shall fit snugly. Prior to receiving caps, untreated timber pile heads shall be treated as specified in **Subsection 601.07**.

After treatment, a covering of 20 gauge galvanized iron shall be placed upon each timber pile and folded down neatly over the side and fastened in such a manner as to shed water.

No treatment or covering of pile heads will be required if they are to be encased in concrete.

606.18-Conditioning of Treated Timber Piles after Driving. All places where the surface is broken by cutting, or otherwise, shall be thoroughly treated as specified in **Subsection 601.07**. Holes caused by withdrawing bolts, spikes, etc. and bored holes shall be treated as prescribed in **Subsection 601.06(k).**

606.19-Painting Steel Piles and Steel Shells. Unless otherwise provided, when steel piles or steel pile shells extend above the ground or water surface, they shall be protected by painting. This protection shall extend from an elevation 2 ft.(600 mm) below the low water or ground surface to the top of the exposed steel. Unless otherwise indicated, painting System A, as specified in **Subsection 603.06**, shall be used, except that the shop coat shall be applied in the field. Painting shall be performed in accordance with the provisions of **Section 603**, Painting.

606.20-Final Cleanup. After driving and completing the piling, the piles shall be cleaned of undue discoloration caused by construction operations. Those areas of concrete piles that will be exposed shall be given the applicable finish, as prescribed in **Subsection 604.22**.

Final cleanup shall be performed in accordance with **Subsection 104.11**.

COMPENSATION

606.21-Method of Measurement. Test piling will be measured by the linear ft.(m). The length of test piles, when driven, will be computed for payment as the total length of test piles indicated on the Plans or as required by the Engineer; or if the penetration for any o1ne test pile is greater than the length of the pile indicated or directed, then the linear ft.(m) of actual penetration of such test pile will be the linear ft. (m) of test pile measured for payment. Where a buildup or extension is placed on a test pile to be left in place, the actual linear feet.(meters) of buildup or extension will be

computed for payment for the size of pile used as the test pile. No allowance will be made for splicing, cutoffs, or cutting off a test pile in order to construct an extension or buildup upon the test pile. No payment will be made for cutting off or removal of test piles not to remain in place.

Pile loading tests will be computed for payment by the unit per each, which will be determined by the number of load tests performed.

Piling of the sizes indicated or as ordered by the Engineer, and constructed, complete in place, including buildups or extensions, will be measured by the linear foot.(meter). Measurement will not include the part cut off after driving.

Piling spliced, built up, or cut off to such an extent as to change the length of the completed piling from 1 size to the other size will be computed for payment in the size originally intended.

Splices for timber and steel piles will be measured for payment by allowing 3 ft.(1 m) of piling, complete in place, for each splice made, except measurement for payment of splices for steel will be made only for splicing performed within the limits noted below.

IN PLACE LENGTH	**MAXIMUM PAY SPLICES**
40 ft.(12 m) or less	None
> 40 ft. (12 m) $\leq$ 80 ft.(24 m)	1
> 80 ft.(24 m) $\leq$ 120 ft.(36 m)	2
> 120 ft.(36 m)	3

No allowance will be made for splicing shells or pipe for cast in place piling. No measurement for payment will be made for splices caused by damage to a pile.

No allowance will be made for cutting off cast in place piles. The length of pile cutoff for precast concrete, precast prestressed concrete, steel, steel shell and steel pipe piles measured for payment will be the actual length of the cutoff. Pile cutoffs shall be measured to the nearest 0.1 ft. (0.1 m). No measurement for payment will be made for steel, steel shell and steel pipe pile cutoffs having a length of 10 ft.(3 m) or greater. For precast prestressed concrete piles, the 2 ft. (600 mm) of piling required for seismic attachment, when the contractor chooses this option, shall not be included in the measurement for cutoff.

Unused lengths of piles and pile cutoffs shall remain the property of the Contractor and shall be removed from the project. No measurement for payment will be made for cutting off and for cutoffs caused by damage to the pile.

No measurement for payment will be made for digging or drilling holes, or for jetting piling, to obtain the required penetration.

606.22-Basis of Payment. Payment will be made only on the linear feet(meters) of piling measured and computed as outlined in **Subsection**

606.21, Method of Measurement**.** Pile cutoffs measured for payment will be paid for at the invoice price of the pile per foot(meter). The costs of preparing precast prestressed concrete piles for buildups will not be paid for directly but shall be considered as a subsidiary obligation in connection with building up the pile.

When the Contractor elects to use high-early-strength concrete, no additional payment will be made.

In the event that test piles and load tests indicate that piling will not be necessary or pile lengths shorter than those shown in the Plans will be acceptable, the price per linear foot(meter) for these test piles shall be full compensation for furnishing and removing all equipment for driving piling and the Contractor will not be compensated for any loss or anticipated profits for failure to use piling as shown. In the event that the Engineer directs the use of individual concrete production piling that is longer by more than 16 ft.(5 m) than that shown in the Plans, that concrete piling shall be paid for at a rate equal to 1.15 times the contract unit price per linear foot(meter) for that size concrete pile.

The accepted quantities will be paid per unit of measurement, respectively, for each of the pay items that is shown in the Bid Schedule, which price shall be full compensation for performing all operations incidental thereto, and for furnishing all materials, equipment, tools, labor, and incidentals necessary to complete the item.

SECTION 607-PIPE CULVERTS AND STORM SEWERS

SECTION 607-PIPE CULVERTS AND STORM SEWERS

607.01-Description. This work shall consist of the construction of pipe culverts, side drains, slope drains and storm sewers of the kinds and dimensions shown on the Plans or stipulated in the Proposal. The construction shall be accomplished in accordance with these Specifications and in reasonably close conformity with the lines, grades, and cross sections shown on the Plans or established by the Engineer. The work shall include such labor, materials, and equipment as may be necessary to make connections with other drainage structures as shown on the Plans or as directed by the Engineer.

MATERIALS

607.02-Materials. Materials used in this work shall meet the following requirements:

Material	Subsection
Concrete Pipe, Reinforced	**914.02**
Corrugated Metal Pipe Culverts, Pipe Arches and Underdrains	**915.02**
Joint Mortar	**905.02**
Rubber Gaskets	**905.03**
Polyethylene Plastic Pipe	**914.10**

Where Slope Drains are specified, they shall be metal pipe meeting the requirements of **Subsection 915.02**, or polyethylene pipe meeting the requirements of AASHTO M 294.

Where Pipe Culverts(Side Drains) are specified they shall be in accordance with the following:

(a) Pipe Culverts(Side Drains) 15 through 36 in.(375 through 900 mm) shall be one of the following:

  (1) Class III Concrete pipe meeting the requirements of either **Subsection 914.02** or AASHTO M 86.
  (2) Metal pipe meeting the requirements of **Subsection 915.02.**
  (3) Polyethylene pipe meeting the requirements of AASHTO M 294, Type S.

(b) Pipe Culverts(Side Drains) larger than 36 in.(900 mm) shall be either Class III Concrete pipe meeting the requirements of **Subsection 914.02** or metal meeting the requirements of **Subsection 915.02**.

Materials for special end connections to other pipes or structures, required to complete the work as indicated on the Plans or directed by the

Engineer shall conform to the requirements of the applicable Subsection of Division III Materials, unless otherwise specified.

Reinforced concrete pipe shall be flat base, round, or oval, as shown on the Plans.

The sizes of pipe shall be identified by the nominal inside diameter. The pipe shall be of the sizes stipulated in the Contract, shown on the Plans, or established by the Engineer.

Steel and aluminum pipe are considered as optional for corrugated metal pipe, pipe arches, and underdrains by the Department. The Contractor may use either option he prefers, however, in no case shall different metals or corrugations be mixed in a single line of pipe.

When paved or coated corrugated metal pipe and pipe arches are specified, either aluminum coating or bituminous coating may be used. The aluminum or bituminous coated pipe shall conform to the requirements of AASHTO M 274 or AASHTO M 190 respectively.

When precoated corrugated metal pipe and pipe arches are specified, polymer coating shall be used in accordance with **Subsection 915.03.** Coupling bands and all hardware except nuts, bolts and washers shall be of the same material and coating as the pipe.

When corrugated metal pipe arches are specified as "size equivalent round" the dimensions shall be as shown in the Plans.

When Polyethylene Plastic Pipe is specified, it shall conform to the requirements of AASHTO M 294, Type S.

EQUIPMENT

607.03-Equipment. The equipment provided by the Contractor shall include hoisting equipment capable of handling and placing the pipe in final position without damage to the pipe. Mechanical tamps shall also be included.

All of the above equipment, as well as any additional equipment necessary for the satisfactory performance of this construction, shall be on the project and approved by the Engineer before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

607.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203**, and **205** of these Specifications.

607.05-Structure Excavation and Foundation Preparation.
This work shall be performed in accordance with the provisions of **Section 204** of these Specifications.

The bedding for pipe culverts shall conform to the requirements of **Subsection 204.10 (b)** for Class A, Class B, or Class C. When no bedding class is specified, the requirements for Class C bedding shall apply.

Bedding for pipe culverts and storm sewer crossdrains shall have a longitudinal camber of the magnitude specified by the Engineer.

When excavation is made for installing storm sewers across private property, the topsoil and sod disturbed by the excavation operations shall be salvaged and replaced in its original position, unless otherwise specified. All costs of restoring the area to its original condition shall be included in the unit price bid for other items of construction.

607.06-Laying Pipe Culverts and Storm Sewers. Pipe culverts and storm sewers shall be laid beginning at the downstream end of the pipe line. The lower segment of the pipe shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid pipe and outside circumferential laps of flexible pipe shall be placed facing upstream. Flexible pipe shall be placed with longitudinal laps or seams at the sides.

Paved invert pipe shall be laid so that the longitudinal centerline of the paved segment coincides with the flow line. Vertical oval and elliptically reinforced pipes shall be placed with the major axis of the reinforcement within five degrees of a vertical plane through the longitudinal axis of the pipe.

All areas of flexible pipe where the spelter or bituminous coating has been damaged shall be painted with two coats of hot asphaltic paint or otherwise repaired in a satisfactory manner.

607.07-Joining Pipe. Rigid pipe may be of bell and spigot or tongue and groove design, unless one type is specified. The method of joining pipe sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints for rigid pipe shall be made with: (a) portland cement mortar; (b) rubber gaskets; or (c) other types of joints recommended by the pipe manufacturer and approved by the Engineer may be permitted.

For mortar joints, the pipe ends shall be thoroughly cleaned and wetted with water before the joint is made. Stiff mortar shall then be placed in the lower half of the bell or groove of the pipe section already laid and on the upper half of the spigot or tongue of the section to be laid. The 2 pipe sections shall then be tightly joined with their inner surfaces flush and even. The inside of the joint shall then be finished smooth and any surplus material removed from the pipe. The completed mortar joints shall be protected against rapid drying by suitable covering material.

Rubber ring gaskets shall be installed so as to form a flexible watertight seal. When other type joints are permitted, they shall be installed or constructed in accordance with the recommendations of the manufacturer.

Flexible pipe shall be firmly joined by approved coupling bands.

Pipe shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be taken up and relaid or replaced.

607.08-Field Strutting. When strutting or vertical elongation is required, it shall be performed in accordance with the details shown on the Plans.

Ties and struts shall be left in place until the embankment is completed, unless otherwise specified.

607.09-Backfilling. After the pipe is installed, the trench shall be backfilled in accordance with the provisions of **Section 204** and the standard drawings..

After the backfilling and embankment are complete and prior to placing the base, the contractor shall, at the request of the Engineer, be required to perform deflection and alignment tests on each line of pipe. For pipes 24 in.(600 mm) in diameter and smaller, this testing shall be performed using a 9 vane mandrel with a diameter that is 5% less than the nominal diameter of the pipe being tested. The mandrel vanes shall be equally spaced around the central core. Any line of pipe through which the mandrel does not freely pass, shall be replaced by the Contractor at his own expense.

Pipes 30 in.(750 mm) and larger in diameter may be tested by a mandrel as described above or they may have their deflection and alignment checked by other means as approved by the Engineer. Any pipe with a deflection in excess of 5% of the nominal pipe diameter, or with undue misalignment shall be replaced by the Contractor as his own expense.

607.10-Disposal of Excess or Unsuitable Material. Excess or unsuitable excavated material shall be disposed of as directed by the Engineer. Excavated material shall be utilized as prescribed in **Subsection 204.08(c).**

607.11-Final Cleanup. Final cleanup shall be performed as prescribed in **Subsection 104.11**.

COMPENSATION

607.12-Method of Measurement. Concrete pipe culverts and concrete storm sewers of the different classes, shapes, and sizes specified, will be measured by the linear foot(meter) of pipe installed and accepted. The quantity of pipe cut off, not to exceed 2 ft.(600 mm), will be paid for at the contract bid price for pipe in place.

Corrugated metal pipe, and corrugated metal structural plate pipe will be measured by the linear foot(meter) of pipe installed and accepted. Measurements will be made as follows:

(a) Metal pipe and metal structural plate pipe, with square and vertical ends or with skewed and vertical ends will be measured, in place, end to end of the metal on the centerline of the structure.
(b) Metal pipe and metal structural plate pipe, with square ends beveled, and with ends skewed and beveled, except arch pipe, will be measured, in place, by averaging the end to end distances at the top and bottom of the pipe, measured parallel to the centerline of the structure.
(c) Metal arch pipe and metal structural plate arch pipe with square ends beveled, and with ends skewed and beveled, will be measured, in place, end to end of the metal along the invert of the structure.

Slope Drains will be measured in the same manner as specified for corrugated metal pipe is **Subsection 607.12**.

Pipe Culverts(Side Drains) of the different sizes specified will be measured by the linear foot(meter) along the centerline of the installed pipe, except that no measurement for payment will be made in excess of the ordered length of the pipe. Pipe Culverts (Side Drains) will be ordered in increments of 2 ft.(600 mm).

Unless otherwise indicated on the Plans, no measurement of structure excavation will be made; and the costs involved shall be included in the unit prices bid for other items of construction. When the Plans provide for direct payment for structure excavation, measurement and payment will be in accordance with **Section 204**.

No payment will be made for labor and materials used in making branch connections. The length of pipe in the branch connection will be measured and included in the quantity of pipe installed in the branch line.

Strutting of corrugated metal pipe and corrugated metal structural plate pipe will not be paid for separately, but the costs thereof shall be included in the unit price bid per linear foot(meter) of pipe.

607.13-Basis of Payment. The accepted quantities of pipe culverts and storm sewers, measured as provided for above, will be paid for at the contract unit price per linear foot(meter) for each type, class, shape, and size constructed, complete in place, which price shall be full compensation for labor and materials used in making joints, and connections to other structures; for strutting, when required, and for completing all incidentals necessary to complete the item.

The accepted quantities of Pipe Culverts(Side Drains) and Slope Drains will be paid at the contract unit price per linear foot(meter) for each size constructed, complete in place, including labor and materials for making joints, excavation and backfill, and all incidentals necessary to complete the work.

SECTION 608-SANITARY SEWERS

SECTION 608-SANITARY SEWERS

608.01-Description. This work shall consist of constructing sanitary sewers, or parts of sewers, composed of the kinds and dimensions of pipe shown on the Plans or established by the Engineer. Sanitary sewers shall be constructed in accordance with the provisions of these Specifications, and at the locations and in reasonably close conformity with the lines and grades indicated on the Plans or as directed by the Engineer.

The work shall include such incidentals, materials, and labor as may be required in making connection with other structures, as indicated on the Plans or as directed by the Engineer.

MATERIALS

608.02-Materials. Materials used in this construction shall meet, in addition to the general requirements of these Specifications, the following requirements:

Material	Subsection
Concrete Pipe, Non-Reinforced	**914.01**
Concrete Pipe, Reinforced	**914.02**
Vitrified Clay Pipe	**914.06**
Cast Iron Pipe	**915.01**
Hemp or Oakum Gaskets	**905.04**
Rubber Gaskets	**905.03**
Joint Mortar	**905.02**
Polyvinyl Chloride (PVC) Pipe	**914.09**

EQUIPMENT

608.03-Equipment. Equipment requirements for this work shall be as prescribed in **Subsection 607.03**.

CONSTRUCTION REQUIREMENTS

608.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203**, and **205** respectively, of these Specifications.

608.05-Structure Excavation and Foundation Preparation. This work shall be performed in accordance with the requirements for pipe culverts specified under **Section 204** of these Specifications.

The bedding for sanitary sewers shall conform to the requirements of **Subsection 204.10(b)** for Class A, Class B, or Class C. When no bedding class is specified, the requirements for Class C bedding shall apply.

608.06-Pipe Laying. When the new facilities or other construction interfere with the existing flow of sewage, the Contractor shall provide

satisfactory by-pass facilities. Sewage shall not be carried in an open ditch at any time. Unless otherwise specified, the costs incurred in providing by-pass facilities will not be paid for directly, but shall be included in the unit price bid for other items of construction.

The pipe shall be laid without break in grade from structure to structure and with the bell or groove end upgrade. Each section shall have firm bearing throughout its length and shall be laid to form a close concentric joint with the adjoining pipe. Junctions and turns shall be made with standard or special fittings.

Water shall not be allowed to run or stand in the trench while pipe laying is in progress, before the joint has completely set, or before the trench has been backfilled. The Contractor shall not open up more trench at any time than his available pumping facilities are able to dewater.

Whenever the work ceases for any reason, the end of the pipe shall be securely closed with a tight fitting plug or cover. All branch openings or service connections provided for future use shall be securely closed with a tight fitting plug and sealed to avoid leakage. Pipe to be abandoned shall have all open ends plugged and sealed in a manner approved by the Engineer.

When the pipe connects with structures, the exposed ends shall be placed or cut off flush with the interior face of the structure and satisfactory connections made.

Any pipe which is not in good alignment or which shows any undue settlement or is damaged shall be taken up and relaid without additional compensation.

608.07-Joint Construction. Laying pipe and sealing joints shall be a continuous operation. All joints shall be sealed during the same day in which the sections of pipe are laid. The joints shall be constructed in such a manner that a watertight joint will result and the method of connection shall meet with the approval of the Engineer.

The joints of cast iron pipe shall be thoroughly cleaned, and then jointed and sealed with materials recommended by the pipe manufacturer.

Joints in concrete or clay pipe shall be made with hemp or oakum gaskets impregnated with hot asphalt and sealed with hot poured sewer joint sealing compound, hemp or oakum impregnated with neat cement grout and sealed with mortar, rubber gaskets, mastic compound, or other elastic material, or other types of joint recommended by the pipe manufacturer.

As the work progresses, the interior of all pipe in place shall be thoroughly cleaned.

608.08-Connections. Connections shall be made by the construction of manholes, other structures or the installation of wyes or tees as shown on the Plans or as directed. Wyes and tees for future connections shall be installed as indicated or directed.

Connections to existing structures and sanitary sewer house service connections shall be made as shown on the plans or directed by the Engineer.

The cost of temporary connections and disinfecting and deodorizing excavation or sewage shall be included in the unit price bid for other items of construction.

608.09-Test for Watertightness. Tests for watertightness, when required, shall be performed by and at the expense of the Contractor. The tests shall be conducted in the presence of the Engineer and in accordance with the established procedures prescribed by the local municipality, utility or owner.

Sanitary sewers and connections showing leakage in excess of that allowed by the local codes or established regulations shall be rebuilt or repaired, as required, at the Contractor's expense before acceptance. Rebuilt or repaired sewers shall pass the above test before acceptance.

608.10-Backfilling. After the pipe is installed, the trench shall be backfilled in accordance with the provisions of **Section 204**.

COMPENSATION

608.11-Method of Measurement. Pipe for sanitary sewers, of the various kinds, types and sizes, will be measured by the linear foot(meter) of pipe installed and accepted. The length will be determined by measuring along the centerline of the pipe from center to center of structures, or junction fittings. An allowance of 2 feet(600 mm) of the kind and size of pipe in the sewer line will be made for each wye or tee required in the line. Each kind, type and size, determined by the nominal inside diameter of the pipe, shall be measured separately.

Sanitary sewer house service connections will be measured per each.

No payment will be made for labor and materials used in making branch connections.

Unless otherwise indicated on the Plans, no measurement of structure excavation will be made; and the costs involved shall be included in the unit prices bid for other items of construction. When the Plans provide for direct payment for structure excavation, measurement and payment will be in accordance with **Section 204**.

608.12-Basis of Payment. Accepted quantities of sanitary sewers, measured as provided for above, will be paid for at the contract unit price per linear foot(meter) of pipe of each kind and size, including incidental appurtenances, complete in place.

Payment for sanitary sewer house connections shall be complete in place including all incidentals of the work.

SECTION 609-PIPE REMOVED AND RELAID

SECTION 609-PIPE REMOVED AND RELAID

609.01-Description. This work shall consist of removing and relaying pipe culverts and storm sewers or sanitary sewers as shown on the Plans, stipulated in the Proposal, or directed by the Engineer. Removal and relaying shall be accomplished in accordance with these Specifications and in reasonably close conformity with the lines, grades, and cross sections shown on the Plans or established by the Engineer.

The work shall include such labor and materials as may be necessary to make connections with other drainage structures as shown on the Plans or as directed by the Engineer.

This item shall not include pipes which are to be removed but not to be incorporated in the work.

MATERIALS

609.02-Materials. Materials used in this construction, in addition to meeting the general stipulations of these Specifications, shall meet the following requirements:

Material	Subsection
Joint Mortar	**905.02**
Rubber Gaskets	**905.03**
Hemp or Oakum Gaskets	**905.04**

All materials and devices used in making connections shall be approved by the Engineer before being used.

EQUIPMENT

609.03-Equipment. Equipment requirements shall be as prescribed in **Subsection 607.03**.

CONSTRUCTION REQUIREMENTS

609.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, and Excavation and Undercutting shall be performed in accordance with the provisions of **Sections 201, 202, and 203**, respectively.

609.05-Removal of Pipe. The pipe shall be carefully removed and so handled as not to damage or cause the pipe to be unfit for relaying.

The Contractor shall be required to replace, at his own expense, pipe of the kind and quality damaged by his negligence or inefficient handling or any other action under his control.

609.06-Preparation of Pipe for Relaying. The pipe shall be thoroughly cleaned, inside and outside, of dirt, debris, mortar, and other foreign matter.

The Contractor shall perform any necessary cutting of salvaged pipe in order to obtain required lengths and shall furnish coupling bands, gaskets, and other jointing materials necessary to make all connections.

All pipe to be relaid shall be sound and in good condition. Any broken or deteriorated section of pipe or connection cannot be used.

609.07-Structure Excavation and Foundation Preparation. This work shall be performed in accordance with the provisions of **Subsection 607.05**.

609.08-Relaying or Placing Pipe. The requirements for relaying or placing pipe of the various types specified shall be as prescribed for the respective types in **Subsections 607.06, 607.07, 607.08, 608.06**, and **608.07**.

609.09-Backfilling. Backfilling shall be performed in accordance with the provisions of **Section 204** for pipe culverts.

609.10-Final Cleanup. All excess or unsuitable material shall be disposed of as directed by the Engineer.

Final cleanup shall be performed as prescribed in **Subsection 104.11**.

All material becoming the property of the Department shall be stored as directed by the Engineer.

COMPENSATION

609.11-Method of Measurement. Pipe removed and relaid, of the various kinds, will be measured by the linear foot(meter) along the center-line of the pipe and from end to end of the pipe, complete in place, including incidentals, after relaying.

Pipe removed but not relaid will not be measured for payment. Excavation, including the volume occupied by the pipe, made for the removal of pipe under this Section will be measured for payment in accordance with the provisions set out in **Subsection 204.12** of these Specifications, for culvert excavation (unclassified).

Unless otherwise indicated on the Plans, no measurement of structure excavation will be made; and the costs involved shall be included in the unit prices bid for other items of construction. When the Plans provide for direct payment of structure excavation, measurement and payment will be in accordance with **Subsection 204.12** for culvert excavation(unclassified), and the volume occupied by the pipe will be included in the measurement for payment.

609.12-Basis of Payment. Accepted quantities of pipe removed and relaid will be paid for at the contract unit price per linear foot(meter) for each type of pipe, complete in place.

Payment for pipe used to replace pipe which has been rejected, except pipe to be replaced at the Contractor's expense will be made under the Section covering the type and kind of pipe being replaced.

SECTION 610-PIPE DRAINS

SECTION 610-PIPE DRAINS

610.01-Description. This work shall consist of furnishing and constructing or placing pipe drains not classified as pipe culverts or storm sewers in **Section 607**, sanitary sewers in **Section 608**, or underdrains in **Section 710**. Pipe drains shall be constructed of the kinds and sizes of pipe as shown on the Plans, called for in the Proposal, or established by the Engineer. Pipe drains shall be constructed above or below ground at the locations and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer, and in accordance with these Specifications.

The work shall include all incidentals, appurtenant materials, and work necessary to perform and to complete the construction.

MATERIALS

610.02-Materials. Materials used in this construction shall meet, in addition to the general requirements of these Specifications, the following requirements:

Material	Section or Subsection
Non-Reinforced Concrete Pipe	**914.01**
Vitrified Clay Pipe	**914.06**
Cast Iron Pipe	**915.01**
Corrugated Metal Pipe (Non-Perforated)	**915.02**
Corrugated Aluminum Pipe (Non-Perforated)	**915.02**
Joint Mortar	**905.02**
Rubber Gaskets	**905.03**
Paint	**910**
Plastic and Polyethylene Corrugated Tubing	**914.07**

The paint system to be used will be indicated on the Plans.

Where Pipe Drains (Bridge Drains) are specified, they shall be metal pipe meeting the requirements of **Subsection 915.02**, or polyethylene pipe meeting the requirements of AASHTO M 294.

EQUIPMENT

610.03-Equipment. All equipment necessary for the satisfactory performance of this construction shall be on the project and approved by the Engineer before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

610.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, and Excavation and Undercutting shall be performed in accordance with the provisions of **Sections 201, 202**, and **203**, respectively.

610.05-Structure Excavation and Foundation Preparation. Structure excavation and foundation preparation shall be performed in accordance with the provisions of **Section 204**.

Bedding for pipe drains, unless otherwise stipulated, shall be Class C bedding as prescribed in **Subsection 204.10(b)**.

610.06-Backfill. Backfilling of trenches shall be performed in accordance with the requirements of **Section 204** for pipe culverts.

610.07-Suspending Pipe Drains. Where pipe drains are to be placed above the ground surface, they shall be suspended as shown on the Plans or as directed by the Engineer. They shall be securely and rigidly held in place.

610.08-Placing and Jointing Pipe. Pipe for drains shall be placed in conformity with all applicable requirements of **Subsection 607.07**. Jointing of concrete, clay, and corrugated metal drain pipe shall be performed in accordance with the provisions of **Subsection 607.07**, Joining Pipe.

Jointing of cast iron pipe shall be performed in accordance with the recommendations of the manufacturer, using the fittings and methods recommended by the manufacturer.

610.09-Painting Pipe Drains. Concrete, vitrified clay, and corrugated metal pipe drains shall not be painted, even if these are to be exposed, unless otherwise shown on the Plans.

Cast iron drains that are to be exposed and which do not have a bituminous coating shall be painted in accordance with the applicable requirements of **Section 603**. Cast iron pipe drains which have a bituminous coating shall be cleaned and treated with 2 coats of bituminous material of such kind and grade that the finished coating will be tough when cold and not tacky during hot weather.

Painting shall include all hangers, braces, and other appurtenances.

610.10-Finishing and Final Cleanup. All excess or unsuitable material shall be disposed of as directed by the Engineer.

Final cleanup shall be performed in accordance with the requirements of **Subsection 104.11**.

COMPENSATION

610.11-Method of Measurement. Pipe drains, of the various kinds and sizes, will be measured for payment by the linear foot(meter)along the centerline of the pipe, and from end to end of the pipe, including incidentals, complete in place. The kinds, and sizes determined by the diameter of each pipe will be measured separately.

No measurement for payment will be made for excavation, foundation preparation or backfilling in the construction of pipe drains.

No measurement for payment will be made of hangers, braces, supports, etc. for suspending or hanging pipe drains.

Pipe used in weep holes and drainage openings 6 in.(150 mm) in diameter or less, through concrete abutments, decks, slabs, floors, walls, etc. will not be paid for directly or under the pay items of this Section, but are treated under **Section 604**.

610.12-Basis of Payment. Accepted quantities of pipe drains will be paid for at the contract unit price per linear foot(meter) for the various kinds and sizes of pipe drains, complete in place.

SECTION 611-MANHOLES, CATCHBASINS, INLETS AND PIPE END WALLS

SECTION 611-MANHOLES, CATCHBASINS, INLETS, AND PIPE END WALLS

611.01-Description. This work shall consist of constructing manholes, catchbasins, inlets, and pipe end walls at the locations shown on the Plans, and in reasonably close conformity to the lines, grades, and design dimensions shown on the Plans, or as directed by the Engineer, and in accordance with the provisions of these Specifications.

The work shall include the furnishing and installation of such incidental appurtenances and connections to pipe and other structures as may be required to complete the construction as shown on the Plans or as directed by the Engineer.

MATERIALS

611.02-Materials. Materials used in this construction, in addition to meeting the general stipulations of these Specifications, shall meet the following requirements:

Material	Subsection
Structural Steel	**908.01**
Building Brick, Concrete (Grade and Size Specified)	**912.01**
Sewer Brick (Grade and Size Specified)	**912.02**
Masonry Mortar	**912.03**
Steel Bar Reinforcement	**907.01**
Gray Iron Castings	**908.07**
Manhole Steps	**918.22**
Precast Manholes and Catch Basins	**918.07**

Cast in place portland cement concrete shall be Class A concrete, and shall be manufactured, placed and cured in accordance with the applicable requirements of **Section 604**.

All bolts, anchors, frames, hangers, etc. for castings and plates shall be as approved by the Engineer.

The Contractor may use either the manhole and catch basin sections detailed on the plans or substitute comparable sections of cast in place concrete, precast reinforced concrete or brick masonry, as may be applicable. When a substitution is proposed for a manhole or catch basin section detailed on the plans, the Contractor shall construct the substitute section in accordance with the applicable Standard Drawing as approved by the Engineer. In the event the Department has no Standard Drawing of the substitute section the Contractor shall submit shop drawings of the revised section to the Engineer for approval prior to construction. After securing the necessary approval, the Contractor shall furnish the Engineer a permanent, 4 mil(100 µm) mylar reproducible of the design.

EQUIPMENT

611.03-Equipment. All equipment necessary for the satisfactory performance of this construction shall be on the project and approved by the Engineer before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

611.04-Preliminary Work. Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203**, and **205**, respectively of these Specifications.

611.05-Structure Excavation, Foundation Preparation and Backfill. Structure Excavation, Foundation Preparation and Backfill shall be performed in accordance with the requirements of **Section 204**. No backfill or traffic shall be allowed on cast in place sections until 7 calendar days have elapsed since the representative test specimens have attained the required compressive strength.

611.06-Concrete Construction. All concrete construction shall be accomplished in accordance with the requirements of **Section 604**.

611.07-Inverts. Inverts shall be of Class A concrete and shall conform to the shapes indicated on the Plans. The inverts shall be so constructed as to cause the least possible resistance to flow. The shape of the inverts shall conform uniformly to inlet and outlet pipes. A smooth and uniform finish will be required.

611.08-Brick Construction. All brick construction shall be performed in accordance with the provisions of **Section 613**.

611.09-Inlet and Outlet Pipes. Inlet and outlet pipes shall extend through the walls of manholes, catchbasins, and inlets for a sufficient distance beyond the outside surface to allow for connections, but shall be cut off flush with the wall on the inside surface, unless otherwise directed.

The concrete or brick and mortar shall be so constructed around the pipes as to prevent leakage and form a neat connection.

611.10-Castings and Fittings. Castings and fittings shall be handled in a manner that will prevent damage. All damaged castings and fittings shall be rejected.

All castings and fittings shall be placed in the positions indicated on the Plans or as directed by the Engineer, and shall be set true to line and grade.

If castings are to be set in concrete or cement mortar, all anchors or bolts shall be in place and position before the concrete or mortar is placed. The casting shall not be disturbed until the mortar or concrete has set.

When castings are to be placed upon previously constructed masonry, the bearing surface of masonry shall be brought true to line and grade and

present an even bearing surface in order that the entire face or back of the casting will come in contact with the masonry. Castings shall be set in mortar beds or anchored to the masonry as indicated on the Plans or as directed by the Engineer.

All castings shall be set firm and snug and shall not rattle.

611.11-Final Cleanup. All excess or unsuitable material shall be disposed of as directed by the Engineer.

Final cleanup shall be performed in accordance with **Subsection 104.11**.

COMPENSATION

611.12-Method of Measurement. When the Bid Schedule indicates manholes, catchbasins, and inlets to be measured by the unit(per each), measurement will be made in accordance with the following:

(a) Manholes will be measured by the unit, per each, for the various types, diameters and ranges of depth as indicated on the Plans.
(b) Catchbasins will be measured by the unit, per each, for the various types and ranges of depth as indicated on the Plans.
(c) Inlets will be measured by the unit, per each, for the various types, indicated on the Plans.

When the Bid Schedule contains items for various components of manholes, catchbasins, inlets, and end walls, measurement will be made in accordance with the following:

(a) Brick masonry will be measured by the 1,000 brick, complete in place, in accordance with the provisions set out in **Section 613** of these Specifications.
(b) Portland cement concrete and steel bar reinforcement will be measured in accordance with the provisions set out in **Section 604**.
(c) Structural steel and gray iron castings will be measured by the computed weight based on the dimensions shown on the Plans and deducting for open holes. To this weight will be added 5% allowance for fillets and overruns. Scale weights may be substituted for computed weights of small complex parts for which accurate computations would be difficult.
(d) Steps will not be paid for directly, but the cost thereof shall be included in the unit price of the pay items of other materials with which the structure is constructed.
(e) Unless otherwise indicated on the Plans, no measurement of structure excavation will be made; and the costs involved shall be included in the unit prices bid for other items of construction. When the Plans provide for direct payment for structure excavation, measurement and payment will be in accordance with **Section 204**.

611.13-Basis of Payment. The accepted quantities will be paid per unit of measurement, respectively, for each of the pay items listed below that is shown in the Bid Schedule, which price shall be full compensation for performing all operations incidental thereto; and for furnishing all materials, equipment, tools, labor, and incidentals necessary to complete the item.

When approved substitutions are made for manhole and catch basin sections detailed on the plans, the accepted quantities will be paid for based on the prices bid for the quantities of the items replaced by the substitute sections.

SECTION 612-STONE MASONRY

SECTION 612-STONE MASONRY

612.01-Description. This work shall consist of the construction of stone masonry structures and stone masonry portions of concrete, steel, timber, and composite structures, at the locations and in reasonably close conformity with the lines, grades, and dimensions shown on the Plans or as directed by the Engineer, and in accordance with the requirements of these Specifications.

MATERIALS

612.02-Materials. Materials used in this work shall meet the following requirements:

Material	Subsection
Masonry Stone	**918.10**
Masonry Mortar	**912.03**

612.03-Classification. Stone Masonry will be classified under the following designations:

Uniform-Course Stone Masonry shall consist of masonry constructed with roughly squared stones laid in uniform courses, and in which all courses have approximately the same thickness.

Nonuniform-Course Stone Masonry shall consist of masonry constructed with roughly squared stones laid in uniform courses, and in which the courses may have different thicknesses.

Uncoursed Stone Masonry shall consist of masonry constructed with roughly squared stones of varying thicknesses and not constructed in courses.

Rustic Stone Masonry shall consist of masonry constructed with stones broken to various shapes and sizes.

EQUIPMENT

612.04-Equipment. All equipment necessary for the satisfactory performance of this construction shall be on the project and approved by the Engineer before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

612.05-Preliminary Work. Before beginning work on stone masonry, all necessary Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203**, and **205**, respectively.

612.06-Structure Excavation, Foundation Preparation, and Backfill. This work shall be performed in accordance with the provisions set out in **Section 204** of these Specifications.

The foundation for this type of construction shall present a uniform bearing surface, and if a reinforced foundation is necessary, it shall be constructed of Class A concrete, in accordance with the applicable provisions and requirements set out in **Section 604** of these Specifications, or as directed by the Engineer.

612.07-Preparation of Stone. All shaping and dressing of stone shall be completed before the stone is placed. Stone for angles, ends of walls, copings, etc. shall be selected, squared, and pitched to line. The faces of stones to be exposed shall not show tool marks.

Uniform-coursed masonry stone shall be of the thickness shown on the Plans. Stones to be used in any one course of nonuniform-coursed masonry shall be of the same thickness, with a minimum thickness of 5 in.(125 mm). In uncoursed masonry, not more than 10% of the stone shall be of the same thickness, with a minimum thickness of 5 in.(125 mm).

Stone for uniform-coursed masonry, nonuniform-coursed masonry, and uncoursed masonry shall have a width not less than 1 1/2 times the thickness with a minimum of 12 in.(300 mm), and a length not less than 1-1/2 times the width, unless otherwise indicated or directed. Headers shall have a width not less than the thickness, with a minimum of 12 in.(300 mm) and a length sufficient to extend entirely through walls of 2 ft.(600 mm) or less in thickness, and at least 1 ft.(300 mm) into the core of the wall for walls more than 2 ft.(600 mm) thick. The beds and sides of all stone shall be so dressed that adjacent stones will not touch and that the face joint will not exceed 1-1/2 in.(38 mm). The face protrusions shall not exceed 2 in.(50 mm).

Rustic masonry stone shall consist of stone broken to various shapes and sizes and roughly squared back from the face not less than 3 in.(75 mm). At least 80% of the stone shall have a minimum face dimension (rise) of not less than 6 in.(150 mm). The other face dimension at right angles to the rise shall not exceed 2 times the rise, or 2 ft(600 mm), whichever is smaller. The third dimension shall be at least 1 1/2 times the rise with a minimum of 12 in.(300 mm). Not more than 10% of the stones shall be of the same face dimensions. Headers shall be of such length as to extend entirely through walls of 2 ft.(600 mm) or less in thickness, and at one foot(300 mm) into the core of walls more than 2 ft.(600 mm) in thickness. The beds and sides of all stones shall be so dressed that the adjacent stones will not contact and so the face joints shall not exceed 1 1/2 in.(38 mm). The face protrusions shall pot exceed 2 in.(50 mm).

612.08-Laying Stone. When indicated on the Plans, the Contractor shall build at a site designated by the Engineer an L-shaped sample section of wall not less than 5 ft.(1.5 m) high and 8 ft.(2.4 m) long, showing an example of face wall, end wall, top wall, method of turning corners, and method of forming joints, which shall be approved by the Engineer before

beginning construction, and no masonry, other than the foundation bed, shall be laid prior to the approval of such sample walls.

Stone masonry shall not be constructed in freezing weather, or when the stone contains frost.

The bottom of foundation course shall be composed of large, selected stones, and shall be laid with bearing beds parallel to the natural bed of the material.

The larger stones shall be used in the bottom of the wall, gradually becoming smaller toward the top, but stones of various sizes shall be uniformly distributed throughout, care being taken to eliminate the meeting or bunching of either small stones or stones of the same size.

Selected large stones, roughly pitched to lines, shall be used at all corners and ends of walls.

Unweathered stones and stones of the same color, where exposed, shall be well and uniformly distributed throughout the wall to avoid appearances of patches. Each stone shall be thoroughly cleaned and well moistened with water before being set, and the bed, which is to receive the stone, shall be thoroughly cleaned and well moistened with water before placing mortar thereon.

All stones shall be well embedded in freshly made mortar. The joints shall be full and the stones carefully settled in place before the mortar is set. Stones shall not contact adjacent stones, but shall be suspended in the mortar. In no case shall the 4 corners of adjacent stones be contiguous unless otherwise indicated or directed.

The backing shall consist chiefly of large stones laid in full mortar beds, well bonded with each other and interlocked and bonded with the face stones. All spaces and interstices shall be filled completely with mortar, or spalls surrounded completely with mortar.

The stones shall be handled in a manner that will not jar or displace stones already set. Rolling or turning of stones on the wall will not be permitted.

In case any stone is moved or the joint broken after setting, the stone shall be taken up, the mortar thoroughly cleaned from the stone bed and joints, and the stones reset in fresh mortar.

Headers shall hold in the heart of the wall, the same size shown in the face, and shall extend not less than 12 in.(300 mm) into the core or backing, unless otherwise indicated. They shall occupy not less than 1/5 of the face of the wall and shall be evenly distributed. Headers in walls 2 ft.(600 mm) or less in thickness shall extend entirely through the walls.

Except in rustic masonry, spalls will not be permitted in the beds or face joints. The bed joints and beds shall have an average thickness of not more than one in.(25 mm). Horizontal face joints shall be not less than 1/2 in.(13 mm) nor more than 1 in.(25 mm) and shall be approximately uniform in thickness. Vertical face joints shall be not less than 1/2 in.(13 mm) nor more than 1 1/2 in. (38 mm) in thickness.

Uniform-course and non-uniform-course masonry shall be laid to line and grade, and in courses roughly leveled up. Vertical joints in coursed masonry shall be broken with those in adjoining courses at approximately the middle of the stones.

Uncoursed stone masonry shall be laid to line and with the bed of the stone approximately parallel and level. Horizontal face joints shall not extend through more than 4 stones and vertical face joints shall not extend through more than 2 stones. All joints shall break approximately at the middle of the adjacent stones.

Rustic stone masonry shall be so constructed that the stone of the various face sizes will be well and uniformly distributed throughout the face of the wall, care being taken to eliminate the meeting or bunching of either small stones or stones of the same size. Spalls may be used but shall not be segregated. The joints along the face shall be not less than 1/2 in.(13 mm) nor more than 1 1/2 in.(38 mm) in thickness; shall be approximately uniform in width and shall not extend in a straight line through more than 2 stones. Face joints shall run in all directions and at various angles with each other. In general, bed surfaces shall be practically perpendicular to the face of the wall for not less than 3 in.(75 mm) from which point they may be irregular and fall off not to exceed 3 in.(75 mm) in 12 in.(300 mm), and shall be free from depressions or projections that will impair the strength of the masonry or hinder the securing of full bearing on the mortar.

Weep holes shall be constructed of such shape and size as indicated or directed; and unless otherwise indicated on the Plans or directed by the Engineer, they shall be spaced not over 10 feet(3 meters) center to center, and shall be located at the lowest point where free outlet may be obtained. The inlet end of weep holes shall be protected by placing a wire basket 1 by 1 by 1 ft.(300 x 300 x 300 mm), filled with coarse aggregate, size 7, 8, 57 or 68 immediately over or behind the holes as directed.

Care shall be taken at all times to keep the surface free from mortar stains. Immediately after laying and while the mortar is fresh, all face stones shall be cleaned thoroughly of all mortar stains and shall be kept clean.

The top edge or course shall be finished to a true line with a uniform surface on top of the wall.

612.09-Pointing. Face joints shall be properly pointed before the mortar in the joints becomes set.

Face joints which cannot be so pointed shall be prepared for pointing by raking them out squarely to a depth of approximately 2 in.(50 mm) before the mortar has set. Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar. The mortar shall be well driven into the joints and finished with an approved pointing tool.

When weather joints are required, the bed shall be weather struck; the joints slightly raked to conform to the bed weather joints and, in no case, shall the mortar be flush with the faces of the stones. If required by the Engineer, they shall be wetted and pointed with mortar.

Joints on top surfaces shall be raked out to a depth of approximately 1 in.(25 mm) at the edges and be crowned to drain.

The walls upon which pointing is being performed shall be kept moist for a period of at least 72 hours after completion, and in hot, dry weather, the pointed masonry shall be protected from the sun during this period.

The face surfaces of stone shall not be smeared with the mortar forced out of the joints, or that used in pointing.

After the pointing is completed and the mortar is set, the stone shall be thoroughly cleaned and left in a neat and workmanlike condition.

612.10-Arch Rings. A full size template of the arch ring shall be laid out near the quarry site, showing face dimensions of each ring stone and thickness of joints. The template shall be approved by the Engineer before shaping of any ring stone is started, and no ring stone shall be placed in the structure until all ring stones have been shaped, dressed, and approved.

Arch centering shall be constructed in accordance with construction drawings submitted by the Contractor as required by **Subsection 105.02**. Suitable wedges shall be provided for raising or lowering the forms to exact elevation and for taking up any settlement occurring during loading. Centering shall be lowered gradually and symmetrically in order to avoid overstresses in the arch.

When directed, centering shall rest upon approved jacks in order to take up and correct any slight settlement that may occur after the placing of masonry has begun. In general, centering shall be struck and the arch made self-supporting before railing or coping is placed.

When additional falsework or bracing is necessary to hold the stones in position, the Contractor shall construct them in a manner satisfactory to the Engineer.

Arch ring stones shall be the size indicated on the Plans and shall be dressed to form radial joints not more than 1 in.(25 mm) in width. On the face and soffit, the joints shall be cut hard for a distance of at least 3 in.(75 mm), from which point, they may fall off not to exceed 1 in.(25 mm) in 1 foot(300 mm). The joints shall be completely filled with mortar; if necessary, they shall be grouted. The joints shall be pointed or finished while the mortar is fresh.

An anchor composed of 1/2 in.(13 mm) steel bar bent into an elongated letter S shall be placed in each voussoir joint extending at least 1 ft.(300 mm) into the backing and to within 3 in.(75 mm) of the face of the stone.

612.11-Copings, Top Walls, Bridge Seats, Back Walls, Etc. Copings, top walls, bridge seats, back walls, etc. shall be constructed to the lines, grades, and cross sections, and of the material, indicated on the Plans or as directed by the Engineer.

Copings, tops of wall, bridge seats, back walls, etc. constructed of concrete shall be of Class A concrete conforming to the applicable requirements of **Section 604**, unless otherwise indicated on the Plans or directed by the Engineer. Concrete copings shall be constructed in sections from 5 to 10 ft.(1.5 to 3 m) long and shall be of such width and thickness as indicated on the Plans. Stone copings shall consist of carefully selected stones of the length, width, and thickness indicated on the Plans. They shall have a uniform surface and be pitched to line along the top and bottom edge.

612.12-Finishing and Final Cleanup. Stone masonry surface, which is to be exposed, shall be cleaned thoroughly of all mortar, scars, or blemishes and shall present a surface having a natural color of stones. Wire brushes

and acid which will not mar or injure the stone or mortar shall be used when required.

Final cleanup shall be performed as prescribed in **Subsection 104.11**.

COMPENSATION

612.13-Method of Measurement. Stone masonry, complete in place, will be measured for payment by the c.y.(m^3). The volume will include the c.y.(m^3) placed within the lines indicated on the Plans and typical cross sections, or as directed by the Engineer. The different classifications of mortar stone masonry will be measured separately. Arch rings will be included in the measurements of the classifications of masonry in connection with which they are constructed, unless otherwise indicated.

Copings, tops of walls, bridge seats, and back walls constructed of concrete will be measured for payment in accordance with the applicable provisions set out in **Section 604** of these Specifications.

Concrete used in reinforcing foundations will be measured for payment in accordance with the applicable provisions set out in **Section 604** of these Specifications.

Copings, tops of walls, bridge seats, and back walls constructed of stone will be included in the measurements of the classification of masonry in connection with which they are constructed.

Unless otherwise indicated on the Plans, no measurement of structure excavation will be made; and the costs involved shall be included in the unit prices bid for other items of construction. When the Plans provide for direct payment for structure excavation, measurement and payment will be in accordance with **Section 204**.

612.14-Basis of Payment. The accepted quantities of Uniform-Course Stone Masonry, Nonuniform-Course Stone Masonry, Uncoursed Stone Masonry, and Rustic Stone Masonry will be paid for at the contract unit price per c.y.(m^3) for the respective classifications and designations, complete in place.

SECTION 613-BRICK MASONRY

SECTION 613-BRICK MASONRY

613.01-Description. This work shall consist of brick masonry structures, and the brick masonry portions of concrete, steel, timber, and composite structures, constructed at the locations and in reasonably close conformity with the lines, grades, and dimensions shown on the Plans, and in accordance with the requirements of these Specifications.

MATERIALS

613.02-Materials. Materials used in this work shall meet the following requirements:

Material	Subsection
Building Brick (Kind and Grade as Specified)	**912.01**
Masonry Mortar	**912.03**

EQUIPMENT

613.03-Equipment. All equipment necessary for the satisfactory performance of this construction shall be on the project and approved by the Engineer before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

613.04-Preliminary Work. Before beginning work on brick masonry, all necessary Clearing and Grubbing, Removal of Structures and Obstructions, Excavation and Undercutting, and Embankment Construction shall be performed in accordance with the provisions of **Sections 201, 202, 203**, and **205**, respectively, of these Specifications.

613.05-Structure Excavation, Foundation Preparation, and Backfill. Structure Excavation, Foundation Preparation, and Backfill shall be performed in accordance with the requirements of **Subsection 612.06**.

613.06-Mortar. Requirements for mortar for brick masonry shall be as prescribed in **Subsection 912.03**.

613.07-Laying Brick. Brick masonry shall not be constructed in freezing weather nor when the bricks contain frost.

Brick for exposed surfaces, corners, etc., shall be selected from approved brick as to color and uniformity.

All brick shall be thoroughly cleaned and well moistened with water immediately before being laid and the bed, which is to receive the brick, shall be thoroughly cleaned and well moistened with water before placing thereon.

All brick shall be laid in freshly made mortar, in a substantial and workmanlike manner and true to the lines and grades indicated on the Plans or as directed by the Engineer. The arrangement of headers and stretchers

shall be such as will thoroughly bond the masonry and, unless otherwise indicated or directed, brick masonry shall be of alternate headers and stretchers with consecutive courses breaking joints.

Brick shall be laid in courses so as to be thoroughly bonded with the joints completely filled with mortar.

The courses shall be laid continuously, and with consecutive courses breaking joints. Face joints shall be neatly struck, using the weather joint. All joints shall be finished properly as the laying of brick progresses and shall be not less than 1/4 in.(6 mm) nor more than 1/2 in.(13 mm) in thickness.

No spalls or bats shall be used except in shaping around irregular openings or when unavoidable to finish out a course, in which case a full brick shall be placed at the corner and the bat in the interior of the course. Filling materials for the interior of the walls shall be of the same quality as used in the face of the unit, unless otherwise indicated on the Plans or directed by the Engineer.

The surface of brick masonry against which embankment or backfill is to be placed shall be neatly plastered with mortar to a thickness of not less than 1/2 in.(13 mm), and the mortar shall be finished to a true and uniform surface. The mortar shall be protected and kept wet for 48 hours after completion.

Care shall be taken to keep the exposed surface of brick free from mortar stains. Immediately after laying, all face brick shall be cleaned thoroughly of all mortar stains.

Weep holes shall be constructed of such shape and size as indicated or directed; shall be spaced not over 10 ft.(3 m) center to center and shall be located at the lowest point where free outlet may be obtained, unless otherwise directed by the Engineer. The inlet end of weep holes shall be protected by placing a wire basket 1 by 1 by 1 ft. (300 x 300 x 300 mm) filled with coarse aggregate size 7, 8, 57 or 68 immediately over or behind the holes as directed.

In case any brick is moved or the joints broken after laying, the brick shall be taken up, the mortar thoroughly cleaned from the brick, bed, joints, and the brick relaid in fresh mortar.

Brick masonry shall be protected and kept wet for a period of 48 hours after laying brick.

All brick masonry shall present an even, uniform, neat and workmanlike appearance.

613.08-Copings, Tops of Walls, Bridge Seats, Back Walls, Etc. Copings, tops of walls, bridge seats, back walls, etc. shall be constructed to the lines, grades, cross sections and of the material indicated on the Plans or as directed by the Engineer.

Copings, tops of walls, bridge seats, back walls, etc., constructed of concrete shall be Class A concrete conforming to the requirements of **Section 604** of these Specifications, unless otherwise indicated on the Plans or directed by the Engineer. Concrete copings, etc. shall be constructed in sections from 5 to 10 ft.(1.5 to 3 m) long and shall be of such widths and thicknesses as indicated on the Plans or as directed by the Engineer. The sections may be cast in place or precast and set in place in full mortar beds.

Concrete shall be finished in accordance with the provisions and requirements of **Subsection 604.22**.

Copings, tops of walls, bridge seats, back walls, etc., constructed of stone shall be of stone masonry of the classifications indicated on the Plans or as directed by the Engineer. They shall be of the design and thickness indicated on the Plans.

Stone copings shall consist of carefully selected large stones of the length, width, and thickness indicated on the Plans. The stone shall have a uniform surface and be pitched to line along the top and bottom edge. All stone shall comply with the requirements and provisions set out in **Section 612** of these Specifications.

613.09-Finishing and Final Cleanup. Brick masonry which is to be exposed in the completed construction shall be cleaned of all mortar, scars, and blemishes, and shall present a surface having the natural color of the brick.

Final cleanup shall be performed as prescribed in **Subsection 104.11**.

COMPENSATION

613.10-Method of Measurement. Brick masonry will be measured for payment by the cubic yard(m^3) or by the 1,000 brick, as called for in the Plans, placed within the lines shown on the Plans and typical cross sections or as established by the Engineer.

When brick masonry is computed by the c.y.(m^3), the volume will include the mortar.

When brick masonry is computed by the 1,000 brick, the mortar will not be considered. Fractional parts of brick used, when 1/2 brick or greater, will be included in the measurements; if less than 1/2 brick, they will not be included.

Concrete used in reinforcing foundations and in copings, tops of walls, bridge seats, and back walls will be measured for payment as prescribed in **Section 604**.

Copings, tops of walls, bridge seats, and back walls constructed of stone masonry will be measured and paid for as prescribed in **Section 612**.

Unless otherwise indicated on the Plans, no measurement of structure excavation will be made; and the costs involved shall be included in the unit prices bid for other items of construction. When the Plans provide for direct payment for structure excavation, measurement and payment will be in accordance with **Section 204**.

613.11-Basis of Payment. Accepted quantities of Brick Masonry will be paid for at the contract unit price per c.y.(m^3) or per 1,000 brick, whichever unit is called for on the Plans or in the Proposal, complete in place.

SECTION 614-PRECAST CONCRETE BRIDGE DECKS

SECTION 614-PRECAST CONCRETE BRIDGE DECKS

614.01-Description. This work shall consist of the manufacture of precast concrete units for bridge decks and the hauling, storage, and placing of the precast members on a prepared substructure, to the established lines and grades, all in accordance with the design, dimensions, and details shown on the Plans and in accordance with the provisions of these Specifications.

The fabrication of these items shall be accomplished in plants that have been certified by the Precast/Prestressed Concrete Institute(PCI). The fabricator shall have been certified by the PCI for the product, which he will be manufacturing and supplying to the State or its Contractor.

MATERIALS

614.02-Materials. The materials used in this construction, in addition to the general requirements of these Specifications, shall conform, unless otherwise stipulated, to the requirements prescribed in **Part 9, Materials**, for the particular kind and type of material specified.

Bolts, dowels, and other miscellaneous hardware shall conform to the requirements shown on the Plans.

EQUIPMENT

614.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on hand and approved by the Engineer before work will be permitted to begin. Such equipment shall include the equipment required under **Subsection 604.04**.

CONSTRUCTION REQUIREMENTS

614.04-General. The substructure upon which precast concrete deck units are to be placed shall be constructed as shown on the Plans and in conformity with the applicable Sections of these Specifications.

The precast concrete deck units shall be cast in a certified precast plant under plant control conditions, and in accordance with the TDOT procedure for the Manufacture and Acceptance of pre-cast concrete drainage structures, noise wall panels, and retaining wall panels".

614.05-Forms. Unless otherwise permitted, all forms shall be metal and they shall be mortar-tight and of sufficient rigidity to prevent any distortion due to pressure of the concrete and other stresses incident to the construction operations. The forms shall be substantial and unyielding and shall be so designed, set and maintained that the finished concrete will conform to the proper dimensions and contours.

Forms shall be filleted at all sharp corners and shall be given a bevel or draft in the case of all projections to insure easy removal.

Forms shall be treated with oil immediately before placing the concrete. Any material that will adhere to or discolor the concrete shall not be used.

614.06-Proportioning and Mixing Concrete. Concrete for precast units shall be air-entrained(6±2%) Class P concrete, meeting the requirements of **Subsection 615.09**. The Contractor shall submit a design in accordance with the applicable provisions of **Subsection 604.03**.

614.07-Handling and Placing Concrete. Prior to placing any concrete, the forms shall be cleaned of construction debris and other extraneous matter. The reinforcing bars, of the size and type specified, shall be placed and secured as shown on the Plans.

Concrete shall be placed in the forms immediately after mixing, and in no case shall concrete be used which does not reach its final position in the forms within 30 minutes after the time the cement is added to the mix. The concrete shall be so placed as to avoid segregation of the materials and displacement of the reinforcement.

Open troughs and chutes used shall be of metal or shall be metal lined, and shall be kept clean and free from hardened concrete. Water used in flushing shall be discharged clear of the forms.

614.08-Consolidation. During and immediately after the placing operation, the concrete shall be well consolidated by the use of vibrators and suitable spading tools. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators used may be internal or external or a combination of both. The vibration shall be of sufficient duration and intensity to compact the concrete thoroughly, but shall not be continued to the extent as to cause segregation. Concrete in the precast units shall be placed in one continuous operation for each unit, except for the minimum delay required for installing voids.

The entire operation of depositing and consolidating the concrete shall be so conducted that the concrete will be smooth and dense and free from any honeycomb or pockets of segregated aggregates. Roadway surfaces shall be given a Class 3 finish in accordance with the provisions of **Subsection 604.22**.

614.09-Placing Bolts, Drains, Etc. All bolts, drains, etc. shall be placed in the concrete by the methods and at the locations indicated on the Plans.

614.10-Removal of Forms, Finishing, and Curing. Side forms may be removed as soon as their removal will not cause distortion or damage to the concrete.

Curing of the precast units shall be by the "Water Method," as prescribed in **Subsection 604.24**, or by steam curing, in accordance with the provisions of **Subsection 615.11**.

The units shall remain on the bottom supporting forms until the concrete has reached a compressive strength of 3,500 psi(24.1 MPa), as evidenced by representative test cylinders cured in the same manner as the unit.

The concrete in the units shall have developed the specified compressive strength, as evidenced by the acceptance test cylinders, before the units are shipped or placed. No traffic will be allowed on the deck until

10 calendar days have elapsed from the date the representative test cylinders have attained the compressive strength specified in the plans.

Test specimens shall be made, cured and tested in accordance with the provisions of **Subsection 615.09** of these Specifications.

614.11-Tolerances. The 4 sides of the units shall not vary more than 1/8 in.(3 mm) for the full depth of the slab when tested with a straight-edge in a vertical position, nor more than 1/4 in.(6 mm) in the full length of the unit when tested with a straightedge in a horizontal position. The top of the units shall not vary more than 1/8 in.(3 mm) in any 12 ft.(3.6 m) length.

614.12-Handling and Placing Precast Units. Beginning with the March 2005 highway contract letting, all contractors or subcontractors directly engaged in the erection of concrete bridge beams or girders over active traffic lanes, on any route, railroads or any streams deemed navigable to commercial or pleasure water craft, shall be required to show proof of a current erector certification. Erectors of concrete beams and girders shall be qualified under the American Institute of Steel Construction. (AISC) Advanced Certified Steel Erector Category. Current certification must be submitted to the Engineer prior to commencing erection.

Precast units shall not be handled in any manner that will result in crushing, spalling, or marring of the concrete.

The abutting edges of each unit shall be carefully cleaned of any concrete or extraneous matter in order that the longitudinal joints may be bolted together tightly.

614.13-Bridge Rail. The bridge rail shall be constructed in conformity with details shown on the Plans and in accordance with the provision of **Section 620**, Bridge Railing.

COMPENSATION

614.14-Method of Measurement. Precast concrete members will be measured by the linear foot(meter) for the various lengths of curb units and interior units, complete in place. The linear measurement will be determined from the nominal lengths shown on the Plans.

Bridge rail, complete in place, will be measured and paid for in accordance with the provisions of **Section 620**, Bridge Railing.

614.15-Basis of Payment. Accepted quantities of precast units for bridges will be paid for at the contract unit price per linear foot(meter) for Precast Concrete Unit(Curb Unit) or Precast Concrete Unit(Interior Unit), for the various lengths, which payment shall be full compensation for completing the work in accordance with these Specifications.

SECTION 615-PRECAST/PRESTRESSED CONCRETE BRIDGE MEMBERS

SECTION 615-PRECAST/PRESTRESSED CONCRETE BRIDGE MEMBERS

615.01-Description. This work shall consist of the manufacture of precast/prestressed structural concrete members and the hauling, storage, and placing of the precast/prestressed members on a prepared substructure, to the established lines and grades, all in accordance with the design, dimensions, and details shown on the Plans and in accordance with the provisions of these Specifications.

The fabrication of these items shall be accomplished in plants that have been certified by the Precast/Prestressed Concrete Institute, Plant Certified Inspector (PCI). The fabricator shall be certified by the PCI for the product, which they will be manufacturing and supplying to the State or its Contractor.

615.02-Pre-stressing Methods. The individual bridge members shall be prestressed by pretensioning, post tensioning, or a combination of both methods.

Plans for prestressed members will be fully detailed for at least one of the above methods. A pre-stressing method other than that detailed on the Plans may be used if approved by the Engineer.

The fabrication of precast/prestressed concrete members shall be in a precast/prestressed Concrete Institute certified plant, category B-3 and have at each fabrication site a technician skilled in the approved pre-stressing method. This technician shall give specialized aid and instruction in the use of the pre-stressing equipment and installation of materials as may be necessary to achieve the required results. The fabricator of precast/prestressed concrete members shall also have at each fabrication site a quality control technician capable of performing all necessary quality control inspection and testing to insure that the precast/prestressed member is applicable for its intended use. The quality control technician shall have direct lines of communication to engineering, production and management with responsibility only to management and shall not be subject to control by production (plant superintendent).

MATERIALS

615.03-Materials. Materials used in this construction, in addition to meeting the general stipulations of these Specifications, shall meet the following requirements:

Material	Section or Subsection
Portland Cement	**901.01**
Fine Aggregate	**903.01**
Coarse Aggregate	**903.03**
Water	**918.01**
Air-Entraining Admixtures	**918.09**

Chemical Additives	**918.09**
Cement Concrete Curing Materials	**913**
Joint Filler, Preformed Type	**905.01**

Material	**Section or Subsection**
Steel Bar Reinforcement	**907.01**
Pre-stressing Reinforcement Steel and Anchorages	**907.04**
Structural Steel	**908.01**
Elastomeric Bearing Pads	**908.12**
Paints	**910**
Grout, Type 1	**918.21**

EQUIPMENT

615.04-Equipment. All equipment necessary for the satisfactory performance of this construction shall be on hand and approved before work will be permitted to begin. Such equipment shall include the equipment specified under **Subsection 604.04**. A Type 'A' field laboratory meeting the applicable provisions of **Subsection 106.06** shall be required.

CONSTRUCTION REQUIREMENTS

615.05-General. The substructure upon which the precast/prestressed structural concrete members are to be placed shall be constructed as shown on the Plans and in conformity with the applicable Sections of these Specifications.

The panels shall be fabricated in a plant certified by the Precast/Prestressed Concrete Institute (PCI) category B-3.

The precast/prestressed structural concrete members shall be constructed in an approved plant under plant control conditions, and shall be placed upon the substructure to the established lines and grades in accordance with the details shown on the Plans.

Each plant shall have a quality control plan as specified in **Subsection 604.03** of these specifications.

615.06-Forms. External forms for this construction shall conform to the requirements of **Subsection 614.05**, except that wooden bulkheads may be used.

Internal forms may be of reinforced cardboard or cellular polystyrene. When cellular polystyrene is used it shall meet the following requirements:

Density (ASTM D 1622)	0.90 pcf (14.4 kg/ m^3) minimum
Compressive Strength @ 10% Deformation (ASTM D 1621)	10 psi(70 kPa) minimum
Absorption (ASTM C 272)	3% (vol.) maximum

Each individual form shall have a cross sectional area equal to the cross sectional area of the beam void and shall be a minimum of 5 ft.(1.5 m) in length. When individual forms are constructed by gluing pieces together they are to be glued with an approved glue. Any form that shows signs of glued joint separations will be rejected.

615.07-Stressing Requirements-General. Prior to use in manufacture of prestressed members under these Specifications, all jacks to be used, together with their gauges, shall be calibrated. When required by the Department, calibrations shall be by proving rings or other acceptable methods performed by an approved testing laboratory at the expense of the Contractor. A calibration chart for each device shall be readily available on site and furnished to the Department. Calibration of jacks and gauges shall be repeated at intervals of not more than 4 months. Means shall be provided for measuring the elongation of reinforcement to at least the nearest 1/16 in.(2 mm).

For all methods of tensioning, force in the tendons shall be determined by monitoring either applied force or elongation and independently checked by measuring the other. At the completion of tensioning operations, the two control measurements, force and elongation, shall agree within 5% of the computed theoretical values. If discrepancies are in excess of 5%, the tensioning operation shall be suspended and the source of error determined and evaluated by qualified personnel before proceeding. Recalibration will be required if the discrepancy cannot be determined. Additionally, the control measurements of force and elongation shall algebraically agree with each other within 5%. If the measurements do not agree within 5%, a load cell may be added at the “dead end” and if force measurements agree within 5% between the gauge at the live end and the load cell at the dead end, the elongation agreement can be waived.

Calculations for elongation and gauge readings shall include appropriate allowances for chuck seating, bed shortening under load, abutment rotation, thermal effects, gauge correction based on calibration data, friction, and any other compensation for the setup.

Methods of measurement of the tensioning force shall consist of one or more of the following:

1. Pressure gauges to measure force from the pressure applied to hydraulic jacks.
2. Dynamometers connected in tension into the tensioning system
3. Load cells connected into the tensioning system so the action of the tensioning operation imparts a compressive force to the sensing element.
4. Digital readouts connected to a pressure transducer to measure force from the pressure applied to the hydraulic jack.
5. Force computed from the actual elongation of the strand based on its physical properties and compensation adjustments

For pretensioned members, independent references shall be established adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the cables.

Stressing of strands for pretensioned members or tendons for post-tensioned members may be from one end, unless otherwise indicated. A discrepancy of more than 5% between stresses in the strand or tendon, computed from the elongation measurement and those indicated by gauge readings, shall be cause for jacking from both ends.

615.08-Pretensioning Procedure. The amount of stress to be given each cable shall be as shown on the Plans. Pretensioning shall be by either the single strand or multi-strand jacking method.

When pre-stressing is performed by the multi-strand jacking method, the cables shall be brought to a uniform initial tension of approximately 5,000 lbs.(22,250 Newtons) prior to being given their full pretensioning. The initial tension of each cable shall be accurately measured by a dynamometer or other approved means.

After the initial tensioning, the cables shall be stressed until the required elongation and jacking pressure are attained and reconciled within the limits specified in **Subsection 615.07**.

Deflected pretensioned strands shall be tensioned by either partially jacking at the end of the bed followed by raising or lowering the strands to their final position, or entirely by jacking, with the strands being held in their final position during the jacking operation.

The tensioning of deflected strands shall be done in such a manner that the final tension in all parts of the strand is uniform, and means shall be provided to reduce frictional forces at the bend points to a minimum.

When strands are deflected after partial tensioning, the strands shall be raised or depressed simultaneously at all points or in an approved specific sequence.

Strand splicing methods and devices shall be approved by the Engineer. When single strand jacking is used, only one splice per strand will be permitted. When multi-strand jacking is used, either all strands shall be spliced or no more than 10% of the strands shall be spliced. Spliced strands shall be similar in physical properties, from the same source, and shall have the same "twist" or lay. All splices shall be located outside of the prestressed units.

Wire failures may be accepted by the Engineer, provided not more than one wire in any strand is broken and the area of broken wires does not exceed 2% of the total area of the strands.

After final stressing, all strands shall be positioned as shown on the Plans and the stress in the strands shall be uniformly distributed throughout the bed length.

With the cables stressed in accordance with the Plan requirements and the foregoing Specifications, and with all other reinforcing in place, the members shall be cast to the lengths specified. Cable stress shall be maintained between anchorages until the concrete has reached a compressive strength as specified in **Subsection 615.09**.

615.09-Proportioning and Mixing of Concrete. The concrete for this construction shall be of such proportions as to attain the required compressive strength at the age of 28 days, and shall be subject to the following specific requirements.

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Class P Concrete shall be proportioned as follows:

Min. 28 Day Comp.Strength Cement PSI(MPa)	Min. cement lbs. (kg) Per c.y. (m^3)	Maximum Water/Cem. lb/lb (kg/kg)	Air in %	Slump in. (mm.)
5,000[1](34.5)	658(390)	0.45	0-8[2]	2±1[3](50±25)

All applicable provisions of **Subsection 604.03** shall be required except as modified herein. The Contractor shall submit a concrete design to the Department for review and approval. In addition to the proportions, the design shall show the source or brand of all materials and the type of cement to be used. The use of Type I or Type III cement will be optional with the Contractor, unless otherwise specified. The use of calcium chloride will not be permitted. A retardant admixture shall be used when the ambient temperature is 75° F(24° C) or higher. The slump of the concrete shall be 2 in. (50 mm) with a tolerance of ±1 in. (25 mm) at the time of placement. When an approved superplasticizer is to be used, the slump of the concrete shall be the same as above before the superplasticizer is added to the mix. After the addition of the superplasticizer, the slump may be increased to a maximum of 8 in. (200 mm) at the time of placement.

The handling, measuring and batching of materials; mixing concrete; and limitations of mixing shall be in accordance with the applicable provisions of **Subsections 501.09, 501.10**, and **501.11**, respectively.

Concrete test specimens for the purpose of determining the adequacy of the concrete design and for the minimum time at which the stress may be applied to the concrete shall be made in accordance with AASHTO T 23. The test specimens used to determine the time at which stress may be applied shall be cured in the same manner and under the same conditions as the bridge members. The initial curing of specimens to determine the design strength of the concrete shall be as specified above with additional curing water, as provided in AASHTO T 23. The compressive strength of the concrete shall be determined from the average strength of at least two representative test specimens made and cured as specified above and tested in accordance with the provisions of AASHTO T 22. The frequency of sampling and testing shall be in accordance with the TDOT sampling and testing schedule.

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[1] Or as specified on the plans, or approved shop drawings.

[2] Air entraining is optional with the contractor, unless otherwise specified on the plans or shop drawings.

[3] Not to exceed 3 in. (75 mm) prior to the addition of high range admixtures, and not to exceed 8 in. (200 mm) after the addition of high range admixtures

615.10-Handling, Placing, and Consolidating Concrete. The handling and placing of concrete for prestressed bridge members shall be performed in accordance with the requirements of **Subsection 614.07** with the following modifications:

(1) Forms, headers, cables, reinforcing bars or other steel that comes in contact with freshly placed concrete shall be kept below 110° F(43° C) during casting operation, except forms for deck panels shall be kept below 90° F(32° C).
(2) Placement of concrete shall not begin when the ambient temperature is below 26° F(-3° C); and if the ambient temperature falls below 26° F(-3° C) during the placement of concrete, the placement shall be discontinued as soon as practical.
(3) Placement of concrete shall not begin during precipitating weather; and when precipitating weather occurs during the pouring operation, only the area where the concrete is being placed is to be left uncovered, this being no more than 10 ft(3 m) of bed length.
(4) No concrete shall be deposited until the Engineer has inspected and approved the placement of the reinforcement, conduits, anchorages and pre-stressing steel. All exposed steel shall be cleaned of all concrete, other than light deposits of cement paste, immediately after placing and consolidation is completed.

The concrete shall be consolidated in accordance with the requirements of **Subsection 614.08** of these specifications.

615.11-Removal of Forms, Finishing and Curing. Side forms may be removed as soon after 6 hours as their removal will not cause distortion of the hardened concrete. The members shall not be removed from the bottom forms until they have been stressed sufficiently to sustain all forces and bending moments which may be applied during handling.

All formed surfaces of the bridge members shall be finished in accordance with the provisions of **Subsection 604.22**, or other satisfactory methods may be used when approved by the Engineer. Roadway surfaces of the members will be finished in accordance with the requirements of **Subsection 604.11(c).** The top surface of members that will not become a part of the roadway surface shall be scored transversely with a stiff wire brush, or by other approved methods. After hold down devices are removed from the bottom of the beams, the resulting holes shall be coated with an approved bonding compound and plugged with mortar.

Curing of the bridge members shall be effected by the water method or by steam curing as specified below. Other methods may be used, provided the details of the proposed methods are submitted to the Department and approved.

Water curing shall be effected in the following manner as soon as the concrete has hardened to a degree that the finish will not be harmed. The member shall be covered with a pre-dampened material suitable for use with the water cure and kept continuously and thoroughly wet until the

member has attained the strength required for stress transfer with a minimum curing time of twenty-four hours. Water cure may not be used when the ambient temperature is expected to drop below 45° F(7° C).

Steam curing shall be effected in the following manner:

(1) After placing and vibrating the concrete, the member shall be held until initial set has been attained, 2 to 4 hours, or 4 to 6 hours if a set retarder has been used, before applying steam. If the ambient air temperature is below 50° F(10° C), enough steam shall be applied during the delay period to hold the air surrounding the member at a minimum temperature of 50° F(10° C) and a maximum of 10° F(6° C) greater than the temperature of the concrete at placement.

(2) To prevent moisture loss on exposed surfaces during the delay period, members shall be covered as soon as possible after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

(3) Enclosures for steam curing shall allow free circulation of steam about the sides, ends, and tops of members and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of significant steam and moisture.

(4) Steam at the jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam the temperature rise within the enclosure shall not exceed 50° F(10° C) per hour. The curing temperature throughout the enclosure shall be not less than 90° F(32° C) nor exceed 160° F(71° C) and, the relative humidity shall be not less than 95%. The difference in the temperature adjacent to the concrete at different locations within the enclosure shall not exceed 20° F(11° C) at any time. Steam curing shall continue until the concrete has reached the required transfer strength. In discontinuing the steam the temperature within the enclosure shall not be reduced more than 50° F(28° C) per hour until the temperature inside is within 10° F(6° C) of the temperature outside. The minimum time from the end of placement and finishing operations to the removal of required covers shall not be less than 12 hours.

(5) When curing has been done at elevated temperatures, the procedures for transferring pre-stressing load shall begin after the forms have been released and steam has been discontinued and while the concrete is still hot in order to prevent cooling shrinking and cracking. If so directed by the Engineer, members shall be covered or otherwise protected so as to cool the concrete slowly after release in order to prevent thermal shock and the evaporation of moisture in the members.

(6) Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be

provided. A minimum of one recording device per 200 ft(60 m) of continuous bed length with a minimum of 2 devices will be required.

(7) Side forms shall be left in place a minimum of six hours after the concrete is cast or until the concrete has set sufficiently to withstand damage when the forms are removed. When the side forms are removed during the curing cycle, only the minimum area of the curing enclosure that is necessary to remove each individual form section area in the enclosure shall be removed and remain uncovered at any one time. The open area in the enclosure shall be immediately closed as each form section is removed.

(8) When the temperature is not expected to rise above 32° F(0° C) the beams shall be protected from freezing temperatures until design strength is reached.

615.12-Post tensioning Procedure. When post tensioning, the anchor plates shall be set normal in all directions to the axis of the steel. In all stressing operations, the stressing forces shall be kept symmetrical about the vertical axis of the member. Tensioning shall not be done until the concrete has reached a compressive strength of at least 3,500 psi(24.1 MPa), unless otherwise indicated on the Plans.

The amount of tensioning to be retained in each posttensioned unit after anchorage shall be as specified on the Plans. A slight overstress, as determined in the field, will be required to overcome friction between steel and enclosure and to allow for relaxation of the anchorage.

The units shall be tensioned until the required elongations and jacking pressures are attained and reconciled within the limits specified in **Subsection 615.07**, with such overstress as approved by the Engineer for anchorage relaxation. The male anchorage element shall then be driven home by the jack action.

The tensioning process shall be so conducted that the tension being applied and the elongation of the pre-stressing elements may be measured at all times. The friction loss in the element, i.e., the difference between the tension at the jack and the minimum tension shall be determined in accordance with the current edition of AASHTO "Standard Specification for Highway Bridges."

615.13-Combined Pre-stressing and Post tensioning. In the event that the members are manufactured with part of the reinforcement pretensioned and part posttensioned, the applicable portions of the requirements listed above shall apply to each type.

615.14-Transfer of Stress. The stress transfer shall not be made to the bridge members until the test specimens indicate that the concrete has reached a compressive strength of at least 4,000 psi(27.6 MPa), unless otherwise indicated on the Plans.

Before any stress is transferred to the bridge members, the pattern and schedule for releasing the strands shall be approved by the Engineer. Forms which tend to restrict the horizontal or vertical movement of the member shall be stripped or loosened prior to stress transfer.

Transfer of stress shall be by either the multiple strand release method or the single strand release method.

When the multiple strand method of release is used, either a symmetrical group of strands or all of the strands shall be released gradually and simultaneously. The load on the strands shall be removed from the anchorage and placed on the jacking system. The jack or jacks shall be gradually released until the strands are relaxed.

When the single strand release method is used, strands shall not be burned quickly but shall be heated with a low oxygen flame played along the strand for a minimum of 3 in.(75 mm) until the metal gradually loses its strength and permits the strand to slowly pull itself apart. Heat shall be applied at such a rate that failure of the first wire in each strand shall not occur until at least 5 seconds after heat is first applied. The strands shall be released in the sequence of the approved pattern and schedule of release.

615.15-Handling and Installation. Beam and girder erectors shall prepare an erection plan in accordance with **Subsection 602.42** and with the requirements of this Subsection.

All members may be handled immediately after completion of stressing. In the event that stressing is not done in a continuous operation, members shall not be handled before they are sufficiently stressed, as determined by the Engineer, to sustain all forces and bending moments due to handling. In the handling of members, they shall be maintained in an upright position at all times and shall be picked up from points designated on the Plans.

The members may be incorporated into the bridge structure at any time after completion of stressing and grouting, provided representative test specimens indicate that the concrete in the members has attained the design strength specified under **Subsection 615.09**.

Before any beams are shipped from the fabrication plant for incorporation into a structure, the beams must be formally accepted in accordance with Departmental procedures.

All prestressed beam members must be erected and the grade of the roadway established on the bridge before forming is started for the bridge deck, unless otherwise noted on the Plans or approved by the Engineer.

Where no note is placed on the Plans and the Contractor wishes to start forming for the bridge deck before all beams have been erected, construction of the forms shall not begin until written approval has been obtained from the Structures Division.

615.16-Grouting. The conduit through post-tensioned members in which the bars or cables are installed shall be equipped with approved grouting vents. After completion of stressing, the space between sides of bar or cable and sides of conduit shall be grouted in accordance with **Subsection 616.09**.

Recesses in girders at the ends of diaphragm bars, any holes left by form ties, or any other surface irregularities shall be carefully cleaned and patched with an approved epoxy grout.

615.17-Tolerances. Unless otherwise specified, the following manufacturing tolerances will be required in standard sections. Any variation beyond these tolerances shall be subject to approval by the Engineer.

	I-Sections	**Box Sections**
Nominal Depth	± 1/2 in. (± 13 mm)	± 1/2 in. ± (13 mm)
Nominal Width	±1/2 in. (±13 mm)	± 1/2 in. (±13 mm)
Nominal Length	Computed Elastic Shortening ±1/2 in. (±13 mm)	Computed Elastic Shortening ± 1/2 in. (±13 mm)
Variation in Straightness in. (mm)	1/4 in x (Total Length in feet)/10 (20 mm x (Total Length in meters.)/10)	1/4 in x (Total Length in feet)/10 (20 mm. x Total Length in meters.)/10)
Variation in Camber in. (mm)	Beams in any 1 span Not more than: 1/8 in x (Total Length in feet)/10 (10 mm. x (Total Length in Meters.)/10)	Beams in any 1 span Not more than: 1/8 in x (Total Length in feet)/10 (10 mm. X (Total Length in Meters.)/10)
Location of Voids	---------	Length ± 1-1/2 in (±38 mm.) Wall Thickness ± 1/2 in (±13 mm.)
Bearing	Full Bearing - Full Width of Beam	Full Bearing on at Least 2/3 of Width of Beam
Tendon Placement	±1/2 in (±13 mm.)	± 1/2 in (±13 mm.)
Reinforcing Steel Placement	±1/2 in (±13 mm)	± 1/2 in (±13 mm)
Reinforcing Steel Concrete Cover	±1/2 in (±13 mm)	± 1/2 in (±13 mm)
Reinforcing Steel Splice Lengths	Minus1-1/2 in. (Minus 38 mm)	Minus 1-1/2 in. (Minus 38 mm)

COMPENSATION

615.18-Method of Measurement. Structural members will be measured for payment by the linear foot(meter) of precast/prestressed concrete structural members of the several types and sizes installed, complete in place. The linear measurement will be determined from the nominal lengths shown on the Plans.

615.19-Basis of Payment. The accepted quantities of precast/prestressed bridge members will be paid for at the contract unit price per linear foot(meter) for the various types and sizes shown on the Plans, complete in place, which payment shall be full compensation for completing the work in accordance with these Specifications.

When the concrete does not meet the specified strength but is allowed to be included in the permanent construction, the bid price shall be adjusted as provided in **Subsection 604.31.**

SECTION 616-POSTTENSIONED PRESTRESSED CONCRETE

SECTION 616-POSTTENSIONED PRESTRESSED CONCRETE

616.01-Description. This work shall consist of pre-stressing cast in place concrete by furnishing, placing and tensioning of pre-stressing steel in accordance with the Plans and these Specifications, and shall include the furnishing and installing of any appurtenant items necessary for the particular pre-stressing system to be used including ducts, anchorage assemblies, pre-stressing steel, grout, etc.

616.02-Pre-stressing Methods. Pre-stressing shall be performed by post tensioning methods.

The Contractor shall submit to the Engineer for review and approval complete details of the method, materials and equipment he proposes to use in the pre-stressing operations, including any additions or rearrangement of reinforcing steel from that shown on the Plans. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the pre-stressing steel and anchoring devices, working stresses, bursting stresses, anchoring stresses, type of ducts, and all other data pertaining to the pre-stressing operation, including the proposed arrangement of the pre-stressing steel in the members, pressure grouting materials and equipment. The Contractor shall not cast any member to be prestressed until the shop detail drawings are approved by the Engineer.

MATERIALS

616.03-Materials. Materials used in this construction, in addition to meeting the requirements of these Specifications, shall meet the following requirements:

Material	Subsection
Portland Cement (Type I or II)	**901.01**
Water	**918.01**
Pre-stressing Reinforcement Steel and Anchorages	**907.04**

Components of Post Tensioning: All components of the post-tensioning system must be certified to meet the Post-Tensioning Institute (PTI) "Acceptance Standards for Post-Tensioning Systems."

EQUIPMENT

616.04-Equipment. All equipment necessary for the satisfactory performance of the construction shall be on hand and approved before the work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

616.05-Protection and Installation of Pre-stressing Steel. The pre-stressing steel shall be located in the girder stems with an equal force in each stem. At the Contractor's option the pre-stressing force may vary 5% from the theoretical equal force per girder provided the required total force is obtained and the force is distributed symmetrically about the centerline of the typical section. Stressing units are to be tensioned a few at a time in each girder to minimize stress differentials. The stressing sequence is subject to approval of the Engineer.

All pre-stressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting. Pre-stressing steel that has sustained physical damage at any time shall be rejected. Light surface rust is not a cause for rejection.

Pre-stressing steel shall be packaged in containers or other shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. An approved corrosion inhibitor which prevents rust or other results of corrosion shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material or, when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

Should the Contractor elect to use a corrosion inhibitor carrier type packaging material, the material shall conform to the provisions of **Federal Specification MIL-P-3420.**

This shipping package or form shall be clearly marked with a statement that the package contains high-strength pre-stressing steel, and the care to be used in handling; and the type, kind and amount of corrosion inhibitor used, including the date when placed, safety orders and instructions for use.

The Contractor shall submit the following for the corrosion inhibitor:

(1) A sample, a list of chemicals and their proportions, and instructions for use.
(2) Evidence that the pre-stressing steel will be protected from rust and other results of corrosion.
(3) A certificate of compliance.

When acceptable pre-stressing steel for post tensioning is installed in ducts after completion of concrete curing, the Contractor shall take necessary steps to ensure that stressing and grouting are completed within 10 calendar days after installation of the pre-stressing steel. Rust which may form during said 10 days will not be cause for rejection of the steel. Pre-stressing steel installed, tensioned and grouted in this manner, all within 10 calendar days, will not require the use of a corrosion inhibitor in the duct following installation of the pre-stressing steel. Pre-stressing steel installed as above but not grouted within 10 calendar days shall be protected by an approved corrosion inhibitor in the duct. The Contractor shall ensure that

the corrosion inhibitor is maintained at an effective level until grouting is complete.

No welds or grounds for welding equipment shall be made on the forms or on the steel in the member after the pre-stressing steel has been installed.

Tendons shall be placed in rigid metal conduit after concrete placement is completed.

616.06-Anchorages and Distribution. All posttensioned pre-stressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

All anchorage devices for post tensioning shall hold the pre-stressing steel at a load producing a stress of not less than 95% of the guaranteed minimum tensile strength of the pre-stressing steel.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete.

Bearing plates shall be placed normal to tendon path and tight against forms. Forms shall be braced and anchored to support the weight of the bearing plates.

Such approved devices shall conform to the following requirements:

(1) The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 psi(20.7 MPa).

(2) Bending stresses in the plates or assemblies induced by the pull of the pre-stressing shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 100% of the ultimate tensile strength is applied as determined by the Engineer.

Should the Contractor elect to furnish anchoring devices of a type which are sufficiently large and which are used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the pre-stressing steel and all parts of the anchoring devices will be at least 2 in.(50 mm) inside of the end surface of the members, unless a greater embedment is shown on the Plans. Following post-tensioning, the recesses shall be filled with grout, and finished flush. The anchorage hardware exposed after stressing shall be protected from corrosion by a suitable rust inhibitor before final embedment in concrete.

Complete details of jacking chairs shall be included in fabrication drawings in order that proper reinforcement clearances can be verified.

616.07-Ducts. Use ducts that are mortar tight and sufficiently rigid to withstand loads imposed during the placing of concrete and the internal pressure during grouting, while maintaining its shape, correct alignment and remaining water-tight, and with minimum wall thickness as follows:

(1) Metal Duct: 0.55 millimeter for ducts 65-millimeter diameter

(2) Metal Duct: 0.70 millimeter for ducts > 65 millimeter diameter

(3) High Density Polyethylene (HPDE): 2.0 millimeter

(4) High Density Polypropylene (HDPP): 2.0 millimeter

(5) Metal Duct: 0.35 millimeter when bar tendons are preassembled with the duct

For tendons composed of single pre-stressing bars, provide ducts with a minimum internal duct diameter of at least 6 millimeters larger than the outside diameter of the pre-stressing bar. For multiple wire, bar, or strand tendons, provide a duct nominal internal cross-sectional area of at least 2.25 times the net area of the pre-stressing steel.

Make positive joints between duct sections. Do not make angles at the joints. Use waterproof tape at the joints. Bend ducts without crimping or flattening. Use ferrous metal or polyethylene couplings to connect ducts to anchoring devices.

Protect ducts against crushing, excessive bending, dirt contamination, and corrosive elements, during transport, storage, and handling of ducts.

In case of duct damage, seal duct with tape, or splice a duct coupler over the damaged section to form a seal that prevents cement paste from entering the duct during the placement of concrete and to prevent leakage during grouting operations.

Provide all ducts and anchorage assemblies with inlets for the injection of grout into the duct after pre-stressing, in accordance with the (PTI) “Guide Specification for Grouting of Post-Tensioned Structures.”

Provide all ducts with outlets to allow the escape of air, water, grout, and bleed water, in accordance with the (PTI) “Guide Specification for Grouting of Post-Tensioned Structures.”

Provide inlets and outlets with an inner diameter of at least 20 millimeter for strand tendons and of at least 10 millimeter for single bar tendons. Extend the length of outlets a sufficient distance out of the concrete member to allow for the proper closing of the outlets.

Place inlets and outlets, at a minimum, in the following locations:

- The anchorage area of the tendon
- All high points of the duct, when the vertical distance between the highest and lowest point is more than 0.5 meter
- Place an inlet at or near the lowest point of the tendon
- Place a free draining outlet at all low points of the duct

- At major changes in the cross-section of the duct, such as couplers and anchorages
- An outlet at a distance less than 1 meter downstream from high point outlets

Show all inlet and outlet locations on drawings.

Provide positive mechanical shut-off valves for all inlets and outlets. Provide inlets and outlets with valves, caps, or other devices capable of withstanding the grouting pressure.

Securely fasten ducts in place to prevent movement. Maintain distances from the forms by stays, blocks, ties, hanger, or other approved supports. Use precast blocks. Space all duct supports in accordance with the (PTI) "Guide Specification for Grouting of Post-Tensioned Structures." Cover the ends of ducts to prevent the entry of water or debris.

Connect inlets and outlets to the duct with metallic or plastic structural fasteners. Do not use components that react with the concrete, cause corrosion of the pre-stressing steel, or contain water-soluble chlorides.

616.08-Pre-stressing. All pre-stressing steel shall be tensioned by means of hydraulic jacks so that the force in the pre-stressing steel shall not be less than the value shown on the Plans. In no case will stressing be allowed utilizing a single strand pull. The jack used in the stressing operation must be capable of making a multiple pull on all strands in a tendon.

Unless otherwise specified or shown on the Plans, the stress in the pre-stressing steel after all losses shall not exceed 80% of the yield point stress of the pre-stressing steel. The maximum temporary tensile stress (jacking stress) in the pre-stressing steel shall not exceed 90% of the yield point stress of the pre-stressing steel. The pre-stressing steel shall be anchored at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the Plans, but in no case shall the initial stress at the anchor exceed 70% of the specified minimum ultimate tensile strength of the pre-stressing steel.

Working force and working stress will be considered as the force and stress remaining in the pre-stressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, relaxation of steel, losses in post-tensioned pre-stressing steel due to sequence of stressing, friction and take up of anchorages, and all other losses peculiar to the method or system of pre-stressing have taken place or have been provided for.

The loss in stress due to all causes in post-tensioned pre-stressing steel shall be in accordance with the AASHTO Bridge Specifications designated on the Contract Plans.

Each jack used to stress tendons shall be equipped with either a pressure gauge or a load cell for determining the jacking stress. The pressure gauge shall have an accurately reading dial at least 8 in.(200 mm) in diameter and each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force, and shall be accompanied by a certified calibration chart. Each gauge should be capable of reading loads directly in pounds or be accompanied by a chart from which the dial reading can be converted to

lbs.(Newtons). The load cell shall be calibrated and shall be provided with an indicator by means of which the pre-stressing force in the tendon may be determined. The range of the load cell shall be such that the lower 10% of the manufacturer's rated capacity will not be used in determining the jacking stress.

Means shall be provided for measuring the elongation of reinforcement to at least the nearest 1/16 in.(2 mm).

The certified calibration charts for the hydraulic jacks, pressure gauges, or load cells used for tensioning pre-stressing steel may be checked before and during tensioning operations by the Engineer.

Prior to placing forms for closing slabs of box girder cells, the Contractor shall demonstrate to the satisfaction of the Engineer that all ducts are unobstructed.

Except as herein provided, cast in place concrete shall not be pre-stressed until at least 10 days after the last concrete has been placed in the member to be pre-stressed and until the compressive strength of the last placed concrete has reached the strength specified for the concrete at the time of stressing.

The tensioning process shall be so conducted that tension being applied and the elongation of the pre-stressing steel may be measured at all times. A record shall be kept of gauge pressures or load cell readings and elongations for each tendon stressed.

Elongations shall be the primary control of the stressing operation; however, the hydraulic pressure gauge readings or the load cell readings at the time of the measured net elongation shall be within 5% of the calculated gauge or load cell reading for that particular elongation. If the gauge or load cell pressure readings vary by more than 5% from their calculated reading, all work shall be stopped and the defect corrected before proceeding. This variance may be cause for jacking at both ends.

Pre-stressing tendons in continuous post-tensioned members shall be tensioned by jacking at each end of the tendon unless otherwise shown on the Plans. Such jacking of both ends need not be done simultaneously. When approved by the Engineer, bent cap tendons may be tensioned by jacking from one end only.

Pre-stressing tendons in single span post-tensioned members may be tensioned by jacking from one end only. When tensioning is done from one end only, half of the pre-stressing steel in each member shall be tensioned from one end of the span and the other 1/2 from the opposite end, unless otherwise permitted by the Engineer.

616.09 Bonding and Grouting. Provide Class A, B, C, or D, grout as specified in the "Post-Tensioning Institute (PTI), "Guide Specifications for Grouting of Post-Tensioned Structures" and Bond all post-tensioned pre-stressing steel to the concrete will be provided by filling the void space between the duct and tendon with grout, in accordance with the (PTI) Guide.

Provide pre-stressing steel to be bonded to the concrete, which is free of dirt, loose rust, grease, or other deleterious substances.

Perform all grouting operations using staff with grouting experience on projects of a similar type and magnitude. Perform grouting operations

under the immediate supervision of an individual skilled in various aspects of grouting, who is certified by the "American Segmental Bridge Institute" (ASBI) Grouting Certification or equivalent certification program, approved by the Engineer. Furnish the name of the grouting operations supervisor and proof of their ASBI certification and grouting experience to the CO, prior to the commencement of any grouting operations.

Make available on-site, prior to the commencement of grouting operations, all the required testing equipment for checking grout workability (flow-cone), temperatures, and other specified tests.

Provide written certification that all ingredients used in the grout meet the ASTM requirements contained in the (PTI) "Guide Specification for Grouting of Post-Tensioned Structures." This includes, but is not limited to the following:

- Cement mill test reports
- Mineral additives test reports
- Chemical admixtures reports
- Test reports for any other ingredients used in the grout

For prepackaged grouts, provide the manufacturer's current certified mill test reports for the product.

Use grouting equipment capable of continuous operation with little variation of pressure, which include a system for recalculating the grout while actual grouting is not in progress. Use grouting equipment capable of maintaining a pressure on completely grouted ducts and fitted with a valve that can be locked off without loss of pressure in the duct.

Do not use compressed air to aid in the pumping of grout.

Provide grout pumps of a positive displacement type, capable of providing a continuous flow of grout, and capable of maintaining an outlet pressure of at least 1 MPa and with a pressure gauge having a full-scale reading of not more than 2.0 MPa.

Determine the flowability of the grout according to ASTM C939. Te efflux time of a grout sample immediately after mixing shall be between 11 and 30 seconds. Do not begin grouting until this test is passed. When hot weather conditions may cause quick setting of the grout, cool the grout by approved methods, as necessary, to prevent blockages during pumping operations. When freezing weather conditions are possible during and following placement of grout, protect the grout from damage by freezing in accordance with the (PTI) "Guide Specification for Grouting of Post-Tensioned Structures."

Provide a supply of potable water and standby flushing equipment capable of developing a pumping pressure of 1.7 MPa and of sufficient capacity to flush out any partially grouted ducts.

Clean all ducts of material that would impair bonding of the grout or interfere with grouting procedures. Blow out each duct with compressed, oil-free air. Check all inlets and outlets for their capacity to accept injection of grout by blowing compressed, oil-free air through the system, and proving each inlet and outlet in turn.

Pass all grout through a screen with 3-millimeter maximum clear openings before entering the grout pump. Open all grout vents prior to the

commencement of grouting. Completely fill the duct by injecting grout from the lowest end of the tendon in an uphill direction. Pump grout continuously through the duct and waste at the outlet until no visible slugs of water or air are ejected, and the efflux time of the ejected grout is between 11 and 30 seconds. Maintain a continuous, one-way flow of grout within a grouting stage.

Close all outlets in a similar manner one after the other in the direction of the flow. For outlets placed a short distance downstream from a high point, close that outlet before its associated high point outlet. Increase the grouting pressure at the injection end to at least 0.7 MPa and hold for at least 10 seconds. Do not remove or open valves and caps until the grout has set.

Abrasive blast-clean the concrete surface of recessed anchorage assemblies. Fill anchor recesses with concrete conforming to the requirements for the structure and finish flush.

Remove ends of vents 25 -millimeters below the roadway surface after grouting has been completed. Permanently seal all recess areas.

Do not release the falsework under the bottom slab supporting the superstructure until at leas 48 hours after grouting of the post-tension pre-stressing steel or until the grout strength is obtained.

616.10-Form Work. In addition to the requirements set out in these specifications the falsework shall not be removed until all pre-stressing is complete, and the structure has been post-tensioned to the Engineer's satisfaction.

616.11-Sampling and Testing. The following shall be furnished by the Contractor to the Engineer well in advance of anticipated use:

(1) One 6 ft(1.8 m) long sample of each size strand shall be furnished for each reel.
(2) One completely fabricated tendon will be tested at a laboratory approved by the Department of Transportation with a notarized letter furnished to the Division of Materials and Tests from the laboratory stating that no deformation has occurred in the anchor head and no slippage of strand has occurred at the wedges.

When pre-stressing systems have been previously tested and approved for similar projects by an agency acceptable to the Department, no testing will be required but a notarized letter stating that the system is the same as a previously tested system will be furnished the Engineer.

COMPENSATION

616.12-Method of Measurement. Pre-stressing cast in place concrete shall be measured by the lump sum as specified on the Plans.

No measurement for payment will be made for furnishing and placing additional deformed bar reinforcing steel required by the particular system used, ducts, anchoring devices, distribution plates or assemblies and

incidental parts, for grouting recesses nor pressure grouting ducts, as these will be considered as incidental to the work and included in the lump sum.

616.13-Basis of Payment. The contract lump sum price paid for pre-stressing cast in place concrete shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in furnishing, placing, and tensioning the pre-stressing steel in cast in place concrete structures, complete in place, as shown on the Plans, as specified in these Specifications, and as directed by the Engineer.

When the concrete does not meet the specified strength but is allowed to be included in the permanent construction, the bid price shall be adjusted as provided in **Subsection 604.31.**

SECTION 617-BRIDGE DECK SEALANT

SECTION 617-BRIDGE DECK SEALANT

617.01-Description. This work shall consist of furnishing and placing a waterproofing system over a properly prepared concrete bridge deck for the purpose of protecting structural concrete from the deterioration caused by absorption of deicing salts and water. This work shall be constructed in accordance with the design, dimensions, and details shown on the Plans and in accordance with the provisions of these Specifications.

MATERIAL

617.02-Materials. The materials used shall meet the requirements of **Subsection 906.04**, Dampproofing and Waterproofing Materials for System A or System B. The selection of the system of sealant used for waterproofing bridge decks will be optional with the Contractor.

EQUIPMENT

617.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on the project and approved before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

617.04-General. In order to minimize the amount of construction traffic during and after placement of the bridge deck seal, installation of the seal shall not be permitted until all major phases of roadway construction have been completed. The roadway base and pavement up to the surface course shall be completed before beginning installation of the bridge deck seal. The construction of the bridge deck sealant and overlay may be performed concurrently with or after the roadway surface course.

All methods employed in performing the work shall be subject to approval of the Engineer before the work is started and whenever found unsatisfactory shall be changed and improved as required.

Concrete surfaces, structural steel, railing, passing vehicles, etc., shall be protected to prevent their being defaced by installation of the sealant. Should defacement occur, the Contractor shall clean surfaces on the structure to the satisfaction of the Engineer and be solely responsible and liable for damage to passing vehicles.

The only traffic permitted on the area being treated shall be the necessary men and equipment to perform the work required. All other traffic shall be maintained on portions of the structure that are not being given the membrane protective coating. At all times, traffic shall be kept off the membrane and particular care shall be taken to protect the membrane from damage. Any damage which may occur shall be repaired by patching in a manner satisfactory to the Engineer.

617.05-Weather Limitations. Work shall not be done during wet weather conditions, when the relative humidity exceeds 85%, nor when the surface upon which the sealant is being placed or the ambient air temperature is

below 50° F(10° C). The surface upon which the sealant is being placed shall be dry at the time of application.

617.06-Application of Membrane. Prior to the application of the membrane, the bridge deck shall be first overlaid with hot bituminous mix in the quantity specified on the Plans.

The prefabricated membrane shall be applied immediately after the compaction of the bituminous mix, in order to avoid contamination of the surface.

The waterproofing membrane shall be applied to the bituminous overlay in a manner to form a butt joint with the face of the curbs.

The operation of the paving equipment shall be in the direction of the transverse lap of the membrane.

The prefabricated membrane shall be applied to the bridge deck bituminous overlay surface by either hand methods or mechanical applicators.

The membrane shall be placed in such a manner that a shingling effect will be achieved so that any water which accumulates will drain toward the low curb or the drain pipes. Each strip shall be overlapped longitudinally and transversely a minimum of 4 in.(100 mm) or as recommended by the manufacturer.

A wide tipped torch to cause tackiness or an adhesive shall be used if necessary to assure a good seal of the joints. Hand rollers or other satisfactory pressure apparatus shall be used on the applied membrane to assure firm and uniform contact with the bituminous overlay. Special care shall be used at the curb face to see that the membrane is uniformly adhered to the concrete. A mastic, of the type specified by the manufacturer, shall be applied to the butt joints at face of the curb. Application of the mastic shall be as set forth in the Plans.

The entire membrane shall be free of placement defects such as wrinkles, air bubbles, and fishmouths. Any torn or cut areas, or narrow overlaps, shall be patched, using a satisfactory adhesive and by placing sections of the membrane over the defective area in such manner that the patch extends at least 6 in.(150 mm) beyond the defect. The patch shall be rolled or firmly pressed onto the surface.

At all open joints, expansion joints, and at other joints as ordered, the membrane shall form a butt joint with the face of the joint and an application of mastic shall be applied as set forth in the Plans.

After the membrane waterproofing has been completed, the membrane shall be cut with 2 right angle cuts at all deck drain pipes. The cuts shall be made to the inside diameter of the drain pipes, after which the corners of the membrane waterproofing shall be turned down into the drains and laid in a coating of mastic.

In all cases, the waterproofing shall begin at the low point of the surface to be waterproofed so that water will run over and not against the laps.

Any air bubbles caused by the formation of vapor pressure or out-gassing under the membrane after placement, shall be removed by puncturing the membrane and repairing the defective area in the manner prescribed for cut and torn areas.

Application of the bituminous overlay shall begin immediately after placement of the membrane has been completed.

A bond coat of an acceptable adhesive shall be applied to the surface of prefabricated membranes, if required, in accordance with the membrane manufacturer's recommendations prior to placing the overlay.

The waterproofing system shall be overlaid with asphaltic concrete of the type and in the quantity specified on the Plans.

All requirements of the specified sections shall apply to this construction with the following revisions and additions:

1. The paving operation shall be in the same direction as the end laps of the membrane.
2. The requirements for automatic grade and slope controls on the paver will be waived.
3. The density requirements will be waived, however, all other applicable compaction requirements in **Subsection 407.15** will apply A breakdown roll shall be given the first asphalt concrete lift as soon as possible after the paving machine has passed.

The overlay shall be deposited, spread, and rolled in such a manner that the membrane will not be damaged.

COMPENSATION

617.07-Method of Measurement. Bridge deck sealant, complete in place and accepted will be measured by the number of square yards(m^2) of bridge deck and approach slabs covered.

Tack coat, when used, and bituminous layers will be measured and paid for as provided for in **Subsection 403.06** of the Standard Specifications for Road and Bridge Construction.

617.08-Basis of Payment. The bridge deck sealant will be paid for at the contract unit price per s.y.(m^2), which price shall include the preparation of surfaces, furnishing and applying the waterproofing system complete in place.

SECTION 619-POLYMER MODIFIED CONCRETE BRIDGE DECK OVERLAY FOR NEW AND EXISTING BRIDGES

SECTION 619-POLYMER MODIFIED CONCRETE BRIDGE DECK OVERLAY FOR NEW AND EXISTING BRIDGES

619.01-Description. This work shall consist of constructing a polymer modified concrete(PMC) bridge deck overlay for the purpose of protecting structural concrete from the deterioration caused by absorption of deicing salts and water. This work includes all labor, materials, equipment and incidentals, and shall be performed in reasonably close conformity with the Plans, these Specifications and as directed by the Engineer.

MATERIALS

619.02-Materials. Materials used in this construction shall meet the following requirements in addition to the general requirements of these Specifications:

Material	Subsection
Portland cement (Type I or Type III)	**901.01**
Fine Aggregate (Natural Sand)	**903.01**
Coarse Aggregate (Size 7)	**903.03**
Water	**918.01**

Polymer used shall appear on the Department's QPL

619.03-Proportioning. The polymer modified concrete mixture shall contain no less than 658 lbs of cement per c.y.(390 kgs per m^3) and shall be accurately proportioned as follows:

Material	Quantity
Type I or III Portland Cement	**94 lbs. (42.5 kg)**
Polymer Admixture	**3.5 gal. (13.2 liters)**
Natural Sand	**215 to 255 lbs. (97.5 to 115.5 kgs)**
Coarse Aggregate	**208 to 168 lbs. (94.5 to 76 kgs)**
Water (including free moisture on the sand and coarse aggregate)	**8 to 22 lbs. (3.5 to 10 kgs).**

The properties of the polymer modified concrete mixture shall be as follows:

Property	**Value**
Slump (measured 4 to 5 minutes after discharge from a continuous mixer)	4 to 6 in. (100 to 150 mm)
Air Content	0 to 8%
Water-Cement Ratio	Not more than 0.40 considering all the nonsolids as part of the water

The polymer admixture shall contain a minimum of 46% solids. The Contractor shall submit in writing a concrete design to the Department specifying the name and location of aggregate suppliers, and the type and brand of the cement and polymer proposed for use. No concrete shall be placed prior to the Department's approval of the design. No change in materials will be permitted unless approved by the Engineer in writing.

EQUIPMENT

619.04-Equipment. Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. Equipment shall be on hand sufficiently ahead of the start of construction operations to be examined and approved.

(a) Mixer.

A continuous type mixer, calibrated to accurately proportion the specified mix, will be used to mix and discharge the PMC overlay. The mixer shall be equipped so that the proportions of the cement, natural sand, and coarse aggregate can be fixed by calibration of the mixer and cannot be changed without destroying a seal or other indicating device affixed to the mixer by the Engineer. In addition to being equipped with a flow meter for calibrating the water supply portion of the mixer, the mixer shall also be equipped with a cumulative-type water meter which can be read to the nearest 0.1 gallon(0.5 liter). The water meters shall be readily accessible, accurate to within 1%, and easy to read. Both water meters will be checked by the Engineer each time the mixer is calibrated. Approved methods for adding the admixture shall be provided. The admixtures shall be added so as to be kept separated as far as is practicable. The continuous type mixer shall be calibrated to the satisfaction of the Engineer prior to starting the work. Yield checks will be made for each 50 c.y. (m^3) of mix. Recalibration will be necessary when indicated by the yield checks, and at any other times the Engineer deems necessary to ensure proper proportioning of the ingredients. Continuous type mixers which entrap unacceptable volumes of air in the mixture

shall not be used. Batch type and drum-type transit truck mixers or rotating drum batch type mixers may not be used for PMC overlay concrete mixing. The mixer shall be kept clean and free of partially dried or hardened materials at all times. It shall consistently produce a uniform, thoroughly blended mixture within the specified air content and slump limits. Malfunctioning mixers shall be immediately repaired or replaced with acceptable units.

(b) Placing and Finishing Equipment.

Placing and finishing equipment shall include hand tools for placement and brushing-in freshly mixed polymer modified concrete and for distributing it to approximately the correct level for striking-off with the screed.

An approved finishing machine complying with the following requirements shall be used for finishing all large areas of work.

1. The finishing machine shall be self-propelled and capable of forward and reverse movement under positive control. Provision shall be made for raising all screeds to clear the screeded surface for traveling in reverse.
2. A self-propelled finishing machine equipped with one or more rotating rollers, augers, and 1,500 to 2,500 vpm vibratory pans may be used.
3. The machine shall be of the vibrating-screed type designed to consolidate the modified composition by vibration. Vibration frequency shall be variable with positive control between 3,000 and 11,000 vpm. The bottom face of the screeds shall be not less than 4 in.(100 mm) wide and shall be metal covered. The screeds shall be provided with positive control of the vertical position.
4. A suitable portable lightweight or wheeled work bridge will be required and used behind the finishing operation.

CONSTRUCTION REQUIREMENTS

619.05-Limitations. On new structures, the deck Class A concrete for the entire structure shall be in place before overlay operations are started. Overlay operations may then commence as soon as the Class A concrete has gained sufficient strength to resist damage from the blast cleaning.

Construction of the overlay shall be performed during favorable weather conditions. Preferably, the mixture should be placed when the atmospheric temperature is between 55 and 75° F(13 and 24° C); when the wind velocity is low; when the relative humidity is normal or high; and when hot conditions or rain are not expected. In all instances, all of the concrete shall be placed and kept at a temperature above 45° F(7° C) for at least 96 hours after it is placed. This will require approved housing, heating, or insulation methods or combinations thereof during cold weather. The mixture shall not be placed when the temperature is 85° F(29° C) or higher; when the wind velocity is high; when the relative humidity is extremely low; when rain is expected within the working period; or when any other atmospheric conditions cause difficulty in the satisfactory

finishing, texturing, or curing of the overlay. This may require night work or other limited work periods.

619.06-Hydro-Demolition. Prior to placing the overlay, the concrete surface to be covered shall be hydro-blasted to a depth as called for in the plans. In areas where machine hydro-blasting cannot reach, in areas of spalling and where steel reinforcement is exposed, deteriorated concrete will be removed to sound material by means of hand tools. Pneumatic hammers heavier than nominal 45 lbs(20 kgs) will not be allowed.

After hydro-blasting, the deck shall be cleared of all debris. Traffic will not be permitted on the cleaned portion of the deck.

Removal of all debris shall be done immediately after hydro-demolition has been accomplished.

619.07- Cleaning. After hydro-blasting but before placing the overlay, the entire area of the deck surface shall be power wash cleaned with a minimum 10,000 psi(69,000kPa) washing system to a bright, clean appearance which is free from laitance, dust, dirt, oil, grease, bituminous material, paint, and all other foreign matter. The hydro-demolition of an area of the deck shall normally be performed within the 24 hour period preceding placement of the overlay on the area The process used to clean the existing deck shall be performed so as to conform with air and water pollution regulations applicable to the county or city where the site of work is located and to also conform to applicable safety and health regulations. Any method that does not consistently produce satisfactory work and conform to the above requirements shall be discontinued and replaced by an acceptable method. All debris of every type, including dirty water, resulting from the cleaning operation shall be reasonably confined during the performance of the cleaning work and shall be immediately and thoroughly cleaned from the blast cleaned surfaces and all other areas where any escaped debris may have accumulated. The cleaned areas shall be protected, as necessary, against contamination prior to placement of the overlay. It shall be covered with a plastic cover that will be rolled up as the placement equipment passes over it so that the cleaned surface is not exposed to wheels, dirt, oil, grease or any other contaminates. Contaminated areas and areas exposed more than 36 hours shall be cleaned again as directed by the Engineer at the Contractor's expense.

619.08-Mixing. Concrete shall be mixed at the work site in accordance with the specified requirement for the equipment used. The maximum time between completion of mixing and placement shall not exceed 5 minutes. Mixing capability shall be such that finishing operations can proceed at a steady pace with final finishing completed before the formation of the plastic surface film.

619.09 Placing, Consolidatingand Finishing. Areas not accessible to the finishing machine may be vibrated and finished by approved hand methods.

Screed rails shall be placed and fastened in position to ensure finishing the new surface to the required profile. Anchorage for supporting rails shall

provide horizontal and vertical stability. Screed rails shall not be treated with parting compound to facilitate their removal.

Two water vacuums shall be present during placement of the PMC for removing excessive water during placement.

Finished surface smoothness shall be in compliance with **Subsection 604.27**.

619.10-Texturing. The transverse grooves shall be formed by mechanical texturing. The grooves shall be formed in the concrete overlay at an appropriate time during the stiffening of the concrete mixture, so that in the hardened concrete, the grooves shall be between 0.09 and 0.13 in.(2 and 3 mm) in width; between 0.12 to 0.19 in.(3 to 5 mm) in depth; and will be spaced at random intervals between 0.3 in. and 1 in.(8 to 25 mm). The grooves shall terminate approximately 18 in.(450 mm) from curbs, concrete parapets, barrier walls, or other vertical walls. The grooves shall be relatively smooth and uniform; shall be formed without tearing the surface or without bringing pieces of the coarse aggregate to the top of the surface; and shall be formed to drain transversely. Any areas which do not conform to these requirements will be corrected at the Contractor's expense by approved methods.

619.11-Curing. The overlay surface shall be covered promptly with a single layer of wet burlap. New burlap, even when pre-soaked, can dry out quickly and should be avoided or pre-soaked for several days. It may be necessary, at the Engineer’s request, for the burlap to be wet, let dry out, and this procedure repeated several times to allow for total absorption. White plastic (visqueen) shall be used to cover the wet burlap.

The wet burlap shall be placed over the surface as soon as possible. Consistently spray a mist of water over the burlap before it is covered with white plastic. However, spraying the burlap with water before covering with white plastic should not be excessive to the point that the water is damaging the fresh overlay surface.

The white plastic should be pulled, placed and kept within 10 to 30 ft(3 to 9 m) of the front cover of burlap. These distances should be adjusted based on the weather conditions at the time of placement. Secure the plastic so that it will not blow off the burlap during the wet cure. The less number of seams in the plastic is best and easier to secure.

Secure the plastic by using the rails, rolling over the edges of wet burlap onto the plastic, laying folded wet burlap transversely across the deck or by keeping water on the surface of the plastic. Seal the plastic to avoid the wind from puffing up the plastic during the wet cure. Exercise caution when wetting down the surface of the plastic so at not to allow the water to run into the overlay being placed.

Soaker hoses shall be placed under the plastic. This shall be done when the overlay has set long enough to support the weight of the soaker hoses and after the overlay placement is completed. Using the coolest water possible will greatly enhance all the procedures in hot weather.

A random sample of the latex shall be taken off each concrete mobile supplier and delivered to the TDOT, Division of Materials and Tests lab for evaluation. The random sample will be approximately 1 quart(1 liter). An

engineer from the office of Bridge Inspection and Repair shall be present for the initial calibration of the concrete mobile. The Engineer will check and measure the volume of the latex, cement, aggregate and water at the concrete mobile before and after as an approximate check of the calibration of the concrete mixer.

The Contractor shall place a plastic cover over the deck area after the deck has received hydro-demolition and the deck area has been cleaned. The plastic shall be removed as the PMC is being placed.

619.12-Reconstruction. All areas of the overlay which either display a significant number of cracks or which are not intimately bonded to the underlying deck shall be removed and replaced with acceptable concrete at the Contractor's expense. All small cracks which exist but are not significant enough to require removal of the overlay shall be thoroughly sealed with a high molecular weight methacrylate sealant at the Contractor's expense.

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619.13-Traffic Loading. The new PMC overlaid surface shall have a traffic loading as follows:

1. When Type I cement is used, the overlay surface must have a 24 hour wet cure and 24 hour dry cure and have attained a compressive strength of 3,500 psi(24,000 kPa) before traffic loading will be allowed.
2. When Type III cement is used, the overlaid surface must have a 12 hour wet cure and a 12 hour dry cure and have attained a compressive strength of 3,500 psi(24,000 kPa) before traffic loading will be allowed.

COMPENSATION

619.14-Method of Measurement. Polymer modified concrete will be measured by the s.y.(m^2) in accordance with **Section 109**-Measurement and Payment.

619.15Basis of Payment. The accepted quantity of Bridge Deck Overlay (PMC) will be paid for at the contract unit price per s.y. (m^2), which price will be full compensation for the placement and finishing of the overlay in accordance with the Standard Specifications and for any tools, labor, equipment or incidentals for such placement. This item shall include only the PMC for the theoretical plan depth of the overlay.

Accepted quantities of Polymer Modified Concrete (Variable Depth) will be paid for at the invoice price of the materials delivered to the project plus 20%, except in no case shall maximum payment exceed $350 per c.y. ($450 per m^3) plus 20% when Type 1 Portland Cement is used and shall not exceed $450.00 per c.y. ($590 per m^3) plus 20% when Type 3 Portland Cement is used. All other costs associated with placement of Polymer Modified Concrete (Variable Depth) shall be incidental to the price bid for, Bridge Deck Overlay (PMC).

SECTION 620-BRIDGE RAILINGS

SECTION 620-BRIDGE RAILINGS

620.01-Description. This work shall consist of furnishing and placing railings for bridges as covered by standard designs or as specially detailed, and shall also include such reinforcing steel, anchor bolts, or insert sleeves as detailed to support the railing.

MATERIALS

620.02-Materials. The materials shall meet the requirements for the respective type of railing as follows:

Material	Specification
Concrete Parapet with Structural Tubing	**(STD-11-1)**
Concrete Parapet	**(STD-1-1)**
Concrete Rail	**(STD-7-1)**

EQUIPMENT

620.03-Equipment. All equipment necessary for the satisfactory performance of this work shall be on the project as approved before work will be permitted to begin.

CONSTRUCTION REQUIREMENTS

620.04-Construction Methods.

(a) The steel or Aluminum tubing shall be constructed according to the details shown on the Plans and the requirements specified under **Section 602**, Steel Structures. Painting meeting the requirements of **Subsection 603.06**, shall be used on metal railing where painting is required, unless otherwise specified. No painting will be required for aluminum or galvanized railing. Metal railing shall be carefully adjusted prior to bolting their connections to insure proper matching at abutting joints and correct alignment throughout their length. Rail posts shall be set plumb, unless otherwise noted on the Plans.

(b) Concrete parapet and concrete railings shall be constructed in accordance with the provisions of **Section 604**, Concrete Structures. Concrete parapet and railings shall not be constructed until all falsework has been struck. Special care shall be exercised to secure smooth and tight fitting forms which can be rigidly held to line and grade and removed without injury to the concrete. All moldings, panel work, and bevel strips shall be constructed according to the details shown on the Plans with neatly mitered joints. All corners in the finished work shall be true, sharp, and clean-cut and shall be free from cracks, spalls, or other defects.

All exposed surfaces shall be given a Class 2 or applied textured finish in accordance with the provisions of **Subsection 604.22**.

COMPENSATION

620.05-Method of Measurement. Bridge railing of the type specified will be measured, in place, by the linear ft.(m), overall dimensions.

620.06-Basis of Payment. Bridge railing, of the type specified, will be paid for at the contract unit price per linear ft.(m), which price shall be full compensation for furnishing all materials and constructing the railing complete in place.

SECTION 621-TEMPORARY STRUCTURES

SECTION 621-TEMPORARY STRUCTURES

621.01-Description. This work shall consist of the construction, maintenance, removal and disposal of temporary structures as specified.

CONSTRUCTION REQUIREMENTS

621.02-Construction. All temporary structures shall be constructed at the location and to the dimensions, grades, and load capacity shown on the Plans or in the Contract, or in accordance with drawings prepared by the Contractor and approved by the Engineer. Alternate design and details prepared by the Contractor must be equivalent to the design and details furnished by the Department.

When alternate design and details are prepared by the Contractor, his responsibility shall be as specified in **Subsection 105.02**.

Unless otherwise provided on the Plans or in the Contract, temporary structures shall be maintained by the Contractor until the completion of the Contract or the opening of the permanent structure.

The maintenance of all temporary structures shall include their replacement in case of partial or complete failure. The Department reserves the right, in case of the Contractor's delay or inadequate progress in making repairs and replacement, to furnish such labor, materials and supervision of the work as may be necessary to restore the structure for proper movement of traffic. The entire expense of such restoration and repairs shall be considered a part of the cost of the temporary structure and where such expenditures are incurred by the Department, they shall be charged to the Contractor.

Unless otherwise noted on the Plans or in the Contract, upon completion and opening to traffic of the permanent construction, the Contractor shall remove and dispose of the temporary structure, and restore the area as nearly as possible to its original condition, and leave the area in a neat condition satisfactory to the Engineer.

COMPENSATION

621.03-Method of Measurement. Temporary structures will be measured per each, completed, accepted, and satisfactorily removed at the designated time in the work.

621.04-Basis of Payment. The completed and accepted work will be paid for at the contract lump sum price for each "Temporary Structure," which price shall include all materials, tools, equipment and labor incidental thereto. Unless otherwise indicated, all salvageable material obtained from the removal and reconditioning work shall be the property of the Contractor.

SECTION 622-PNEUMATICALLY PLACED CONCRETE

SECTION 622-PNEUMATICALLY PLACED CONCRETE

622.01-Description. This work shall consist of the furnishing and placing of "Pneumatically Placed Concrete" including wire mesh reinforcement for slope stabilization, for lining ditches and channels, constructing warped sections, and rebuilding of deteriorated areas of concrete bridges or culverts to original lines.

Pneumatically placed concrete as herein specified is a mixture of Portland cement and sand thoroughly mixed dry. It is then passed through a cement gun and conveyed by air through a flexible tube. Water is added to this mixture immediately previous to its expulsion from the nozzle at which point the hydrated mixture is pneumatically applied through this nozzle onto the prepared foundation.

622.02-Materials. The materials used in this construction shall conform to the following requirements:

Material	Subsection
Portland Cement (Type I)	**901.01**
Sand	**903.01**
Water	**918.01**
Reinforcement	**907.03**

622.03-Proportioning. Pneumatically placed concrete shall be mixed in the proportion of 94 lbs(50 kgs) of Portland Cement to 3 c.f.(0.1 m^3) of sand. Batches may be measured by weight or volume. Unless otherwise specified, the compressive strength shall be not less than 3,000 psi(20.7 MPa) in 28 days.

622.04-Test Specimens. The pneumatic concrete Contractor shall furnish at his own expense, especially constructed cylinder molds 6 in.(150 mm) in diameter and 12 in.(300 mm) high, made of 1/2 in.(13 mm) opening hardware cloth. The test cylinders shall be made with the same pressure, nozzle tip, and hydration as the pneumatic concrete in the structure where the cylinders were made. The number of cylinders required will be approximately 6 per day; however, additional cylinders and other test methods may be required by the Engineer.

622.05-Equipment. Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly and approved.

(a) Cement Gun.

The pneumatic mixing and delivering equipment shall be the vertical double chamber type. The upper chamber shall receive

and pressurize the dry mix and deliver it to the lower chamber. The lower chamber shall force the pressurized mix into the delivery hose by means of the feed wheel. The type of feeder utilized should be of sufficient capacity that the lower chamber may continuously furnish all required material to the delivery hose while the upper chamber receives the recharge. All equipment must be kept in good repair. The interior of drums, feed gearing and valves shall be cleaned as often as necessary (at least once every 8-hour shift) to prevent material from caking on critical parts. Gaskets in the equipment shall be kept in good condition to avoid reduced pressure and consequent reduced velocity of material during the recharging periods.

(b) Air Compressor.

Any standard type of compressor shall be satisfactory if it is of sufficient capacity to provide, without interruption, the pressures and volume of air necessary for the longest hose delivery. The air compressor capacity determinations shall include allowances made for the air consumed in blowing rebound, cleaning reinforcing, and for incidental use. Compressor equipment shall be of such capacity so as to insure air pressure at the mixer capable of producing the following material velocities:

1. 375 to 500 ft.(115 to 150 m) per second using 3/4 in.(19 mm) nozzle.
2. 425 to 550 ft.(130 to 170 m) per second using 1 1/2 in.(38 mm) nozzle. Nozzles shall be of the "Pre-Mixing" type with perforated water-feed ring inside the nozzle to direct an even distribution of water through the material at the place of application.

(c) Hose & Nozzle.

The nozzle shall be the premixing type with perforated water feed ring inside the nozzle. The maximum length of material hose for the application of pneumatically placed concrete shall be approximately 100 ft.(30 m) although it shall be permissible to use as much as 500 ft.(150 m) of material hose if the supply nozzle pressures are increased to maintain proper velocity The nozzle pressures shall be determined by the type of work involved:

1. For rough or heavy work: Nozzle pressures of 50 to 60 psi(350 to 415 kPa).
2. For high lifts or long hose to insure against clogging, pressures of 70 to 75 psi(480 to 520 kPa).

(d) Water Pump.

Water pressures shall be maintained at approximately 20 psi(140 kPa) higher than the highest air pressure required for placing. Both air and water pressure shall be uniformly steady (non-pulsating).

CONSTRUCTION REQUIREMENTS

622.06-Surface Preparation. The surface to receive the pneumatically placed concrete shall be graded(smoothed) and cleaned of loose, deteriorated, or undesirable material as directed by the Engineer.

Pneumatically placed concrete used in the repair of concrete structures shall be placed on a surface of sound concrete. All disintegrated and spalled concrete shall be removed by chipping with pneumatic hammers and chisels to sound concrete. All cracks and cavities shall be chipped to such formation that their sides are approximately perpendicular to the exposed surface forming a mechanical shoulder for at least 2 in.(50 mm) in depth. All concrete surfaces to receive pneumatically placed concrete shall be cleaned by flushing or scouring with water and compressed air jets to assure removal of all loose particles. Corroded and rusted reinforcing steel shall be cleaned by sandblasting to insure positive bond of the pneumatically placed concrete. To insure a good bond, the newly chipped and sandblasted surface shall be thoroughly moistened with water not less than one hour prior to application of the pneumatically placed concrete. In no instance shall pneumatically placed concrete be applied to an area where free running water exists.

Reinforcing steel may be welded to other exposed steel or may be grouted securely into drilled holes in the accepted manner of placing anchor dowels within the proposed repair area of concrete structures. In drilling dowel holes, care must be exercised to avoid damage to existing reinforcing steel. Spacing of the steel reinforcing shall depend on the location, nature, and extent of the repair and shall be determined by the Engineer. Wire mesh or fabric used as reinforcement shall be determined by the Engineer and shall be anchored by means of 1/4 by 4 in.(6 x 100 mm) expansion hook bolts spaced 24 in.(600 mm) on center in each direction, or by secure wire ties to existing steel. The full area of mesh or fabric shall be held firmly in position by means of 16 gauge or 18 gauge wire ties. The reinforcement shall not be less than 1/2 in.(13 mm) from the surface on which the pneumatically placed concrete is to be placed, and there shall not be more than 3/4 in.(19 mm) between the reinforcement and the final surface of the pneumatically placed concrete. In places where the depth of the section removed exceeds 3 in.(75 mm) over an appreciable area, 2 or more layers of fabrics shall be used. Steel bar reinforcing shall be lapped 40 diameters; mesh or fabric shall be lapped at least one full mesh longitudinally and the same width in inches transversely. Laps shall be tied with 16 or 18 gauge wire at 12 in.(300 mm) spacing.

Reinforcement in new construction shall be placed as specified in the Plans and secured to insure no displacement from impact of the pneumatically placed concrete during application.

622.07-Mixing. Pneumatically placed concrete shall be thoroughly mixed in a dry state either by hand or in a mechanical mixer before placing in the hopper of the cement gun or other apparatus. The term "dry" as applied to sand, designates a normal moisture content of from 3 to 8%.

Water shall not be added to the mix after mixing or before using the cement gun.

Remixing or tempering shall not be permitted.

622.08-Limitations of Application Pneumatically placed concrete shall not be placed on a frozen surface nor when the ambient temperature is less than 40° F(4° C). Pneumatically placed concrete shall not be placed when it is anticipated that the temperature during the following 24 hours will drop below 32° F(0° C).

The application of pneumatically placed concrete shall be suspended if high winds separate the cement from the sand at the nozzle, or rain occurs which would wash out the pneumatically placed concrete.

622.09-Application. Corners shall be filled first. "Shooting" shall be from an angle as near perpendicular to the surface as practicable, with the nozzle held approximately 3 ft.(1 m) from the work (except in confined control), If the flow of material at the nozzle is not uniform and slugs, sand spots, or wet sloughs result, the nozzle-man shall direct the nozzle away from the work until the faulty conditions are corrected.

Such defects shall be replaced as the work progresses.

Sequence of application may be from bottom to top or vice versa if rebound is properly removed.

The time interval between successive layers in sloping, vertical or overhanging work shall be sufficient to allow initial but not final set to develop. At the time the initial set is developing the surface shall be cleaned to remove the thin film of laitance in order to provide for a bond with succeeding applications.

The construction joints or day's work joints shall be sloped off to a thin clean, regular edge, preferably at a 45° slope. Before placing the adjoining work, the sloped portion and adjacent pneumatically placed concrete shall be thoroughly cleaned as necessary, then moistened and scoured with an air jet.

Pneumatically placed concrete shall be applied in one or more layers to such total thickness as required to restore the area to 2 in.(50 mm) over the original line of the adjoining surface, unless otherwise specified by the Engineer.

622.10-Rebound. Rebound recovered clean and free of foreign matter may be reused as sand in quantity not to exceed 20% of the total sand requirements.

622.11-Finishing. After the pneumatically placed concrete has been placed as nearly as practicable to the required depth, the surface shall be checked with a straightedge, and any low spots or depressions shall be brought up to proper grade by placing additional pneumatic concrete in such a manner that the finished surface shall be reasonably smooth and uniform for the type of work involved.

When the body coat has been placed, the surface shall be trued with a thin edge screed to remove high areas and expose low areas. Low areas

shall be properly filled to insure a true flat surface. After the surface has been trued the entire surface shall be given a natural gun finish.

Loose areas of pneumatically placed concrete shall be removed and replaced by the Contractor at his expense.

622.12-Curing. As soon as the fresh pneumatically placed concrete surface shows the first dry patches, a fine spray of water shall be applied to keep it moist. After the surface has hardened, it shall be kept moist for a period of 7 days.

622.13-Adjacent Surface Protection. During progress of the work, where appearance is important, adjacent areas or grounds which may be permanently discolored, stained, or otherwise damaged by dust and rebound, shall be adequately protected and, if contacted, shall be cleaned by early scraping, brushing or washing, as the surroundings permit.

622.14-Qualifications and Duties of Workmen. Only experienced foremen, gunmen, nozzle-men, and rodmen shall be employed and satisfactory written evidence of such experience shall be furnished the Engineer upon request.

COMPENSATION

622.15-Method of Measurement. The completed and accepted pneumatically placed concrete as specified and indicated on the Plans, will be measured in s.f.(m^2). Measurement will be made over and parallel to the actual area of the pneumatically placed concrete.

622.16-Basis of Payment. Pneumatically placed concrete measured as provided above will be paid for at the unit bid price per s.f.(m^2) for "Pneumatically Placed Concrete" of the type specified.

The unit price bid per s.f.(m^2) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing the work involved in placing pneumatically placed concrete, including preparing the foundation, reinforcement, as shown on the Plans, as specified in these Specifications and as directed by the Engineer.

SECTION 623- BRIDGE EXPANSION JOINTS

SECTION 623- BRIDGE EXPANSION JOINTS

623.01-Scope of Work. This work shall consist of the fabrication and installing shop fabricated bridge expansion joint systems joints, of the general size, configuration, and joint movement specified; in accordance with these provisions and within reasonable close conformity to the lines, elevations, locations, details, and notes shown on the plans and on approved shop drawings.

623.02-Modular Roadway Expansion Joints. This section is applicable to expansion joints having a required movement in excess of 4 in. (100 mm).

A. Fatigue Design All modular expansion devices proposed by the contractor must be certified to have been tested in accordance with the **National Research Program Report 467** "Performance Testing for Modular Bridge Joint Systems."

B. Materials.

1. General - All parts and elements shall be of the material and design indicated in the manufacturer's catalog, except as otherwise specified in these provisions or on the plans.

2. All steel plates, bars, rolled shapes and extrusions shall be fabricated from high-strength, low alloy grade 50 steel, conforming to the requirements of ASTM A 709 grade 50 or 50W, as shown on approved shop drawings. Anchor bars may be A36 steel. All membrane retainers shall have a 3/8-in. (9.5 mm) minimum thickness.

Stainless steel sheets for the sliding surfaces of the support bars shall conform to the requirements of ASTM A 167, alloy 304, 20 micro-inch RMS finish.

Anchor bolts, bolts, nuts, and washers shall conform to the requirements of ASTM A 307, as indicated on the plans.

3. Preformed Elastomeric Seals - The elastomeric sealing element shall be a polychloroprene (neoprene) seal that is resistant to heat, oil, jet fuel, and ozone. The seal shall be one piece full length of the expansion joint including curb and parapet face projections.

In addition, the sealing elements shall conform to ASTM designation D 2628, modified to omit the recovery test and as noted herein:

Property	Requirements	ASTM Method
Hardness Type A	60 +/- 7 Durometer	D-2240 Modified

Lubricant/Adhesive for installing the preformed elastomeric elements in place shall be a 1-part moisture-curing, polyurethane and hydrocarbon solvent mixture or as recommended by the manufacturer and approved by the Engineer.

4. Support Bar Bearings - Support bar bearings shall be fabricated from polyurethane compound with polytetrafluorethylene (PTFE) self-lubricating surfaces having engineering properties equivalent to adiprene, teflon or cast nylon w/MDS (molybdenum disulfide) respectively, (i.e. - high-load bearing and high-impact resistance characteristics plus low coefficient of friction).

5. Joint Control Mechanism - Suitable equilibrium type springs which operate counter to compression forces of the sealing elements and colinear with the axis of structure movement, will be provided to insure equal distribution of the total joint opening.

6. Support Bars - Shall as a minimum:

a. Incorporate stainless steel sliding surfaces to minimize resistance to joint movements.
b. Provide support above, below and laterally as required to prevent lifting, transmit bearing loads and maintain positioning of the bar. Support bars shall be placed at right angles to each transverse rail.
c. Support bars shall not be less than 2 in. (50 mm) in width and 3 in. (75 mm) in height, and each transverse rail (separation beam) shall rest on a separate support bar at each support assembly.

7. Separation Beams/Transverse Dividers - Shall not be less than 2-1/2 in. (65 mm) in top width and 4 in. (100 mm) in height and shall be designed for the design live load (AASHTO HS 20-44, minimum plus 50% for impact), using working stress limits. Support bars and transverse rails shall be analyzed using both vertical and horizontal live load components.

8. Miscellaneous Hardware - Shall be as described in the manufacturer's literature.

C. Fabrication and Construction.

The manufacturer of the prefabricated expansion joint assembly shall prepare shop drawings showing details of the assembly and installation. Installation drawings shall include concrete, reinforcing steel and/or anchorage details falling within the respective modular joint stress zones.

1. The expansion joint systems shall be constructed in accordance with the details shown on the shop drawings. Tolerance requirements shall be in accordance with AASHTO specifications. All welding shall be in accordance with AWS specifications and shall be done by certified welders only. Fabricators shall be certified under the AISC Quality Certification, Category I, Simple Bridges, SBR-1B.

2. Shop drawings shall also supply information regarding material specifications, geometry, a table of variable temperature and dimensions and a bill of material. The maximum joint opening for a single modular unit shall be 4 in. (100 mm) measured at right angles to the rails.

3. All steel, with the exception of the stainless steel elements, shall be either painted in accordance with 'System A' of the Standard Specifications, **Subsection 603.06** or galvanized unless specified otherwise on the plans.

4. The profile of the joint in the pavement area shall conform to the roadway cross section, slope, skew and grade. Slider plates shall be provided at curbs, walkways, and parapets, as part of the completed joint assembly, in accordance with details shown on the plans and Standard Drawings.

5. The modular expansion joint assembly shall be preset, in accordance with approved shop drawings, joint setting data, and specifications. The assembly shall be properly secured for shipping and contain temporary self-aligning guide angles or other structural members to span over the blockout for joints and allow for proper grade and elevation adjustment between the bridge deck and approach roadway. Final adjustment shall be made at the discretion of the Engineer. All movements due to factors such as shrinkage, creep, and midslab deflection, shall be properly accounted for prior to this final adjustment. Adjustments other than for temperature settings shall require the permission of the joint manufacturer's technical representative.

6. The prefabricated joint assembly shall be properly positioned and attached to the superstructure by means of anchorages provided with the assembly.

7. The use of drilled and grouted, or cast-in-place inserts, for the anchoring of the expansion device to the structure is prohibited.

Anchorage shall be accomplished by attachment to each longitudinal bridge girder, supplemented by 2 in. (50 mm) wide straps, providing no less than 1.25 in.^{2}(2,650 mm^2) of cross-sectional area per linear foot(meter) of expansion joint between direct connections at girders. The straps shall be a minimum length of 1 ft. (300 mm) with a 2 in. (50 mm), 90° bend at the free end.

8. Girder attachments shall provide a means of adjustment so that the expansion device can be installed to line and grade in conformance with approved shop drawings and contract plans, and the manufacturer's recommendations.

9. The backwall anchorage shall be of a similar configuration.

10. It shall be the sole responsibility of the contractor to coordinate with the joint supplier, remain-in-place form supplier and/or beam fabricator to assure that all details impacting the acceptable installation of the expansion joint are in harmony.

11. Formed recesses shall be thoroughly cleaned of foreign material and prepared by an approved method. Deck concrete shall be well consolidated behind and around both sides of the joint edge rails and support boxes.

D. Installation Supervision and Certification:

A manufacturer's representative shall be present at the time of installation to assist the contractor in the proper setting of the joint. If the individual representing the manufacturer is not a full time employee of the manufacturer, he shall provide written certification that he is a duly authorized agent of the manufacturer prior to beginning joint installation. After installation, the representative shall be required to inspect and certify to the Engineer that the joint has been installed in accordance with the manufacturer's recommendations, and that it is water tight. Joints for which such certifications are not provided will not be accepted.

Tests for water tightness shall be conducted by the contractor and the manufacturer's representative in the presence of the Engineer by ponding water upon the joint for a period of 15 minutes. Corrective measures shall be taken to eliminate all leaks.

E. Measurement.

Modular type expansion joints will be measured horizontally by the linear foot(meter) along the center of the joint from outer face to outer face of the concrete superstructure of the bridge. No direct measurement and payment will be made for slider plate assemblies at curbs, walkways, medians, median barriers and parapets, the cost of

which shall be included in the contract price for the modular type expansion joints.

F. Basis of Payment.

Payment of each designated item at the specified contract price per linear foot(meter) shall be compensation in full for all costs of furnishing and installing the device complete in place, and shall include all labor, materials, equipment and other incidentals necessary to complete the work in accordance with plans, specifications, and these provisions.

The deck concrete placed within the limits of the expansion joint block-outs shall be paid for at the applicable contract unit price per c.y. (m^3). Otherwise, the cost of all modifications of bridge details, including parapet and/or median slider plate assemblies, forming for adequate block-outs of the concrete deck slab and any additional reinforcing steel required in the concrete deck slab block-outs, necessary to properly install the roadway expansion joint shall be included in the price bid for the joint.

623.03-Strip Seal Expansion Joints.

A. Description of Work. This subsection is applicable to expansion joints having a required movement of 4 in. (100 mm) or less.

B. Materials

1. General. - All parts and elements shall be of the material and design indicated in the Manufacturer's catalog, except as otherwise specified in these provisions or on the plans.

2. All steel plates, bars and shapes shall be fabricated from high-strength, low alloy grade 50 steel, conforming to the requirements of ASTM A 709 grade 50 or 50W, as shown on approved shop drawings. Anchor bars and plates may be A36 steel. The membrane retainer may be either an extrusion or rolled shape.

Anchor bolts, bolts, nuts, and washers shall conform to the requirements of ASTM A 307, as indicated on the plans.

3. Preformed Elastomeric Seals - The elastomeric sealing element shall be EPDM or a polychloroprene (neoprene) seal that is resistant to heat, oil, jet fuel, and ozone. The seal shall be one piece full length of the expansion joint including curb and parapet face projections. The seal shall be a mechanically locked seal element placed in a solid steel extrusion or rolled shape conforming to the Plans dimensions.

In addition, the sealing elements shall conform to ASTM designation D 2628, modified to omit the recovery test and as noted herein:

Property	Requirements	ASTM Method
Hardness Type A	60 +/- 7 Durometer	D 2240 Modified

Lubricant/Adhesive for installing the preformed elastomeric elements in place shall be a 1 part moisture-curing, polyurethane and hydrocarbon solvent mixture or as recommended by the manufacturer and approved by the Engineer.

4. Miscellaneous Hardware - Shall be as described in the Manufacturer's literature.

C. Fabrication and Construction.

1. The Manufacturer of the prefabricated expansion joint assembly shall prepare shop drawings showing details of the assembly and installation. Installation drawings shall include concrete, reinforcing steel and/or anchorage details falling within the respective joint zones. Also, any changes to the reinforcing steel or concrete limits from the Contract Plans due to the type joint being used must be shown on the shop drawings.

2. Shop drawings shall also supply information regarding material specifications, geometry, a table of variable temperature and dimensions and a bill of material. The maximum joint opening shall be 4 in. (100 mm). The expansion joint systems shall be constructed in accordance with the details shown on the shop drawings. Tolerance requirements shall be in accordance with AASHTO Specifications. All welding shall be in accordance with AWS specifications and shall be performed by certified welders only. Fabricators shall be certified under the AISC Quality Certification, Category I, Conventional Steel Structures.

3. The profile of the joint shall conform to the roadway cross section, slope, skew, and grade.

4. All steel that is part of the joint assembly shall either be painted in accordance with 'System A' of the Standard Specifications, **Subsection 603.06**, or galvanized, in accordance with ASTM A 123, unless shown otherwise on the plans.

5. The prefabricated joint assembly shall be properly positioned and attached to the superstructure by means of anchorages provided with the assembly.

6. The use of drilled and grouted, or cast-in-place inserts, for the anchoring of the expansion device to the structure is prohibited on new construction. Anchorage shall be accomplished by

attachment to each longitudinal bridge girder, supplemented by 2 in. (50 mm) wide straps, providing no less than 1.25 in.^{2}(800 mm^2) of cross-sectional area per linear ft. (0.3 m) of expansion joint between direct connections at girders. The straps shall be a minimum length of 1 ft. (300 mm) with a 2 in. (50 mm) 90° bend at the free end.

7. Anchorage details for repair of expansion joints on existing structures shall be as shown on the contract drawings and/or approved shop drawings.

8. Girder attachments shall provide a means of adjustment so that the expansion device can be installed to line and grade in conformance with approved shop drawings and contract plans, and the Manufacturer's recommendations.

9. The backwall anchorage shall be of a similar configuration.

10. It shall be the sole responsibility of the contractor to coordinate with the joint supplier, remain-in-place form supplier and/or beam fabricator to assure that all details impacting the acceptable installation of the expansion joint are in harmony.

11. Formed recesses shall be thoroughly cleaned of foreign material and prepared by an approved method. Deck concrete shall be well consolidated behind and around both sides of the joint steel.

D. Measurement

Strip seal type expansion joints will be measured horizontally by the linear foot(meter) along the center of the joint, from outer face to outer face of the concrete superstructure of the bridge. No direct measurement and payment will be made for slider plate assemblies at curbs, walkways, medians, median barriers and parapets; the cost of which shall be included in the contract price for the strip seal type expansion joints.

E. **Basis of Payment**.

Payment of each designated item, at the specified contract price per linear foot(meter), shall be compensation in full for all costs of furnishing and installing the device, complete in place, and shall include all labor, materials, equipment, and other incidentals necessary to complete the work in accordance with plans, specifications, and these provisions.

The cost of all modifications of bridge details including parapet and/or median slider plate assemblies, necessary to properly install the roadway expansion joint shall be included in the price bid for the joint.