CATEGORY 400
STRUCTURES

SECTION 401 - MAINTAINING EXISTING BRIDGE DECK DURING LIFE OF CONTRACT

401.01 DESCRIPTION. This work shall consist of patching the existing bridge deck as specified in the Contract Documents or as directed by the Engineer.

401.02 MATERIALS.

The Contractor shall select the patching material from the prequalified list of rapid hardening cementitious materials maintained by the Engineer.

401.03 CONSTRUCTION. The Engineer and Contractor shall periodically review the existing deck and determine if any patching is necessary. All holes over 1 in. (25 mm) deep having an area greater than 2 ft^2 (0.186 m^2) shall be patched.

Before patching begins, the Contractor's Traffic Manager shall confer with the Engineer to decide on a plan for diverting or detouring traffic during patching operations. All items relating to traffic safety and traffic control requirements shall conform to the Contract Documents.

The areas requiring repairs shall be clean and free of loose material.

When working on a full depth repair area, the Contractor shall protect waterways and roadways under the structure from falling debris. No removed material shall be disposed of in any waterway.

The patching material shall be placed full depth to the top of the existing bridge deck surfaces.

New reinforcement shall only be required when directed by the Engineer.

If a patch has been made and it has not yet reached sufficient strength to

support traffic when this section of the structure is opened to traffic, it shall be covered with a steel plate as specified in 522.03.13. All areas around the plate shall be built up with asphalt material.

401.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

401.04.01 Patch For Maintaining Existing Bridge Deck will be measured and paid for at the Contract unit price per square foot.

401.04.02 The removal of material required to prepare the patch area, including chipping, hand cleaning, as well as furnishing and placing reinforcement steel, forming, providing protective structures, furnishing, placing and removing any steel plates, and labor will not be measured but the cost will be incidental to the pertinent patching items specified in the Contract Documents.

401.04.03 All work, materials, sequence of operations and cones required to maintain traffic during each occurrence of patching including removal after patching is complete, will be measured and paid for at the Contract unit price per each for the pertinent Maintenance of Traffic for Bridge Patching Operation item. If more than one patch is made under one movement of traffic for patching, then this item will only be paid for once, regardless of the number of patches made or the length of time traffic is rerouted. If traffic must be maintained more than once for a particular patching operation, then this work will only be measured and paid for once.

401.04.04 Floodlighting. Floodlighting will not be paid for unless approved by the Engineer in writing. Repairs performed at night will be paid for at the Contract unit prices.

SECTION 402 — REMOVAL OF EXISTING STRUCTURES

402.01 DESCRIPTION. This work shall consist of the removal and disposal or salvage, wholly or in part, of existing structures as specified in the Contract Documents.

402.02 MATERIALS. Not applicable.

402.03 CONSTRUCTION. Before removal operations begin, the Contractor shall submit to the Engineer for approval a list of the equipment to be used and the removal method.

Unless otherwise specified in the Contract Documents, the limits of removal for existing structures shall be 1 ft (0.3 m) below the proposed groundline or to the limits necessary to avoid conflict with the proposed construction. The material obtained from the removal of the existing structures shall become the property of the Contractor who shall be responsible for removing and disposing of the material on approved spoil areas.

402.03.01 Removal of Bridge Deck Slabs. The Contractor shall protect the public against injury and damage from demolition operations when removing portions of existing bridge deck slabs. When deck removal is performed over or near roadways, railroads or waterways, the Contractor shall furnish and erect temporary protective shields to prevent any material or debris from entering these areas.

The protective shields shall be acceptable to the Engineer. Flooring and siding shall have no cracks or openings through which material particles may pass. The shields shall be able to support over their entire area 150 lb/ft^2 (730 kg/m^2) in addition to their own dead weight.

A minimum underclearance of 14.5 ft (4.4 m) shall be maintained over the roadway pavement and shoulders. No portion of the shield including connection devices shall encroach on this underclearance. If less than 16.0 ft (4.9 m) underclearance is provided, the Contractor shall furnish and erect signs indicating the exact minimum underclearance. The signs and their location shall be approved by the Engineer. They shall be removed when the original underclearance is restored and shall become the property of the Contractor.

After the Engineer determines that the protective shields have served their purpose, they shall be removed and become the property of the Contractor.

402.03.02 Bridge Deck Slabs to be Replaced. On structures where the

existing structural steel will be used in the finished structure and the Contractor elects to support the protective shields from the steel, all connections thereto shall be made by means of clamps or other approved devices. The drilling of holes in the existing steel work, or welding to the steel work for this purpose is prohibited.

Before removal operations begin, the outlines of the top flanges or cover plates of all stringers and floor beams shall be drawn on the bridge deck and 1 in. (25 mm) diameter pilot holes made outside these lines to confirm the location of the steel.

Prior to removing the existing slabs, the Contractor shall take elevations at locations along the bottom of the bottom flange or top of the top flange by removing small sections of slabs over stringers using pilot holes at the center and quarter points of all stringers, and at other points if necessary, to provide a maximum spacing of 25 ft (7.6 m) between elevations. After removing the deck, the Contractor shall take a new set of elevations at the same points and ascertain the rebound. These rebounds shall be used in lieu of dead load deflections to establish grade controls and to produce finished tops of concrete bridge decks that will be true to as planned line and grade. For bridge decks constructed with a longitudinal construction joint between stringers, diaphragms between these stringers shall not be disconnected unless specified in the Contract Documents.

On continuous bridges, the Contractor's proposed sequence of deck removal shall address uplift at the ends of continuous spans.

If damage results from the Contractor's operations, the removal operation shall be modified and the damaged items shall be repaired or replaced by the Contractor in a manner acceptable to the Engineer at the Contractor's expense.

402.03.03 Removal and Salvage of Steel Members. When steel is to be salvaged for the Administration, it shall be removed with care to prevent damage. Before dismantling trusses, the Contractor shall match mark all members, mark the size and length of both the beam and cover plate on top and bottom flanges and both sides of the web with white paint. No burning, cutting, or bending of the structural steel members will be permitted. All

diaphragms and connector plates attached to existing beams shall be carefully removed. Riveted and bolted joints may be disconnected by cutting the rivet or bolt heads. Removal of welds from existing beams, diaphragms and connector plates shall be by the air arc method.

Salvaged materials shall be loaded, hauled, unloaded and stacked at a site specified in the Contract Documents or as directed by the Engineer. The Contractor shall notify the Engineer a minimum of 48 hours prior to delivery of salvaged materials. The Contractor shall arrange for provisions to store the material off the ground and for unloading and neatly packing of the material at the Administration's designated storage site. The material shall be stored as specified in 408.03.09

402.03.04 Removal of Existing Bridge. Existing bridges, including piles, shall be removed as specified in 207.03.01 and from any area that will interfere with proposed construction.

402.04 MEASUREMENT AND PAYMENT.

402.04.01 The Removal of Existing Structures will not be measured for payment but will be paid for at the Contract lump sum price. The payment will be full compensation for all excavation, backfill, temporary protective shields, hauling, disposal, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

402.04.02 The removal of existing concrete parapets on bridges and wing walls, concrete median barriers on bridges and barrier portion of retaining walls will not be measured but will be paid for at the Contract lump sum price for the pertinent Removal of Existing Concrete Parapet or Removal of Existing Concrete Barrier from Structure items. The payment will be full compensation for all temporary protective shields, hauling, disposal, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

402.04.03 When the item Removal of Existing Bridge is specified in the Contract Documents, the item will not be measured for payment but will be paid for at the Contract lump sum price. The payment will be full compen-

sation for the removal of the structure, substructure, piles, supports, cribbing, grillage, salvage or disposal, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

402.04.04 Contingent Removal of Portions of Existing Structure. **Reserved**

402.04.05 Removal of existing structures for which no specific pay item is included in the Contract Documents will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

SECTION 403 — DRILLED HOLES IN EXISTING MASONRY

403.01 DESCRIPTION. This work shall consist of drilling holes in existing masonry for grouting of bars, bolts or anchorages, as specified in the Contract Documents or as directed by the Engineer.

403.02 MATERIALS.

Grout	902.11(c)

403.03 CONSTRUCTION. Holes shall be drilled only in the solid portion of the masonry. No holes will be permitted at points where cracks exist. The holes shall be drilled at least 1/2 in. (13 mm) larger than the outside diameter of the insert to be grouted. Holes shall be cleaned and then filled two thirds full of grout. The insert shall be placed and allowed to set for 24 hours or the holes shall be filled with the cement mortar of the concrete mix placed around the inserts and placed simultaneously with the placing of the concrete.

403.04 MEASUREMENT AND PAYMENT. Drilled Holes in Existing Masonry will be measured and paid for at the Contract unit price per linear feet of drilled holes. The payment will be full compensation for all material,

labor, equipment, tools, and incidentals necessary to complete the work.

Inserts required for insertion in these holes will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

Drilled holes for which no specific pay item is included in the Contract Documents will not be measured but the cost will be incidental to the other pertinent items specified in the Contract Documents.

SECTION 404 — STRUCTURE EXCAVATION (Class 3 and Class 4)

404.01 DESCRIPTION. This work shall consist of excavation and backfill for structures as specified in the Contract Documents or as directed by the Engineer. Classes of structure excavation are:

Class 3 Excavation — Excavation above the water line specified in the Contract Documents.

Class 4 Excavation — Excavation below the water line specified in the Contract Documents.

If Class 4 Excavation is not specified in the Contract Documents, all excavation shall be Class 3 Excavation.

404.02 MATERIALS.

Crusher Run Aggregate CR-6	901, Table 901 A
Subfoundation Concrete	902

404.03 CONSTRUCTION. All excavation contiguous to existing pavements and structures shall be sheeted, shored, braced, and supported in a substantial manner to prevent settlement, movement, or damage to the pavement or structure. Excavated material shall not be placed in any manner that may endanger any structure and shall be kept out of waterways.

404.03.01 Backfill and Embankment Material. All suitable material removed from the excavation shall be placed in backfill or stored for future use. Excavated material shall not be wasted without permission of the Engineer. Boulders, logs or other unforeseen obstacles encountered shall be removed. Unsuitable material shall be disposed of in an approved disposal area.

404.03.02 Footing Elevations. The elevation for the bottom of the footing specified in the Contract Documents shall be considered as approximate only, and the Engineer may, during the period of construction, order changes in dimensions or elevations of footings to secure a satisfactory foundation.

404.03.03 Footing Foundations. Footings for structures shall be on suitable foundations, and no concrete shall be placed or foundation piles driven until the foundations are approved by the Engineer.

All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface, either level or stepped as directed by the Engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed. When concrete is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation. Final removal of the foundation material to grade shall not be made until just before concrete is placed. If the Contract Documents include an item for Subfoundation Investigation (Section 406) the item shall be used to verify the character of the foundation if directed by the Engineer.

Faces of footings shall be placed plumb against either undisturbed material, rock, sheeting, shoring, or forms. Faces of footings in rock shall bear against a minimum 1 ft (0.3 m) depth of rock. If the excavation will not stand plumb, the Contractor shall furnish and install sheeting, shoring, or forms as required. When specified in the Contract Documents, sheeting used to construct spread footings shall be left in place and cut off 2 ft (0.6 m) below finished grade. When not specified, or when sheeting is used to construct pile supported foundations, the sheeting may be removed.

The design of sheeting and shoring shall be the responsibility of the Contractor. When the material retained by the sheeting and shoring is greater than 6 ft (1.8 m) high, the detail, procedure, and computations shall be submitted the same as specified for falsework details in TC-4.01 and the Contract Documents. The experience specified in TC-4.01 will be waived.

Forms used for footings shall be removed and the void between the footing and the embankment shall be backfilled with subfoundation concrete or tamped fill utilizing crusher run aggregate CR-6. The material shall be compacted to not less than 92 percent of maximum density when tested in conformance with T 180, Method C. Subfoundation concrete shall be used for this backfill when footings are submerged. Working drawings for forms used for footings are not required to be submitted for approval unless directed by the Engineer or the footing thickness exceeds 6 ft (1.8 m). However, working drawings for forms are required for footings of any thickness in submerged areas, cofferdams and adjacent to railroad tracks.

Where foundation piles are used, the excavation of each pit shall be completed to the as planned bottom of footing elevation before the piles are driven. After the driving is completed, all loose and displaced material shall be removed, without damaging the placed piling, leaving a suitable bed to receive the footing concrete. For tremie seal, the displaced material may remain in place provided the minimum thickness of footing concrete, pile embedment and the required sealing of the foundation seal is maintained.

Where foundation piles are not used to support bridge piers or abutments, retaining walls, or wing walls of box culverts or rigid frames, and excavation to suitable bearing must be made below the as planned bottom of the foundation, the additional excavated spaces under these substructure units shall be backfilled with subfoundation concrete or the footing elevation shall be lowered, or the footing deepened as specified in the Contract Documents or as directed by the Engineer. Rock foundations which are to receive footing concrete shall have a rough finish. Where excavation to suitable bearing for box culverts must be made below the as planned bottom of the foundation, additional excavated spaces under the barrels shall be backfilled with selected backfill. The spaces under the wing wall footing shall be backfilled with subfoundation concrete or the footing elevation lowered or footing depth deepened.

404.03.04 Cofferdams and Foundation Seals. When cofferdams are required, the Contractor shall submit for review, drawings and a complete description of the process for construction of the cofferdam. Timber or bracing left in the cofferdams or cribs shall not extend into the substructure concrete. Cofferdams shall be constructed to protect the concrete against damage.

(a) Foundation Seal. When the foundation cannot be dewatered, the Engineer may require the construction of a concrete foundation seal. The Contractor shall submit for review drawings and description of the process before placing of the seal. If a mud wave is created during the placement of the tremie seal, the displaced material shall be removed in order to preserve the full foundation cross section specified in the Contract Documents. The foundation shall then be pumped out and the footing placed in the dry. When weighted cribs are employed and the crib weight is utilized to overcome a part of the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level as directed.

(b) Pumping. Pumping will not be permitted during the placing of concrete. Pumping to dewater a sealed cofferdam shall not begin until the seal has set sufficiently to withstand the hydrostatic pressure.

(c) Removal of Cofferdams or Cribs. Cofferdams or cribs shall be removed by the Contractor after the completion of, and without damage to, the substructure.

(d) Stability of Foundation. The Contractor shall be responsible for stabilizing the foundation area so that the concrete footing can be constructed in the dry and in its proper place.

404.03.05 Backfilling. All excavated spaces resulting from structure excavation not occupied by the portions of the permanent work shall be backfilled with suitable material. The backfilling shall be carried to the surface of the surrounding ground or grade as specified in the Contract Documents.

Borrow shall not be used until the available project excavation is exhausted. The top surface of the backfilled areas shall be neatly graded. Backfill compaction shall conform to Sections 204 or 210.

Backfilling Against Structures. Backfilling against various structures shall be done as follows:

(a) Brick Masonry. Backfilling is not permitted until seven days after completion of the section.

(b) Concrete Structures. Backfilling is not permitted until curing is completed and the concrete has achieved 80 percent of the specified compressive strength.

(c) Footings, Culverts and Piers. Fill placed around footings, culverts and piers shall be deposited on both sides to approximately the same elevation at the same time.

(d) Abutments, Retaining Walls, Culverts or Other Structures. The bed for the backfill shall be built up in horizontal layers so that at all times there is a horizontal berm of uniformly compacted material behind the structure for a distance at least equal to the height of the abutment or wall remaining to be backfilled, except insofar as undisturbed material protrudes into this area. Compaction of the berm shall conform to 204.03. Jetting of fills or other hydraulic methods involving liquid or semi-liquid pressure within the berm area is prohibited.

404.04 MEASUREMENT AND PAYMENT. Class 3 and Class 4 Excavation will be measured and paid for at the Contract unit price per cubic yard for the volume of material actually removed from within the limits specified.

No measurement or payment will be made for removing any water or liquids.

Class 3 and Class 4 Excavation will extend a maximum of 18 in. to vertical planes outside of the structure. Where blasting is required, a maximum

of 6 in. will be allowed below the planned elevation.

Class 3 and Class 4 Excavation will include excavation for bridges, box culverts, and other structures as specified in the Contract Documents.

The upper limits for Class 3 Excavation on existing ground or embankments will be the existing groundline or the lower limit of roadway excavation. The lower limit of the two will control.

The upper limits for Class 3 Excavation on preliminary embankments will be the bottom of the as planned footing elevation. For stepped footings the upper limits will be the bottom of the as planned footing elevation of the highest portion of the footing. If the preliminary embankment has a surcharge, the upper limits will be the lower limit of roadway excavation.

The upper limits for Class 4 Excavation will be the bottom of the stream bed or at the top of the waterline shown on the Contract Documents. The lower limit of the two will control.

The payment per cubic yard for Class 3 Excavation and Class 4 Excavation specified in the Contract Documents will be full compensation for all excavation, backfill, filling void around footings due to removing forms, blasting, grout, dewatering, removal and disposal of excess or unsuitable material, and for all material, labor, equipment, tools, and incidentals necessary to complete the work. When an item for Class 3 Excavation and Class 4 Excavation is not included in the Contract Documents, the excavation will not be measured but the cost will be incidental to other items.

Excavation for Pipe Culverts, Culvert Endwalls, Inlets, and Manholes is not included in the Class 3 Excavation or Class 4 Excavation.

404.04.01 Additional excavation required below the elevation specified in the Contract Documents and necessitated by the lowering or deepening of footings, or the placing of subfoundations or underpinning, will be measured and paid for at the Contract unit price per cubic yard for either Class 3 Excavation or Class 4 Excavation as directed by the Engineer.

404.04.02 Sheeting, bracing, and shoring either removed or left in place,

will not be measured but the cost will be incidental to other pertinent items unless otherwise specified in the Contract Documents.

404.04.03 Excavation necessary to expose or remove piles, grillages, sheeting, cribbing, masonry, or other obstructions will not be measured nor paid for if the excavation occurs outside the limits of excavation. The removal and disposal of obstructions within the limits of excavation will not be measured but the cost will be incidental to the Contract unit price per cubic yard for either Class 3 or Class 4 Excavation.

SECTION 405 - POROUS BACKFILL

405.01 DESCRIPTION. This work shall consist of furnishing and placing of porous backfill material, reinforced concrete base and pipe drains at the rear of abutments, wing walls and retaining walls and other locations as specified in the Contract Documents or as directed by the Engineer.

405.02 MATERIALS.

Porous Backfill, No. 57, Aggregate	901
Concrete Mix No. 1	902.10.03
Pipe Drains	905
Reinforcement Steel	908.01
Geotextile Class E	921.09

405.03 CONSTRUCTION. Porous backfill material shall be placed in layers in conjunction with the adjacent fill. Any fill material removed for placing the porous backfill material shall be at the expense of the Contractor. When a form is used between the porous backfill material and the earth backfill, the form shall be completely removed from the completed fill.

Concrete base shall be sloped to drain to points of discharge.

405.04 MEASUREMENT AND PAYMENT. Porous Backfill will not be measured for payment but will be paid for at the Contract lump sum

price for the pertinent Porous Backfill item. If no item for Porous Backfill appears in the Contract Documents, the work will not be measured but the cost will be incidental to other items specified in the Contract Documents.

The payment will be full compensation for all excavation, concrete, reinforcement, drains, geotextile, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

SECTION 406 - SUBFOUNDATION INVESTIGATION

406.01 DESCRIPTION. This work shall consist of drilling or augering test holes in rock or other foundation material as a means of verifying the character and suitability of material for foundation purposes.

406.02 MATERIALS. Not applicable.

406.03 CONSTRUCTION. Test holes shall be drilled or augered as specified in the Contract Documents, or as directed by the Engineer.

406.04 MEASUREMENT AND PAYMENT. Subfoundation Investigation will be measured and paid for at the Contract unit price per linear foot for the actual total length of holes drilled or augered as directed by the Engineer. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

SECTION 407 - PILING

407.01 DESCRIPTION. This work shall consist of furnishing and installing piling as specified in the Contract Documents or as directed by the Engineer.

407.02 MATERIALS.

Sand	901, Table 901 A
Concrete for Cast-In-Place Piles	902.10.03 Mix No.3 Slump 4 to 6 in. (100-150 mm)
Concrete Grout	902.11(a)
Epoxy Grout	902.11(d)
Timber Piles	907.01
Timber Sheet Piles	907.01
Resin and Fiberglass Caps	907.01.01
Casings for Cast-In-Place Piles	907.02
Steel H Piles	907.03
Steel Sheet Piles	907.04
Reinforcement for Cast-In-Place Piles	908.01
Hardware	909.09
Water	921.01
Timber Preservatives	921.06

407.03 CONSTRUCTION. The Contractor shall be responsible for ordering and delivering piling of the proper type and length to the structure site.

407.03.01 Storage and Handling. Piling shall be stored and handled to avoid damage. Damaged piling shall be repaired or replaced as directed by the Engineer.

407.03.02 Preparation for Driving. Piling shall not be driven until embankments and excavation have been completed as specified in the Contract Documents or as directed by the Engineer.

The Contractor shall provide templates or other approved means to assure that the piles are properly aligned and positioned.

The heads of all piling shall be equipped with a cap or cushion so that the energy imparted by the hammer can be transmitted to the pile evenly without injury to the top or butt. The top of the pile, irrespective of its type, shall be normal to the axis of the moving parts of the hammer.

407.03.03 Tapered Shells. Tapered shells shall conform to the following:

(a) When used for piles of footings where the footing is below the existing and proposed groundline (i.e., footings for piers), the diameters of the piles at cutoff elevation shall not be less than the nominal butt size specified in the Contract Documents.

(b) When used for the piles of footings where the footings are above the existing groundline (i.e., pedestal abutment), the diameters of the piles at the existing groundline shall not be less than the nominal butt size specified in the Contract Documents.

(c) When used for trestles or bents, the diameters of the piles 10 ft (3 m) below existing or finished groundline, whichever is lower, shall not be less than the nominal butt size specified in the Contract Documents.

407.03.04 Pile Tips.

(a) Timber piles shall be pointed where driving conditions require. The point shall be symmetrical and not less than a 4 in. (100 mm) diameter. Timber piles shall have their tips or bottoms shod with a metal shoe or point when specified in the Contract Documents or as directed by the Engineer.

(b) Timber sheet piling shall be drift sharpened or beveled at the bottom so as to wedge contiguous piles in tighter contact.

(c) Steel H piles shall be driven without any special tip reinforcement unless otherwise specified in the Contract Documents.

Shells or casings for cast-in-place concrete piles shall be shod with steel tips or points as directed by the Engineer. The tip or point shall be electrically welded and guaranteed for permanent fixity. The end closures approved for cylindrical piles shall not project beyond the diameter of the pile casing. Tips for shells or casings with no deformations may be flat plates provided driving can be accomplished in a manner acceptable to the Engineer. If the Engineer determines that the tips are unsatisfactory, then the tips

shall be conical in shape, manufactured from pressed, cast, or forged steel as directed by the Engineer. Steel for pressed steel tips shall conform to A 709 Grade 36 or other equally strong and weldable steel.

If shells or casings have approved deformations, they shall have tapered tips and uniform sections above the tips in conformance with the Contract Documents.

407.03.05 Splicing. Splicing of timber piles is prohibited. In event of an isolated timber pile penetrating below planned tip elevation resulting in the top being below planned elevation, the Engineer will determine if it must be replaced, supplemented by an additional pile or if the structure can be changed without detriment.

If splicing of steel H piles and shells for cast-in-place concrete piles is necessary, they shall be spliced as specified in the Contract Documents by electric arc welding conforming to AWS Structural Welding Code for the full periphery. The number of splices permitted shall be compatible with driving conditions at the site and the standard lengths of piling produced by manufacturers.

Where a manufactured pile type is designed to be spliced by screwing two pieces together or by the use of couplings or collars, and the details for the splice are not specified in the Contract Documents, the device shall be submitted to and approved by the Engineer before use.

It is intended insofar as practical that piles be driven in a continuous operation, and that splicing be performed prior to approaching the estimated tip elevation.

407.03.06 Test Piling. The depth of penetration and the length of piling for structures will generally be determined by driving test piles. The Contract Documents will specify the test pile locations, minimum penetrations and bearing values and estimated tip elevations. From this information the Contractor shall order and drive the test piling. The actual safe bearing value of the test piling can then be determined as specified in 407.03.10. From the test pile data and behavior, the Contractor shall order the permanent piling required to complete the work.

407.03.07 Pile Driving. The Contractor shall submit to the Engineer, a plan of the pile driving method, including type of hammer, for approval prior to driving any piling.

The hammer to be used for driving permanent piles shall be the same hammer that was used to drive the test piles. If the Contractor changes hammers, the Contractor shall drive additional test piles at his expense before driving the permanent piles, even if the energy ratings of the hammers are identical.

Hammers shall be operated at speeds recommended by the manufacturer for the bearing value specified. The manufacturer's manual for the hammer employed shall be available to the Engineer at the project site.

Hammer energy is defined for the purpose of these Specifications as the approved rated energy per blow of the power hammer.

Tests may be directed by the Engineer to determine the acceptability and energy rating of power hammers that are not on the Engineer's approved list. The Contractor shall pay all costs, including the Administration's expenses, for approval and energy rating of any pile driving hammer.

When considering the hammer for approval, the ratio of the weight of the pile to the weight of the striking unit will be evaluated to determine the adequacy of the hammer.

Leads or spuds shall be constructed to afford freedom of movement of the hammer during the driving phases. The Contractor shall drive the piles within the tolerance as specified without injury to the piles. Any leads that do not produce satisfactory end results in the driving of piling shall be removed from the work.

No driving shall be done with the hammer out of the leads.

On all special, marine or water projects and pile bents, the leads shall be of sufficient length so that the use of a follower will not be necessary. Long piles and batter piles may require guides at intervals and additional support to prevent excessive bending or buckling under the hammer blow. Piles shall

be held in place and alignment by templates or other means approved by the Engineer.

Water jets shall not be used unless specified in the Contract Documents or as directed by the Engineer.

If the driving of test piles indicates that a thicker shell is necessary for cast-in-place concrete piles to obtain the penetration and bearing required without failure during driving, a shell of required thickness shall be provided.

Where piling must perforate strata which resists driving, the Contractor shall auger or drill holes through the strata. The size of the auger or drill to be used shall not be larger than the nominal diameter of a round pile or the minimum diameter of a circle in which an H pile will fit and shall meet with the approval of the Engineer before use. After the hole is completed, the pile shall be inserted and dry sand shall be used to completely fill any voids between the pile and the walls of the hole. Driving shall then be completed, after which any remaining voids shall be completely filled with dry sand.

407.03.08 Pile Driving Tolerances.

(a) General. Foundation piles shall not be used out of the position specified in the Contract Documents by more than 6 in. (150 mm) in any direction after driving regardless of the length of piles. Variation from the vertical or from the batter shall not be more than 1/4 in./ft (20 mm/m).

(b) H Piles. Rotation of the pile in excess of 25 degrees from the as planned axis will not be permitted.

(c) Bents. Piles shall be driven so that the cap may be placed in its proper location.

407.03.09 Unacceptable Piles. Any pile not in conformance with the Contract Documents shall be corrected at the Contractor's expense by one of the following methods or other methods approved by the Engineer.

(a) The pile shall be withdrawn and replaced by a new pile.

(b) A second pile shall be driven adjacent to the unacceptable pile.

(c) The pile shall be spliced or built up.

(d) A sufficient portion of the footing shall be extended to properly embed the pile.

407.03.10 Bearing Value. The determination of the bearing value shall be primarily obtained from observation and reporting of the behavior of the test pile from the time first placed in the leads until it attains practical refusal or reaches a stratum specified in the Contract Documents or as directed by the Engineer. To furnish the Engineer and Contractor with a guide as to the probable supporting value at each position, the Engineer will compute the safe bearing value from the following formulas:

UNITED STATES SYSTEM

$$P = \frac{2WH}{S + 0.1}$$ for single acting power hammers

$$P = \frac{2E}{S + 0.1}$$ for double acting power hammers

where:

P = safe bearing value in pounds.
W = weight in pounds of striking parts of hammer.
H = height of fall in feet.
E = approved hammer energy per blow in foot pounds for double acting, differential acting, and diesel hammers.
S = the average penetration in inches per blow for the last several inches of penetration.

METRIC SYSTEM

$$O = \frac{1\ (H \times W)}{6(S + 0.00254)} = \frac{1\ (E)}{6(S + 0.00254)}$$

where:

O = safe bearing value in kilograms.
H = height of fall in meters.
W = weight in kilograms of striking parts of hammer.
E = HW = approved hammer energy per blow in joules for double acting, differential acting, and diesel hammers.
S = the average penetration in meters per blow for the last several meters of penetration.

$$S = \frac{1}{\text{blows per meter}}$$

The foregoing formulas are applicable only when:

(a) The hammer is operating properly and at the manufacturer's recommended speed in the case of a power hammer.

(b) The head of the pile is not broomed or crushed.

(c) The penetration is reasonably quick and uniform.

(d) There is no discernible bounce after the blow.

(e) A follower is not used.

If the Contract does not provide for test loading, the results of these formulas as applied to the test piles shall be used to designate the proposed penetration or lengths of piles. However, each pile shall have its driving record evaluated to assure its ability to carry the intended load.

Test piles shall be driven in permanent vertical pile locations as directed by the Engineer or as specified in the Contract Documents. Test piles found to be satisfactory by the Engineer shall be utilized as permanent piles.

407.03.11 Pile Load Test. The load test setup, the measuring system, the loading device, the loading procedure, the frequency of measuring the movement of piles and the record keeping shall conform to D 1143 unless otherwise specified in the Contract Documents.

At each load test location, the Engineer will provide driving criteria for the test pile. The pile shall then be driven and load tested to the test load specified in the Contract Documents or as directed by the Engineer. If the pile fails to achieve this capacity, a contingent load test shall be performed on a second test pile. This pile shall be located adjacent to the initial test pile and driven according to revised driving criteria provided by the Engineer. The Engineer may elect to have the Contractor redrive piles that do not meet the required penetration resistance.
The equipment and methodology used for driving the load test piles shall be the same as the equipment and methodology used for driving the permanent piles.

At each load test location, the Contractor shall construct a test enclosure to protect the dial gauges, load cells, loading apparatus and all other equipment, as well as the personnel taking readings. Heat shall be provided, if necessary, so that a minimum temperature of 50 F (10 C) is maintained within the enclosure. The test enclosure shall be adequately illuminated so that the readings can be taken inside the enclosure at all times of the day. The enclosure shall be ventilated to prevent fogging or frosting of gauges.

TheContractor shall submit drawings to the Engineer showing all details of the proposed load test setup. The submittal shall include method of applying the load, the reaction frame and reaction pile configuration, if used, and the placement and support of measuring devices. The submittal shall be made at least seven days prior to the start of the first pile load test. The Contractor shall revise the load test setup if so directed by the Engineer.

The reaction frame shall be designed by a professional engineer (PE) experienced in structural design and registered in the State of Maryland.

The load test setup shall be capable of supporting the test load for the duration of the test.

The clear distance from reaction piles to the test pile shall be at least 10 times the distance from the midpoint of web to end of flange for H piles or 10 times the radius of pile at the top for cast-in-place concrete or timber piles.

Where necessary, and if directed by the Enigneer, the unsupported length of load test piles shall be braced to prevent buckling without influencing the test results.

The primary instrument for measuring the movement shall be dial gauges. The dial gauges shall have an accuracy of 0.001 in. (0.03 mm) and shall have a minimum travel of 2 in. (50 mm). Three dial gauges spaced 120 degrees apart shall be used for measuring the movement of the top of the pile. A secondary system consisting of a scale, mirror and piano wire shall be used to measure the movement of the pile top.

Load apparatus shall conform to D 1143, Apparatus for Applying Loads. The loading apparatus shall have a capacity of 150 percent of the test load. If more than one hydraulic jack is used, the jacks shall be of the same piston diameter, connected to a common manifold and pressure gauge, and operated by a single hydraulic pump.

Loads shall be applied uniformly with no impact. If the hydraulic jacks are used, they shall be equipped with automatic regulators so that constant pressure can be maintained for the long term test without frequent manual adjustment.

Unless weights of known magnitude are used to load the test piles, the primary method of measuring the test load shall be by a load cell with an accuracy tolerance within +/- 2 percent of the applied load. The load cell shall be calibrated prior to the test and a copy of the calibration report supplied to the Engineer. A pressure gauge shall be provided as a secondary system. The pressure gauge, hydraulic ram, and hydraulic pump shall be calibrated as a unit to an accuracy within 5 percent of the applied load. The use of a single high capacity jack is preferred to the use of multiple jacks. If a multiple jacking system is used, each jack shall be fitted with a pressure gauge in addition to the master gauge in order to detect malfunctions.

Load measuring devices shall be recalibrated if required by observed performance.

The load test pile shall be cut off in a manner that ensures a surface that is perpendicular to the longitudinal axis to allow for full bearing of the test pile. A steel plate of 1 in. (25 mm) minimum thickness shall be placed over the cutoff surface in a manner that facilitates axial loading and even bearing on the test pile.

The test procedure for all test piles driven to the embedded depths specified in the Contract Documents shall be the standard loading procedure conforming to D 1143 or as directed by the Engineer. Loading shall be continued to the test load or to failure, whichever occurs first.

The Contractor shall provide equipment to determine if reaction piles are moving. A scale attached to the reaction piles that can be monitored with a transit shall be used for this purpose.

If at any stage during the test, the Engineer detects malfunctioning of any apparatus furnished by the Contractor, or the load being eccentrically applied, or the anchor piles yielding, the Engineer will order the test abandoned and the Contractor shall replace it with another test at no additional cost to the Administration. The Contractor shall have an employee present at the site at all times during the performance of the test to maintain the required load.

After the pile test program is complete, anchor (reaction) piles shall be removed or cut off a minimum of 1 ft (0.3 m) below existing grade, channel bottom or mud line, as applicable. All removed material shall be disposed of by the Contractor on approved spoil areas.

Cast-in-place concrete piles shall be load tested before filling.

407.03.12 Pile Cutoff. The tops of all piles and pile casings except timber piles which support timber caps shall be cut off at the elevations specified in the Contract Documents and on a true plane perpendicular to the axis of the pile unless otherwise specified. Timber piles which support timber caps shall be cut off to insure that the plane of the bottom of the cap will bear fully

on the pile head. Shimming between the timber cap and pile head is prohibited.

407.03.13 Cast-In-Place Concrete Piles. Cast-in-place concrete pile shells shall be inspected for their entire length after driving, prior to placing reinforcement with the aid of a suitable light for illuminating the interiors of the piles. No reinforcement or concrete shall be placed until the pile is approved by the Engineer.

The Contractor shall provide all required equipment for inspection including oxygen, light, boatswains chair and lift. The Contractor shall comply with federal and local safety regulations while performing this work.

407.03.14 Concreting Cast-In-Place Piles. Concrete work shall conform to Section 414. Reinforcement shall conform to Section 416. Reinforcement shall be securely fastened together to form a cage which shall be positioned and held at a uniform distance from the shell.

Tie bars and bands for reinforcement cages of foundation (footing) piles shall be tie wired. Tack welding may be used, provided an Administration certified welder is used.

Tie bars, bands and spacer lugs for bents or column piles shall not be tack welded to any of the main reinforcement bars except that the Contractor may place a band at the top and bottom of the pile cage and weld all main bars to the band. The remainder of the intersections of ties and main bars shall be fastened by tie wiring.

After the pile shells have been accepted and the reinforcement unit is ready the shells shall be filled with concrete. Concrete shall not be placed in any casing or shell until all driving within a radius of 15 ft (4.6 m) has been completed nor until all the shells for any unit of the structure (pier, bent or abutment) have been driven to their final penetration and accepted by the Engineer. In the event that this procedure cannot be followed, all driving within the above limits shall be discontinued until the concrete in the last pile placed has set at least three days.

Immediately prior to concreting, water or other foreign substances found

in a shell shall be removed. The concrete shall be deposited in one continuous operation. The restriction in Section 414 for dropping concrete more than 5 ft (1.5 m) shall not apply.

Reinforcement steel cages shall be set and fastened in proper position in the pile before any concrete filling is placed, except that when the reinforcement steel cage extends 6 ft (2 m) or less below the top of the pile, the concrete filling may be placed before the reinforcement is installed. Concrete deposited in piles shall be thoroughly consolidated with mechanical vibrators from the bottom of the reinforcement steel cages to the tops of piles.

Freshly concreted piles shall not be disturbed in any way nor shall any loads be allowed upon any of them until all concrete has been in place and cured a minimum of 72 hours.

407.03.15 Treatment for Timber Pile Heads. Timber pile heads that are not to be imbedded in concrete shall be painted with an approved asphalt treatment. After the asphalt has sufficiently cured, it shall be covered with a glass resin composite shield. The first coat of resin shall be applied to the top and down the side a minimum of 1 in. (25 mm) beyond the limits of the woven glass. Precut woven glass cloth shall be applied using a 3 in. (75 mm) grooved aluminum roller to achieve "wet out." Woven glass cloth shall be neatly wrapped over the top of the pile, draped down the side a minimum of 2 in. (50 mm) and nailed with copper nails. When the first coat of resin has taken a tack free set, a second coat of resin shall be applied to seal the entire application.

407.04 MEASUREMENT AND PAYMENT. The payment for the items specified in the Contract Documents will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

407.04.01 Piling (permanent and test) will be measured and paid for at the Contract unit price per linear foot for the pertinent Piling item. The measured length of all piling will be taken from its tip up to final cutoff unless otherwise specified in the Contract Documents. For test piles not utilized as permanent piles, the measurement for cutoff will be at the same elevation as

the nearest proposed permanent pile or to actual top of test pile, whichever is lower. Where piling designated as test piles is accepted for use in the permanent structure, measurement will be made as test piles and no additional allowance will be made in other piling items.

When thicker shells are necessary for cast-in-place concrete piles, the Contractor will be paid for the additional shell thickness on the basis of the differential in the manufacturer's quotation for the heavier piling, which differential will be the net increase in cost to the Contractor for the heavier piling over and above that which is specified in the Contract Documents.

407.04.02 Furnishing and setup of pile driving equipment required for driving permanent and test piles will be measured and paid for at the Contract unit price per each for the pertinent Setup for Driving Pile item. The unit price per each for the Setup required for driving each pile for the proposed structure will be used regardless of the distance that the equipment must be moved for each pile setup. A maximum of one setup will be paid for any setup required for redriving or any additional driving of any pile, no matter what reason the particular pile may require redriving or additional driving.

407.04.03 Pile Points for Steel H Piles will be measured and paid for at the Contract unit price per each for the pertinent Pile Point for Steel H Pile item.

407.04.04 When the project includes an item for load test, it will be paid for at the Contract unit price per each for the pertinent Load Test item. In the event the load test fails to achieve the designated capacity, the additional tests will be measured and paid for at the Contract unit price per each under the Contingent Load Test item.

407.04.05 Timber Sheet Piling will be measured and paid for at the Contract unit price per 1000 board feet (MBM) for the pertinent Timber Sheet Piling item. Computation of quantities will be based on nominal thickness of lumber, the length of the sheet piling, and the average depth of the sheet piling from cutoff at the top to the tip of the sheet piling in the completed structure. No allowance will be made for waste.

407.04.06 Steel Sheet Piling will be measured and paid for at the Contract unit price per square foot as measured along the plane of surface for the

pertinent Steel Sheet Piling item.

407.04.07 The following will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents:

(a) Tips for pile shells or casings.

(b) Test pieces of sheet piling (timber or steel).

(c) Reinforcement and concrete used in cast-in-place piles.

(d) Pile splices.

(e) Augering.

(f) Cleaning, painting, or coating of piling.

(g) Piling or sheet piling for temporary structures, piles or sheet piling driven for the Contractor's convenience, or for any piles or sheet piling not specified in the Contract Documents.

(h) Piling not approved by the Engineer, such as piles not properly driven, piles with questionable safe bearing values, piles damaged during driving, or piles driven below planned cutoff or the removal of any pile rejected by the Engineer as unsatisfactory.

(i) Delays that are a result of changing cast-in-place concrete pile shell thickness resulting from driving test piles or for delays incurred by performing load tests not specifically called for in the Contract Documents.

SECTION 408 - METAL STRUCTURES

408.01 DESCRIPTION. This work shall consist of furnishing, fabricating, transporting and erecting of steel beams, plate girders, trusses, grillages,

columns and bents, shoes, pedestals, castings, miscellaneous steel and all incidental structural steel as specified in the Contract Documents or as directed by the Engineer.

408.02 MATERIALS.

Grout	902.11(c),(d),(e)
Metals	909
Bolts	A 325
Nuts	A 194
Washers	F 436
Bearing Pads	910.02
Epoxy Adhesive	921.04

408.03 CONSTRUCTION. Unless otherwise specified, all welding and dimensional tolerances shall conform to AWS D1.5.

408.03.01 Working Drawings. Working drawings shall be provided by the Contractor as specified in TC-4.01. The Contractor is responsible for the erection of curved girders and if lateral bracing is required for shipping or erection, the details shall be specified on the working drawings.

408.03.02 Work Scheduling. The Contractor shall give a minimum of two weeks notice to the Engineer when and where shop work shall begin to allow for inspection. No materials shall be fabricated until directed by the Engineer.

408.03.03 Facilities for Shop Inspection. The Contractor shall furnish all facilities for the inspection of material and workmanship in the shop. The Inspector shall be allowed free access to the required areas of the premises and shall be provided with an approved office area.

408.03.04 Material Identification. Main member material shall be identified by the Contractor by heat number.

408.03.05 Mill Orders. The Contractor shall furnish the Engineer with copies of mill orders and test reports.

408.03.06 Testing. The Contractor shall furnish, without charge, sample specimens as directed by the Engineer.

408.03.07 Defective Material and Workmanship. The acceptance of any material and workmanship by the Inspector will not deter subsequent rejection. Rejected material and workmanship shall be replaced or repaired as directed by the Engineer.

408.03.08 Marking and Shipping. Each member shall be painted or marked with an erection mark for identification. An erection diagram shall be furnished with erection marks clearly delineating the orientation of diaphragms.

Erection marks for the field identification of members and weight marks for members over 6000 lb (2724 Kg) in weight shall be painted upon surface areas previously painted with the shop coat. Material shall not be loaded for shipment until the shop coat is thoroughly dry and in any case not less than 24 hours after the paint has been applied.

Where unpainted steel is specified for a finished structure, the Contractor shall not place the Contractor's or any other company's name on any of the structural steel. Mark numbers and inspection stamps shall appear only on the top surface of the top flange of all girders, beams, and diaphragms unless otherwise directed.

No painting shall be done after loading of materials for transport.

The Contractor shall furnish the Engineer copies of material orders, shipping statements, and erection diagrams. The weights of the individual members shall be shown on the shipping statements. The loading, transportation, unloading and storing of structural material shall be conducted so that the metal shall be kept clean and shall not be excessively stressed, deformed or otherwise damaged.

When handling long steel members, handling devices shall be placed at approximately the quarter points. When storing and shipping members, blocking shall be placed at intervals that prevent sag and distortion. All beams and girders shall be stored, shipped and handled in an upright posi-

tion. Members other than beams and girders shall be handled, hauled and stored with the stronger axis vertical to resist gravity.

All girders having stiffeners the full height of the web on both sides of the web shall be adequately blocked before shipment. This blocking shall be located at the quarter points and midpoint of the girder and at additional locations to assure that the maximum interval between blocking does not exceed 25 ft (8 m).

Members too long to fit inside a truck or trailer shall not cantilever beyond the bed more than 1/4 of its length. Members too long to comply with this requirement shall be supported on dollies, additional vehicles, or other vehicles that fully support the long pieces as approved by the Engineer.

408.03.09 Storage of Material. Fabricated material shall be stored off the ground and protected as far as practicable from surface deterioration by exposure to conditions producing rust. These materials shall be kept free of dirt accumulation, oil or other deleterious matter.

408.03.10 Changes and Substitutions. No changes or substitutions shall be made in any approved drawing unless approved in writing by the Engineer.

408.03.11 Fabrication. Fabrication and construction shall be bolted or welded as specified in the Contract Documents or as directed by the Engineer.

When curved girder bridges are to be curved by the heat shrinkage method, the proposed method shall be submitted to the Engineer for approval.

408.03.12 Holes.

(a) Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 in. (1.5 mm). Holes requiring enlargement shall be reamed. Holes shall be clean cut with no torn or ragged edges. Holes punched full size or subpunched shall be punched so that after the steel is assembled and before any reaming is done, a cylindrical pin 1/8 in. (3 mm) smaller in diameter

than the nominal size of the punched hole shall be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If this requirement is not met, the nonconforming punched pieces will be rejected. Holes not passing a pin 3/16 in. (5 mm) smaller in diameter than the nominal size of the punched hole will be rejected. Drifting done during assembling shall be only to bring the parts into position and not sufficient to enlarge the holes or distort the material. If the required accuracy cannot be obtained otherwise, holes for connections shall be subpunched and reamed with the members assembled instead of being punched full size.

(b) Reamed or Drilled Holes. Holes shall be cylindrical, perpendicular to the member, and not more than 1/16 in. (1.5 mm) larger than the nominal diameter of the bolts. Where practical, reamers shall be directed by mechanical means. Burrs on the surface 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 securely held while being reamed or drilled and shall be match marked before disassembling. When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 in. (1 mm) between adjacent thicknesses of metal.

(c) Subpunching and Reaming. Holes in all field connections and field splices of main truss or arch members, continuous beams, plate girders and rigid frames shall be subpunched and reamed while assembled in the shop unless otherwise specified. The assembly, including camber, alignment, accuracy of holes and milled joints shall be acceptable to the Engineer before reaming is started.

All holes for floor beam and stringer field end connections shall be subpunched and reamed utilizing a template or reamed while assembled.

If additional subpunching and reaming is required, it will be specified in the Contract Documents. The accuracy of subpunched holes shall be the same as required for punched holes.

408.03.13 Shop Assembly. Surfaces of metal which will be in contact after assembling shall be cleaned. The parts of a member shall be assembled, well pinned and firmly drawn together with bolts before reaming or tightening of fasteners is started. The member shall be free from twists, bends and other deformations. Material that has been punched full size shall be reamed, if necessary, prior to tightening of fasteners. Refer to 408.03.12(c).

Parts not completely fastened in the shop shall be secured by bolts insofar as practicable to prevent damage in shipment and handling. Members assembled in the shop for reaming of field connections shall remain assembled until the Engineer's shop inspection.

408.03.14 Camber Diagram. A camber diagram shall be furnished to the Engineer showing the camber at each panel point for each truss, taken from actual measurements during truss assembly. A camber diagram shall be furnished to the Engineer showing the camber at all splice points, points of dead load inflection, and any other points designated by the Engineer for all beams and girders.

Stringers shall be cambered to the dimensions specified in the Contract Documents. The camber specified shall mean the camber as measured after all shop welding has been completed. The maximum tolerance for camber shall be zero (0) under to ½ in. (13 mm) over.

Full provisions shall be made for dead load deflections, fabricating tolerances, and irregularities at all points along all stringers so that the superstructure concrete may be placed to match the profile grade line.

408.03.15 Match Marking. Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be matched marked, and a diagram showing these marks shall be furnished to the Engineer.

408.03.16 Use of High Strength Bolts and Lock-Pin and Collar Fasteners. High strength bolts and lock-pin and collar fasteners shall be used unless otherwise specified in the Contract Documents. Unfinished bolts or machine bolts may be used for the temporary erection of structural steel and shall be replaced with high strength bolts, lock-pin and collar fasteners or welding for final erection. Turned bolts shall only be used when specified. The heads, nuts, and washers shall be drawn tightly against the work. Where bolts or lock-pin and collar fasteners are used in beveled surfaces, beveled washers shall be provided to give full bearing to the head, nut, or collar except as otherwise specified in 408.03.17. Where high strength bolt assemblies are used for joint connections, the Contractor shall also perform the additional testing specified in 408.03.34

408.03.17 High Strength Bolt Joint Requirements.

(a) Only one grade of bolts, nuts and washers shall be used in a structure. Bolts may be supplied from various manufacturers provided that each bolt of a given length and diameter shall be made by the same manufacturer. Nuts and washers may be supplied from different manufacturers provided that the same manufacturers make all the respective nuts and washers to be used throughout the structure on all bolts having the same diameter. All bolts, nuts and washers used with A 709, Grade 50W steel shall conform to A 325, Type 3.

(b) 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. Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism. When assembled, bolted parts shall fit solidly together and shall not be separated by gaskets or any other interposed compressible material. The holes shall be truly cylindrical and at right angles to the surface of the metal so that both head and nut will bear

squarely against the metal. When assembled, all joint surfaces including those adjacent to the bolt heads, nuts or washers, shall be free of scale (except tight mill scale), dirt, burrs, and other deleterious material and defects that would prevent solid seating of the parts. Contact surfaces within joints shall be free of oil, lacquer, or rust inhibitor. For contact surfaces to be painted refer to 413.03.06.

(c) When all bolts in the joint are tight, every bolt shall conform to the minimum bolt tension which is equal to the proof load specified in A 325. When field conditions prevent tightening at the nut, bolts may be tightened at the head, provided that the nut is prevented from turning. All bolts shall have a washer under the element (nut or bolt head) turned in tightening. Threaded bolt connections shall be tightened by the turn-of-nut method. If impact wrenches are used, they shall be of adequate capacity and have a sufficient supply of air to perform the required tightening of each bolted connection.

(d) To provide the bolt tension specified in 408.03.17(c), there shall first be enough bolts brought to a "snug tight" condition to insure that the parts of the joint are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be additionally tightened with tightening progressing systematically from the center of connection plates of the joints to the free edges. During this operation there shall be no rotation of the part not turned by the wrench.

After all bolts in the joint have a snug fit, the joint shall be additionally tightened by the applicable amount of nut rotation specified in the Nut Rotation From Snug Tight Condition table below. All bolt assemblies in the completed structure shall have full thread engagement which is accomplished when the end of the bolt is flush with or extends beyond the outer face of the nut.

NUT ROTATION FROM SNUG TIGHT CONDITION

DISPOSITION OF OUTER FACES OF BOLTED PARTS

Both length (as measured from underside of head to extreme end of bolt)	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (beveled washer not used)	Both faces sloped not more than 1:20 from normal to bolt axis (beveled washer not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn

NOTE 1: This table is for coarse thread, heavy hexagon structural bolts of all sizes and lengths and heavy hexagon semifinished nuts.

NOTE 2: Nut rotation is rotation relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation: ±30 degrees for bolts installed by 1/2 turn or less, and ±45 degrees for bolts installed by 2/3 turn or more.

(e) Inspection. The Engineer will be present during the installation and tightening of bolts to determine that the tightening procedure is properly followed and all bolts are properly tightened.

The Contractor shall provide a sufficient number of safe working platforms at splices where high strength bolts will be checked for torque requirements. Platforms shall be maintained at splices until all checking is complete and the splice is acceptable to the Engineer.

The Contractor shall provide a calibrated torque wrench to be used as the inspection wrench and a calibrated bolt tension calibrator. Both have to be approved by the Engineer.
The Contractor shall conduct the following inspections unless oth-

erwise specified in the Contract Documents. Bolts, nuts, and washers that were previously torqued to proof load shall not be reused in the structure.

(1) Three bolts of the same size, length, and condition as those under inspection shall be placed individually in the bolt tension calibration device. There shall be a washer under the part turned in tightening each bolt.

(2) Each of the three bolts shall be tightened in the calibration device by any convenient means to the proof load specified for its size. The inspecting wrench shall then be applied to the tightened bolt, and the torque necessary to turn the nut or head 5 degrees approximately 1 in. (25 mm) at 12 in. (300 mm) radius in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspecting torque to be used in the manner specified in paragraph (3).

(3) Bolts represented in the sample above which have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to 10 percent of the bolts but not less than two bolts selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection; and all bolts whose nut or head is turned by the job inspecting torque shall be tightened and reinspected. Alternatively, the fabricator or erector may opt to retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

408.03.18 Lock-Pin and Collar Fastener Requirements.

(a) Lock-pin and collar fasteners shall conform to 408.03.17 for one manufacturer, weathering characteristics, sloped surfaces and applicable inspection.

(b) A representative sample of not less than three sets of lockpin and collar fasteners of each diameter, length and grade shall be checked at the job site in a device capable of indicating bolt tension. The test assembly shall include flat hardened washers, if required in the actual connection, arranged as in the actual connections to be tensioned. The calibration test shall demonstrate that each assembly develops a tension not less than 5 percent greater than the tension required for the comparable A 325 or A 490 bolt. Manufacturer's installation procedure shall be followed for installation of bolts in the calibration device and in all connections. Periodic retesting shall be performed when required by the Engineer.

(c) Fasteners shall be installed in all holes of the connection and initially tightened sufficiently to bring all plies of the joint into firm contact but without yielding or fracturing the control or indicator element of the fasteners. All fasteners shall then be further tightened, progressing systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. In some cases, proper tensioning of the bolts may require more than a single cycle of systematic partial tightening prior to final twist off of the control or indicator element of individual fasteners.

408.03.19 Welding. Welding of structures shall conform to the Contract Documents and AASHTO/AWS Bridge Welding Code D1.5 unless otherwise specified. The provisions contained herein shall apply to both shop and field welding.

All welders, welding machine operators and tackers employed to work on structures for the Administration shall be approved by the Engineer.

(a) Qualification Testing. Welders will be approved based on Qualification Testing conforming to AASHTO/AWS Bridge Welding Code D1.5. Qualification testing will be conducted by the SHA Office of Materials and Research, Metals Group.

The Contractor shall contact the Metals Group at least 30 days prior to the start of welding operations to schedule welder tests. At

the time of test, welders shall have an authorization from the Contractor. This authorization shall contain the welder's name, social security number, Contract number and the Contractor's name and phone number.

(b) Qualifications from Outside Sources. Welders having certifications from outside sources in conformance with the AASHTO/AWS Bridge Welding Code D1.5 may submit that certification for approval to the Metals Group.

All field welders approved by the Metals Group shall have a current Administration (here meaning State Highway Administration, not Baltimore County) Welders Certification card available at all times for inspection by the Engineer.

Unless otherwise specified by the Engineer in writing, only submerged arc welding will be permitted on members carrying primary stress. Members carrying primary stress include but are not limited to the following: rolled beams, cover plates on rolled beams, welded splices, girders and connection material of the members and other parts as specified in the Contract Documents.

After fabrication, no welding will be permitted on tension flanges for attachments such as metal forms and tie screws, except for steel stud shear developers specified in the Contract Documents.

Welding transversely across the tension flanges of beams or girders is prohibited and is cause for rejection unless otherwise specified in the Contract Documents.

408.03.20 Inspection of Fabricated Metal Structures. Fabricated metal structures shall conform to AASHTO/AWS Bridge Welding Code D1.5. Quality control inspection shall be the responsibility of the Contractor.

The Contractor shall have on file with the Baltimore County Test Lab a current approved quality control plan prior to receiving source approval. This plan shall specify the frequency, method of inspection and provide for documentation. The inspection frequency shall be at least the minimum

specified in AASHTO/AWS D1.5. The Administration requires 30 days to review quality control plans not previously on file.

The Contractor shall also keep complete and current records which shall be available to the Administration's representatives at all times.

When work is completed, the documentation for all quality control tests and inspections shall become the property of the Administration.

408.03.21 Planing. The top and bottom surfaces of steel slabs, base plates, and cap plates of columns and pedestals shall be planed or the plates or slabs shall be hot straightened. Parts of members in contact with them shall be faced. In planing the flat surfaces of expansion bearings, the cut of the tool shall be in the direction of expansion.

408.03.22 Abutting Joints. Abutting joints in compression members and in tension members where specified in the Contract Documents shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/8 in. (3 mm).

408.03.23 End Connection Angles. Floor beams, stringers, and girders having end connection angles shall be built to exact length back-to-back of connection angles. If end connections are faced, the finished thickness of the angles shall not be less than specified in the Contract Documents.

408.03.24 Main Members. Principal portions of main members carrying primary stress (i.e., webs, flanges, girders and trusses) shall be fabricated so that the direction of stress and rolling are the same.

408.03.25 Web Plates. 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 1/4 in. (6 mm).

408.03.26 Bent Plates. Unwelded, cold bent, load carrying, rolled steel plates shall be taken from the stock plates so 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 and shall conform to the following:

(a) Bending shall be so that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal shall conform to the following:

THICKNESS (t) IN INCHES (mm)					
Structural Steel	Up to 1/2 (13 mm)	Over 1/2 to 1 (13 to 25 mm)	Over 1 to 1-1/2 (25 to 40 mm)	Over 1-1/2 to 2-1/2 (40 to 65 mm)	Over 2-1/2 to 4 (65 to 100 mm)
A 709, Grades 36, 50 & 50W	2t	2-1/2 t	3t	3-1/2 t	4t

(b) For brake press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

(c) If a shorter radius is essential, the plates shall be bent at a temperature not greater than 1200 F (650 C). Hot bent plates shall be taken from stock so that the bend line will be at right angles to the direction of rolling.

(d) Before bending, the corners of the plate shall be rounded to a radius of 1/16 in. (1.5 mm) throughout the portion of the plate where the bending is to occur.

408.03.27 Erection Plan. The Contractor shall submit for approval, an erection diagram plan outlining erection procedure of the main members. The plan shall conform to TC-4.01 and shall be submitted for approval to the Engineer a minimum of 30 days prior to beginning erection. This plan shall include the numbers and types of equipment to be used including crane capacity, location of crane for lifting, falsework when required, and main member erection sequence and weight.

All wheels and outriggers of a crane or wheels of a structural steel delivery truck shall be at a minimum distance from the rear face of an abutment equal to the vertical distance from the top of a spread footing or to the original

groundline if the footing is on piles. No other heavy construction equipment shall be operated within this minimum distance from the rear face of abutments.

The Contractor shall erect bridges with continuous main members in a manner providing the proper reactions, and avoiding overstressing main members.

The Contractor when preparing erection plans and procedures shall take into account the restrictions imposed by the Water Resources Administration relative to pollution or disturbance of existing waterways.

408.03.28 Falsework. The Contractor shall comply with the provisions specified in TC-4.01. The falsework shall be built and maintained in conformance with the approved falsework plans. Any changes subsequent to initial approval which are proposed by the Contractor through the Contractor's professional engineer must be approved by the Engineer.

Before permitting any loads to be placed on falsework, the Engineer shall receive written certification by the Contractor's professional engineer that the falsework system has been assembled in conformance with the approved falsework drawings. This certification shall be accompanied by a Certificate of Compliance stating that all manufactured materials and assemblies fully comply with the falsework design and plans. The Engineer may either accept the certificate or invoke any provision of GP-5.08. All tests required shall be made by and at the expense of the Contractor.

In addition to protective measures shown on the falsework plans, the Engineer may direct the Contractor to provide further protection of falsework against accidental collision by highway or construction traffic and equipment, traffic vibration, flood waters or high winds, etc., that are necessary for public safety and protection of the work.

408.03.29 Damaged or Defective Material. The correction of damaged or defective material shall not begin until a written procedure prepared by the Contractor is approved by the Engineer. Correction of damaged or defective material shall be by methods that do not produce fracture or injury. All damaged or defective material will be inspected by the Engineer

before and after correction. Corrections shall be conducted in the presence of the Engineer.

408.03.30 Assembling Steel. Material shall be carefully handled and no parts shall be bent, broken, or otherwise damaged. Bearing surfaces and those to be in permanent contact shall be cleaned before the members are assembled. Before beginning the field bolting and welding, the structure shall be adjusted to correct grade and alignment and the elevations of panel points (ends of floor beams) properly regulated. Splices and field connections shall have one half the holes filled using bolts and cylindrical erection pins (40 percent bolts and 10 percent pins) before torquing high strength bolts. Splices and connections in members carrying traffic during erection shall have three fourths of the holes filled before torquing. Cylindrical erection pins shall be 1/32 in. (1 mm) larger than the diameter of the fasteners.

408.03.31 Anchor Bolts. No anchor bolts shall be cast in the concrete.

Anchor bolts shall be set in round holes drilled or cast in the concrete. Bolts shall be accurately positioned by using templates set to correct location and alignment to insure proper span lengths, and tops of bolts shall be carefully set to proper elevation. Unless otherwise noted, bolts shall be installed plumb or normal to the finished bearing surface of the masonry.

Bolts set in holes drilled or cast into the concrete shall have the portion below the bridge seat swedged. The drilled or cast holes shall have a diameter at least 1 in. (25 mm) larger than the bolt diameter.

Anchor bolts, nuts, and washers shall not be painted.

After anchor bolts are finally and correctly positioned, the holes shall be completely filled with grout. No grouting of anchor bolts will be permitted until all structural steel is set in its final position. After the masonry plates or shoes are set, the space between the bolts and the round holes through fixed plates or shoes shall also be filled with the same material. Slotted holes in expansion devices shall remain unfilled unless otherwise specified in the Contract Documents.

The Contractor shall maintain a minimum air temperature of 40 F (4 C)

around the mortar surface for a period of three days unless otherwise recommended by the manufacturer.

When mortar filling is used for bolts inserted in holes drilled or cast in the concrete, the holes shall first be checked for depth by inserting and withdrawing the bolts. They shall then be partially filled with mortar into which the bolts shall be forced by uniform pressure or light blows from a hammer (flogging and running will not be permitted) so that excess mortar is pushed out at the top of the hole. The excess mortar shall be removed.

Bolts shall be set to project approximately 1/2 in. (13 mm) above the nut and shall be threaded to approximately 1/2 in. (13 mm) below the nut in their final position.

Rockers or expansion plates with slotted holes shall be set with the proper tilt or offset as determined by the temperature prevailing at the time and so that they will be in their midway position at 68 F (20 C) or as specified in the Contract Documents.

408.03.32 Maintenance of Concrete. The Contractor is responsible for keeping all exposed concrete surfaces free from stains and discoloration. The Contractor shall prevent staining of the finished concrete surfaces where unpainted structural steel is specified. Any stains shall be removed and the concrete restored to its original color.

408.03.33 Safety Hazards. The Contractor shall be responsible for gas detection in and ventilation of confined spaces as specified in TC-3.06.

408.03.34 Supplemental High Strength Bolt Requirements. All A 325 bolts, nuts and washers shall be furnished in conformance with the appropriate materials specifications as amended and revised herein.

(a) Manufacturing. Bolts. Bolt diameters 1/2 to 1 inch inclusive shall have a Rockwell hardness of Rc24 to Rc33 (Brinell hardness of 248 to 311).

Nuts. Plain (ungalvanized) nuts shall be grades 2, C, D or C3 with

a minimum Rockwell hardness of Rb89 (Brinell hardness 180), or heat treated grades 2H, DH, or DH3. (The hardness requirements for grades 2, C, D, and C3 exceed the current AASHTO/ ASTM requirements.)

Nuts to be hot dip or mechanically galvanized shall be heat treated grade 2H, DH, or DH3. These nuts shall be tapped oversize the minimum amount required for proper assembly. The amount of overtap in the nut shall be so that the nut will assemble freely on the bolt in the coated condition and shall conform to the mechanical properties of A 563 and the rotational capacity test herein (the overlapping requirements of A 563 shall be considered maximum values instead of minimum, as currently shown.)

Galvanized nuts shall be lubricated with a lubricant containing a dye of any color that contrasts with the color of the galvanizing.

Marking. All bolts, nuts and washers shall be marked in conformance with the appropriate AASHTO/ ASTM Specifications.

(b) Testing

Bolts. Proof load tests conforming to F 606 Method 1 shall be conducted. The minimum frequency of tests shall be specified in A 325.

Wedge tests on full size bolts shall conform to F 606. If bolts are to be galvanized, tests shall be performed after galvanizing. Minimum frequency of tests shall be as specified in A 325.

If galvanized bolts are specified, the thickness of the zinc coating shall be measured on the wrench flats or top of bolt head.

Nuts. Proof load tests conforming to F 606 are required. Minimum frequency of tests shall be as specified in A 563 or A 194. If nuts are to be galvanized, the tests shall be performed after galvanizing, overlapping, and lubricating.

If galvanized nuts are specified, the thickness of the zinc coating shall be measured on the wrench flats.

Washers. If galvanized washers are specified, hardness testing shall be performed after galvanizing. The thickness of the zinc coating shall be measured and the coating shall be removed prior to taking hardness measurements.

Assemblies. Rotational capacity tests shall be performed on all black or galvanized (after galvanizing) bolt, nut and washer assemblies by the manufacturer or distributor prior to shipping.

The following shall apply:

(1) Except as modified herein, the rotational capacity test shall be performed in conformance with A 325.

(2) Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly.

(3) A rotational capacity lot number shall be assigned to each combination of lots tested.

(4) The minimum frequency of testing shall be two assemblies per rotational capacity lot.

(5) The bolt, nut, and washer assembly shall be assembled in a Skidmore Wilhelm Calibrator or other calibration device approved by the Engineer (note that this requirement supersedes the A 325 requirement that the test be performed in a steel joint). For bolts which are too short to too long to be assembled in the Skidmore Wilhelm Calibrator, refer to 408.03.34 (f) and (g).

(6) The minimum rotation from a snug tight condition (10 percent of the specified proof load) shall be as specified in the following table. Note that the values in the table differ from A 325.

Degrees	Turns	Bolt Length
240	2/3	Less than 4 diameters
360	1	4 to 8 diameters
480	1 1/3	Greater than 8 diameters

(7) The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test are shown below.

Property	Installation Tension & Turn Test Tension								
Diameter, in.	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Installation Tension kips	12	19	28	39	51	56	71	85	103
Turn Test Tension kips	14	22	32	45	59	64	82	98	118

(8) After the required installation tension listed above has been exceed, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following:

Torque = measured torque (ft. lb)
P = measured bolt tension (lb)
D = bolt diameter (ft)

(9) Bolts that are too short to test in a Skidmore Wilhelm Calibrator may be tested in a steel joint. The tension requirement of (7) need not apply. The maximum torque requirement of (8) shall be computed using a value of P equal to the turn test tension shown in the table in (7).

Reporting.

(1) The result of all tests (including zinc coating thickness) required herein and in the appropriate ASTM specifications shall be recorded on the appropriate document.

(2) Location where tests are performed and date of tests shall be reported on the appropriate document.

Witnessing. The tests need not be witnessed by an inspection agency. However, the manufacturer or distributor that performs the tests shall certify that the results recorded are accurate.

(c) Documentation

Mill Test Reports (MTR)

(1) MTR shall be furnished with all mill steel used in the manufacturer or the bolts, nuts, or washers.

(2) MTR shall indicate the placed where the material was melted and manufactured.

Manufacturer Certified Test Reports (MCTR).

(1) The manufacturer of the bolts, nuts and washers shall furnish test reports (MCTR) for the items furnished.

(2) Each MCTR shall show the relevant information specified in (b) Testing, Reporting.

(3) The manufacturer performing the rotational capacity test shall include on the MCTR:

The lot number of each of the items tested,

The rotational capacity lot number as specified in (b) Testing, Assemblies (3),

The results of the tests specified in (b) Testing, Assemblies,

The pertinent information specified in (b) Testing, Reporting,

A statement that MCTR for the items are in conformance to this specification and the appropriate ASTM Specifications.

The location where the bolt assembly components were manufactured.

Distributor Certified Test Reports (DCTR).

(1) The DCTR shall include MCTR above for the various bolt assembly components.

(2) The rotational capacity test may be performed by a distributor (in lieu of a manufacturer) and reported on the DCTR.

(3) The DCTR shall show the results of the tests required in (b) Testing, Assemblies.

(4) The DCTR shall also show the pertinent information specified in (b) Testing, Reporting (2).

(5) The DCTR shall show the rotation capacity lot number as specified in (b) Testing, Assemblies (3).

(6) The DCTR shall certify that the MCTR are in conformance to this Specification and the appropriate ASTM Specification.

(d) Shipping

(1) Bolts, nuts, and washers from each rotational capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer the nuts and washers may be shipped in separate containers. Each container shall be permanently marked with the rotational capacity lot number so that identification will be possible at any stage prior to installation.

(2) The appropriate MTR, MCTR, or DCTR shall be supplied to the Administration.

(e) Installation. The following requirements for installation apply in addition to the specifications in AASHTO Division II, Section 10 when high strength bolts are installed in the field or shop.

(1) Bolts shall be installed in conformance with AASHTO Division II Article 10.17.4. During installation, regardless of the tightening method used, particular care shall be exercised so that the snug tight condition as defined in Article 10.17.4 is achieved.

(2) The rotational-capacity test described in (b) Testing, Assemblies above shall be performed on each rotational capacity lot prior to the start of bolt installation. Hardened steel washers shall be used as part of the test.

(3) The Contractor shall supply a Skidmore Wilhelm Calibrator or an acceptable equivalent tension measuring device at each job site during erection. Periodic testing (at least once each working day when the calibrated wrench method is used) shall be performed to assure compliance with the installation test procedures required in AASHTO Division II, Article 10.17.4.1 for Turn of Nut Tightening, Calibrated Wrench Tightening, Installation of Alternate Design Bolts and Direct Tension Indicator Tightening. Bolts that are too short for the Skidmore Wilhelm Calibrator may be tested using direct tension indicators (DTIs). The DTIs shall be calibrated in the Skidmore Wilhelm Calibrator using longer bolts.

(4) Lubrication. Galvanized nuts shall be checked to verify that a visible lubricant is on the threads.

Black bolts shall be oily to the touch when delivered and installed.

Weathered or rusted bolts or nuts not conforming to (e) Installation, 2 or 3 shall be cleaned and relubricated prior to installa-

tion. Recleaned or relubricated bolt, nut, and washer assemblies shall be retested in conformance with (e) Installation, 2 prior to installation.

(5) Bolt, nut, and washer combinations as installed shall be from the same rotational capacity lot.

(f) Requirements for bolts too short to fit tension calibrator.

Equipment.

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

(2) Spacers or washers with hole size no larger than 1/16 inches 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 place thickness that will provide the number of threads under the nut required in Step (1) below. Mark off a vertical line and lines a third of a turn (120 degrees); half of a turn (180 degrees); and two-thirds of a turn (240 degrees), from vertical in a clockwise direction on the plate.

Procedure.

(1) Install nut on bolt and measure stick out of bolt when three to five full threads of the bolt are located between the bearing face of the nut and 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 washers (at least one washer is required under the nut) to produce the thread stick out measured in Step (1).

(3) Snug the bolt using a hand wrench. The snug condition specified in 408.03.17 (d). The applied torque shall not exceed 20 percent 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 shall be used to prevent rotation of the bolt head during tightening. Record the torque required to reach this rotation. Torque shall be measured with the nut in motion.

Bolt length measured in step (1)	4xbolt dia. or less	Greater than 4 but no more than 8 x bolt dia.	Greater than 8x bolt dia.
Required Rotation	1/3	1/2	2/3

The measured torque shall 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	1/8	1/4	1 3/4	1 1/2
Torque, ft lb	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	Greater than 4 but no more than 8x bolt dia.	Greater than 8x bolt dia.
Required Rotation	2/3	1	1 1/3

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

(g) Requirements for Long Bolts in Tension Calibrator.

Equipment.

(1) Calibrated bolt tension measuring device of six required for bolts to be tested. Mark off a vertical line and lines a third of a turn (120 degrees), and two-thirds of a turn (240 degrees) from vertical in a clockwise direction on the face plate of the calibrator.

(2) Calibrated manual torque wrench.

(3) Spacers or washers with hole size no larger than 1/16 in. 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).

Procedure.

(1) Install nut on bolt and measure stick out of bolt when three to five full threads of the bolt are located between the bearing face of the nut and bolt head. Measure the bolt length, this 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 or washers (at least one washer is required under the nut) to produce the thread stick out measured in (1).

(3) Tighten the bolt using a hand wrench to the snug condition listed below (-0, +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	1	2	3	4	5	6	7	8	9

(4) Match mark the nut to the vertical stripe on the face place 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 shall 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	Greater than 4 but no more than 8 x bolt dia.	Greater 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 shall not be less than the values listed below. Assemblies which do not conform to this tension test fail the test.

Bolt dia., in.	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/4	1 1/2
Tension, kips	14	22	32	45	59	64	82	98	118

(8) Loosen and remove the nut and examine the threads on the nut and bolt for signs of thread shear failure, stripping or torsional failure of the bolt. Assemblies having any of these signs fail the test.

(9) Calculate and record the value of 0.25 x the tension (lb=kips x 1000) measured in Step (5) x bolt diameter in feet. The torque measured and recorded in Step (5) shall not be greater than this calculated value. Assemblies with torque values exceeding this calculated value fail the test.

408.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

408.04.01 Fabricated Structural Steel will not be measured for payment but will be paid for at the Contract lump sum price.

408.04.02 Fabricated Structural Steel will be measured and paid for at the Contract unit price per pound computed on the theoretical weight.

Where measurement and payment of Fabricated Structural Steel is based on weight, the weight will be computed on the basis of the net finished dimensions of the parts as shown on the approved working drawings, deducting for copes, cuts, clips, and all open holes.

Computations will be made on the basis of the following:

Material	Pounds Per Cubic Foot
Aluminum, cast or wrought	173.0
Bronze, cast	536.0
Copper alloy	536.0
Copper, sheet	558.0
Iron, cast	445.0
Iron, malleable	470.0
Lead, sheet	707.0
Steel, rolled, cast, copper bearing, silicone, nickel and stainless	490.0
Zinc	450.0

The weights of rolled shapes will be computed on the basis of their nominal weight per foot as specified in the Contract Documents or listed in the handbooks.

The weights of rolled shapes will be computed on the basis of their nominal

weight for their width and thickness as specified in the Contract Documents, plus an estimated overrun computed as one half the permissible variation in thickness and weight as tabulated in A 6.

The weight of all shop weld metal (not included in weighed unit) and field weld metal will be computed on the basis of the theoretical volume from dimensions of the welds.

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 in the payment weight.

Structural members or materials which fail to meet the requirements of tests and all materials rejected as a result of these tests will not be measured nor paid for under any method of payment.

408.04.03 When a pay item for Fabricated Structural Steel is not specified in the Contract Documents, the Fabricated Structural Steel will not be measured but the cost will be incidental to other pertinent items.

408.04.04 Rotational capacity testing for high strength bolt assemblies will not be measured but the cost will be incidental to the Contract price for the Fabricated Structural Steel item or other pertinent items specified in the Contract Documents.

SECTION 409 - STEEL STUD SHEAR DEVELOPERS

409.01 DESCRIPTION. This work shall consist of furnishing, fabricating and installing, complete in place, steel stud shear developers as specified in the Contract Documents or as directed by the Engineer.

409.02 MATERIALS.

Steel Stud Shear Developers	909.05

409.03 CONSTRUCTION. All structural steel in a particular span of a bridge shall be erected and have forming and decking complete in place in that particular span before shear developers are attached to the structural steel. Shear developers shall be installed as specified in AWS D1.5. After welding is completed, an inspection of all studs will be made by the Engineer prior to placing of concrete. All defects shall be corrected at the Contractor's expense.

409.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

409.04.01 Steel Stud Shear Developers will not be measured but will be paid for at the Contract lump sum price.

409.04.02 Steel Stud Shear Developers will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

409.04.03 Steel Stud Shear Developers will be measured and paid for at the Contract unit price per each.

SECTION 410 - EXPANSION JOINTS IN STRUCTURES

410.01 DESCRIPTION. This work shall consist of furnishing, fabricating, and installing preformed joint fillers, preformed elastomeric joint seals, troughs, structural steel and metal plates to be utilized in providing expansion and contraction capabilities in structures as specified in the Contract Documents.

410.02 MATERIALS.

Preformed Joint Fillers	911.02
Preformed Polychloroprene Elastomeric Compression Joint Seals	911.04
Lubricant Adhesive	911.04.03

Troughs	911.11
Paint	
New Expansion Joints	912.16 System A
Existing Expansion Joints Including New Portions	912.16 System B
Top Coat Color, Federal Standard 595	No. 26440
Structural Steel	A 709 Grade 36

The Contractor may substitute two coats of epoxy protective coating conforming to 917.01 in lieu of vinyl paint on new expansion joints.

410.03 CONSTRUCTION. Expansion joint material delivered to the bridge site shall be stored under cover on platforms above the surface of the ground. It shall be protected at all times from damage and when placed it shall be free from dirt, oil, grease, or other foreign substances. All welding shall conform to AWS D1.1 unless otherwise specified in the Contract Documents. No expansion joint material shall be installed prior to approval by the Engineer of all material and installation methods.

The preformed material shall consist of the longest length possible with a minimum of joints. Lengths less than 4 ft (1.2 m) shall be one piece. The material shall be cut to a clean, true edge with a sharp tool. Care shall be taken to insure straight lines at the joint.

When installing the seal, the Contractor shall not use any type of equipment that will damage the seal. If the seal is damaged during installation, the Contractor shall remove and replace the seal at the Contractor's expense.

New Expansion Joints. Prior to any shop painting operations, all surfaces of the expansion dam and backwall angles shall be cleaned as specified for nonweathering steel in 413.03.07. The prime coat shall be applied in the shop to the entire area of the backwall and expansion dam angles including those areas in contact with concrete, except the portion which is masked to receive adhesive for the seal.

Existing Expansion Joints. Prior to any painting operations on existing expansion joints and new steel used to modify them, all surfaces of the expansion dam angles and backwall angles which will be painted and areas

to receive adhesive for the seal shall be thoroughly cleaned to conform to a Near White condition as specified in 413.03.06(d) or (f). The area that will be in contact with the seal shall then be completely masked for full length and depth of seal.

The backwall and expansion dam angles shall have all prime coats applied to the entire area that will be exposed in the finished structure, both above and below the seal. These coatings shall be applied in the shop for new steel members.

Paint. If this is the only portion of bridge to be painted, the paint need not be tested by the Laboratory if, prior to use, a copy of the certified test results has been furnished to the Engineer specifying that the paint conforms to Section 912.

The primer shall be applied on the same day that the blast cleaning takes place. The primer shall be spray applied in a single application with dry film thickness of 3 to 5 mils (0.08-0.13 mm). All touch-ups may be applied by brush and shall have the same dry film thickness as the coat being repaired.

After the joints are complete in place and just prior to placing the compression seal, the masking tape shall be removed and the seal installed. The finish coat shall then be applied to the exposed portion of the angles above the seal.

Joint Seals in Bridge Decks. The transverse compression seals shall be one piece for the entire length of the roadway joint. Shop or field splices in the seal are prohibited. Compression seals for longitudinal bridge joints shall consist of the longest piece practical.

Lubricant adhesives shall be applied in conformance with the manufacturer's recommendations. If stretching of the seal in excess of five percent occurs, the Contractor shall remove and reinstall the seal as directed by the Engineer.

410.03.01 In-Place Testing. The completed joint shall be subjected to a water test to detect any leakage. All facilities required for the Engineer's inspections of the underdeck areas shall be provided at the Contractor's

expense. The roadway section of the joint from curb to curb, or parapet to parapet, shall be covered with a minimum of 1 in. (25 mm) of water. If this is not possible, the water test may be performed in part section along the joint. When testing subsequent part sections, the test shall overlap a minimum of 1 ft (0.3 m) of the joint previously tested.

The ponding shall be maintained for a period of five hours for the entire roadway or each section of joint being tested. During and at the conclusion of the test, the underside of the joint shall be closely examined for leakage. The expansion joint seal shall be considered watertight if no obvious wetness is visible.

If the joint system exhibits evidence of water leakage at any point, the Contractor shall locate and repair all leaks at the Contractor's expense.

When repairs are required, a subsequent water test shall be performed.

If the joint leaks after the second test, the Contractor shall remove, replace and retest the seal at his expense.

410.04 MEASUREMENT AND PAYMENT. Expansion joints in structures will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

SECTION 411 - BEARINGS

411.01 DESCRIPTION. This work shall consist of furnishing and installing bearings of the type and size specified in the Contract Documents or as directed by the Engineer.

411.02 MATERIALS.

Steel Plates	909.02
Bronze or Copper Alloy Bearing and Expansion Plates	910.01
Elastomeric Bearing Pads	910.02

Preformed Fabric Pads	910.02
Epoxy Adhesives	921.04

411.03 CONSTRUCTION.

411.03.01 Storage and Handling. Bearings shall be stored under cover on a platform above the ground surface. They shall be protected from damage at all times and, when placed, shall be dry, clean, free of dirt, oil, grease, or other foreign substances.

411.03.02 Installation. Masonry bearing plates shall be erected on surfaces conforming to 414.03.07 (c). The masonry bearing plates shall be placed on a single thickness of preformed fabric bearing pad.

The bearings and pedestals of truss, beam and girder spans, and the center and end bearing of swing spans shall be rigidly and permanently located to correct alignments and elevations.

The attachment of bearings or plates to steel superstructures shall conform to the applicable portions of Section 408.

411.03.03 Steel, Bronze or Copper Bearings. When steel, bronze or copper alloy bearings are specified in the Contract Documents, the machined bearing surfaces shall be thoroughly cleaned immediately before erection. As soon as practicable after erection, all unpainted exposed surfaces of the bearings, scheduled for painting, shall be given one prime coat before application of the specified field coats.

411.03.04 Elastomeric Bearing Pads. When elastomeric bearing pads are specified in the Contract Documents, the pads and abutting surfaces shall be given a final cleaning to assure that they are free of all dust, dirt, oil, grease, moisture or other foreign substances. Cleaning shall be done with an approved solvent which is compatible with the adhesive prior to application of the epoxy adhesive. The epoxy adhesive shall be mixed and applied in conformance with the manufacturer's recommendations.

When the elastomeric pads are used without masonry bearing plates, the masonry bearing surfaces shall be ground to remove all laitance before the

application of the adhesive. The surfaces of the concrete bearing areas that will be in contact with the bearing pads and the full contact area of the bearing pad shall be coated with the epoxy adhesive. After the adhesive is applied and the pads are set in place, blocking or other approved mechanical methods shall be used to secure the pads in their final position until the adhesive has set up.

Surface temperatures and predicted ambient air temperature for the next four hours shall be 50 F (10 C) or higher at the time of application unless otherwise specified in the Contract Documents or recommended by the epoxy adhesive manufacturer and approved by the Engineer.

411.04 MEASUREMENT AND PAYMENT. Bearings will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

SECTION 412 - BRIDGE MOUNTED SIGN SUPPORTS

412.01 DESCRIPTION. This work shall consist of furnishing and constructing bridge mounted sign supports and sign luminaire supports as specified in the Contract Documents. The work does not include sign panels, electrical work and luminaires.

412.02 MATERIALS.

Epoxy Grout	902.11(d)
Structural Steel	909.01
Paint	912

On new structures, the structural steel and fasteners for the sign support shall be the same as used for the fabrication of the structure on which it is to be mounted, including the additional requirements for Charpy V-notch testing. When A 709, Grade 50W structural steel is used, the vertical supports shall be made of steel conforming to A 709, Grade 36 or 50.

On existing structures, the structural steel for the sign support shall include the additional requirements for Charpy V-notch testing and conform to A 709, Grade 36 or 50. When the existing structure consists of A 709, Grade 50W structural steel, the structural steel for the sign support shall conform to A 709, Grade 50W, except that the vertical supports shall be made of steel conforming to A 709, Grade 36 or 50. The fasteners shall conform to 909.07 and shall be Type 3 when used with A 709, Grade 50W structural steel.

Vertical supports to which the sign panels are attached shall be galvanized in conformance with A 123. All bolts, nuts, and similar fasteners in contact with the galvanized material shall be mechanically or hot-dipped galvanized. The coating shall conform to the thickness, adherence, and quality requirements of A 153.

412.03 CONSTRUCTION. Construction shall conform to Section 408. Painting shall conform to Section 413, except as otherwise specified herein.

The Contractor shall set the anchor bolts by epoxy grouting or casting in place when applicable.

On new structures, the nongalvanized portions of the sign support shall be cleaned and painted in conformance with the system specified for the structure on which it is to be mounted. Portions of the sign support mounted on structures constructed with Grade 50W steel, and attached to areas that are to be painted, shall also be cleaned and painted.

On existing structures not constructed with Grade 50W structural steel, the Contractor may elect to galvanize the entire sign support or paint those areas not designated to be galvanized. The nongalvanized portions of the sign support shall be blast cleaned as specified in Section 413 to meet the surface condition of Near White Sa 2½, and painted using the following:

Shop Coat	912.02
First Field Coat	912.02
Second Field Coat	912.05
Third Field Coat	912.06 Match Original Color

Portions of the sign support mounted on existing structures constructed with Grade 50W steel, and attached to areas that are painted shall also be cleaned and painted.

412.04 MEASUREMENT AND PAYMENT. Bridge Mounted Sign Supports will not be measured but will be paid for at the Contract lump sum price. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

SECTION 413 - CLEANING AND PAINTING STRUCTURAL STEEL

413.01 DESCRIPTION. This work shall consist of cleaning and painting of new and existing structural steel. The work shall conform to SSPC-VIS-1 and SSPC Good Painting Practices. Any structural defects including cracks, missing bolts or rivets, deterioration, etc., detected during cleaning and painting shall be brought to the attention of the Engineer.

The Contractor shall provide all equipment, labor and facilities required for the safe and convenient inspection and measurement of the work by the Engineer throughout the course of the project, and for final and warranty inspections. The cost shall be included in the various items in the Contract Documents.

The Contractor shall conform to the minimum compliance level as stated by EPA Method 40 CFR Part 50. Existing paint systems may include toxic substances such as red lead oxide which may be considered hazardous waste when removed and tested as specified in the Toxicity Characteristic Leaching Procedure (TCLP) and Extraction Procedure Toxicity Test (EP Tox).

Prior to bidding the Contractor should be familiar with the current environmental regulations and safety procedures. The Administration is considered the "Generator" of all waste associated with the work, however, the Contractor shall be responsible for preventing waste from entering into the environment by containing, collecting, storing, testing and disposing of all waste in conformance with federal, state and local regulations.

413.02 MATERIALS.

New Structures	912.16, Paint System A
Existing Structures (Includes Existing and New Members)	912.16, Paint System B
Widening Structures (Includes existing and New Members)	912.16, Paint System C except Coat I for new members shall conform to Paint System A, Coat I

Abrasive particles used in blast cleaning operations shall result in blasted surfaces having a surface profile height of 1 to 3 mils (0.03 to 0.08 mm) as determined by a spring micrometer with surface profile replica tape. If the surface profile is greater than 3 mils (0.08 mm), the Contractor shall apply additional coating equivalent to the excessive profile height at no additional cost to the Administration.

413.03 CONSTRUCTION.

413.03.01 The Contractor shall provide, for the exclusive use of the Engineer, the following equipment for the inspection of the Contractor's cleaning and painting operations. All equipment shall be maintained by the Contractor in a condition that is satisfactory to the Engineer and shall remain the property of the Contractor at the conclusion of the Contract.

(a) Sling Psychrometer (F).

(b) Surface Thermometer 0 to 150 F (-17.8 to 66 C).

(c) U.S. Weather Bureau Psychrometric Tables.

(d) Spring Micrometer with Surface Profile Replica Tape.

(e) SSPC Vis 1-89 Standards (Latest Edition).

(f) SSPC Manual Volumes 1 and 2 (Latest Edition).

(g) Wet Film Thickness Gauge.

(h) Wind Meter.

(i) Digital Magnetic Dry Film Coating Thickness Gauge (SSPC-PA2).

(j) Plastic Calibration Shims for Digital Magnetic Dry Film Thickness Gauge.

(k) Inspector's Mirror.

(l) High/Low Thermometer for Paint Storage Area.

(m) Latest edition of SSPC-Guide 61 (CON) and SSPC-Guide 71 (DIS).

(n) Clean absorbent Rags

413.03.02 Floodlighting. The Contractor shall provide floodlighting, including power source, to supply adequate illumination to the underside of the structure for all cleaning and painting operations and inspections. The floodlighting shall be in good working condition and of a design approved by the Engineer. The floodlighting shall be adjusted to avoid glare that may blind marine and vehicular traffic.

413.03.03 Waste Containment. The Contractor shall provide for total containment of all spent materials allowing no blast dust or debris to escape into the environment. Prior to beginning any cleaning operations, the Contractor shall prepare a Cleaning Containment System Plan conforming to 413.03.04 for the capture, containment, collection and storage of the waste generated by the work, which includes blasting residue, spent blasting mediums, rust, paint particles, dust, etc. Applicable portions of these requirements apply to shops when existing steel coated with hazardous material is being cleaned in the shop.

The containment system shall be capable of containing residue generated

by the work. The Contractor shall conform to all required regulations using the best available technology for each location.

The Contractor should contact the State's Department of Environment, prior to bidding, for interpretation of the regulations.

The Contractor shall also submit details for the recovery system for recycling steel grit used for blast cleaning; a written compliance program for worker protection conforming to OSHA and the MOSH - Lead in Construction standard; and the industrial hygienist's Plan of Action indicating procedures for monitoring air, soil, and water. The recovery system shall be capable of keeping the grit dry, and free of oils, grease, and other harmful materials. The Action Plan shall include the type of equipment, approximate location of monitors, and test samples for each bridge site.

Depositing or dropping spent materials into water or onto ground or roadways below the structure outside or below the containment areas is prohibited. Waterways shall be protected against conveyance of any paint drift and overspray. Dust shall be contained.

All waste discharged and collected from the containment system shall be protected in a manner so as to prevent migration of the waste into the environment. For bridges over water, the containment system shall include a skimming boom for emergency backup consisting of a float with a skirt or other approved system to collect floating debris. The skimming boom shall be cleaned at least once a day.

Within 14 days after receiving award and prior to the Preconstruction Conference, the Contractor shall submit working drawings of the proposed containment system to the Office of Bridge Development Working Drawing Review Section as specified in 413.03.04. The Contractor shall also submit the design of the systems to be employed, including an analysis of the load which will be added to the existing structure by the containment system and blast waste. The load analysis shall be performed and stamped by a licensed professional engineer registered in the State of Maryland and having a minimum of five years experience in bridges. The analysis shall assure that the system will not induce a load on the bridge which will create an overstress condition or otherwise effect the structural integrity of the bridge. The

containment system or equipment shall not encroach upon the minimum bridge clearances shown on the Contract Documents, unless otherwise approved by the Engineer.

The review and acceptance of the working drawings by the Administration (and Railroad when applicable) shall in no way relieve the Contractor of any responsibility for obtaining the required degree of capture, containment and collection.

An industrial hygienist certified by the American Board of Industrial Hygiene and experienced in this type of work shall be obtained by the Contractor. The industrial hygienist shall have $1,000,000 errors and emissions insurance coverage for this type of work. All sampling and testing shall be performed by the industrial hygienist or an employee of that firm under the direct supervision of the industrial hygienist.

The industrial hygienist shall monitor worker exposure and ambient air before and during cleaning operations. Worker exposure monitoring tests shall be performed inside the blasting hood and outside the face mask of workers and outside and downwind of the containment system. Monitoring shall be performed during the first three days of blasting and as work operations change. The number of tests required shall be determined by the Contractor's industrial hygienist and approved by the Engineer. Results of this analysis may require adjustments to the containment system such as dust collectors and airflow systems.

The Contractor shall comply with SSPC - Guide 61 (CON), and the requirements pertaining to specific portions thereof listed below. The Contractor shall provide a copy of all reports, analysis, etc. to the Engineer within three working days unless otherwise approved by the Engineer.

(a) The containment system shall conform to Class 3 Containment with impermeable walls. The Contractor shall provide dust collectors and airflow systems capable of satisfying ambient air and worker exposure requirements established by the Maryland Department of the Environment and MOSH.

(b) Methods for Accessing Quantity of Emissions:

(1) Level 1 Emissions for all bridges.

(2) Air monitoring conforming to Method B shall be performed to insure compliance with air quality standards specified in the National Air Quality Standards issued by EPA under 40 CFR, Part 50.

(3) A soil analysis for hazardous elements conforming to Method E shall be performed as directed by the industrial hygienist. A minimum of four soil samples shall be taken and analyzed, one at each corner of the bridge. A test analysis shall be performed prior to work, during and at the completion of all work at the bridge. If the final test results indicate a minimum increase in lead content of 500 ppm, the Contractor shall clean the site to reduce the lead content to pre-existing conditions.

(4) Total suspended particle (TSP) monitors shall be placed adjacent to homes, businesses, parks or pedestrian walkways that are within 500 ft of the bridge in conformance with Method D1.

(5) When the bridge is within 500 ft of a stream or other body of water, the water shall be tested before work begins, during work operations, and after work operations are completed.

Daily air monitoring shall begin one week prior to beginning work, during the first two weeks of blast cleaning operations and at least one 24-hour period one month later unless otherwise directed by the Engineer. If the data measured is acceptable as determined by the industrial hygienist, additional monitoring will only be required when problems appear to be occurring as determined by visual assessments of the Contractor's operations. Visible residue on the ground, in the water, or visible dust will not be acceptable. The Contractor shall be responsible for any damage or loss to the monitors for the life of the Contract.

The containment system shall be properly maintained while work is in progress and shall not deviate from the approved working drawings without approval of the Engineer. Public access to all rigging, scaffolding and the containment systems shall be denied at all times.

If at any time during the execution of the work the containment system or the steel grit recovery system fails to function at the required level of efficiency, the Contractor shall immediately suspend all operations until modifications have been made to correct the cause of failure.

413.03.04 Containment System Plan Guidelines. Connections to the steel work of the bridge shall be made with clamps or other devices approved by the Engineer. Drilling holes into or welding to the existing steel work will not be permitted.

(a) All drawings shall be made on standard 22 x 36 in. (559 x 914 mm) linens with proper lettering. General notes shall be placed in the space above the title box.

(b) Show the containment system in plan and elevation views including details of clips and hangers.

(c) Indicate maximum permissible load waste permitted on the containment system.

(d) Indicate if vehicles with abrasive and waste will be stationed on the bridge; if so, indicate allowable load and location. Vehicle and equipment loads shall not be permitted behind abutments if surcharging results.

(e) Indicate all restrictions on the bridge and if the bridge is posted.

(f) Indicate which bridges are covered by the plans submitted.

(g) Attachments or fasteners to the bridge shall not be permanent.

(h) When the bridge is over water show a skimming boom for emergency backup.

(i) Identify all containment system components on the plan sheets. Indicate the type and size of scaffolding or rigging to be used and

clearly state erection procedures. Indicate sizes of the containment areas, the capacity of the dust collectors**,** and types of airflow systems to be provided, including volume of air from ventilation fans and minimum velocity of air movement. Include number of blasters, capacity of blasting equipment and hose pressure.

(j) All curtains, screens or tarps used for containment shall be weighted down.

(k) No load shall be attached to the bridge railings unless railing is in good condition, and details and calculations showing loading have been approved by the Administration.

(l) Submit six copies of each linen. Each sheet shall be stamped and signed by a professional engineer. The submittal letter shall be on company letterhead.

(m) Include A Written Compliance Plan and the industrial hygienist's Plan of Action.

(n) Submit six copies each stamped with a professional engineer's seal for review. All submittals shall be in writing and on company letterhead.

413.03.05 Waste Disposal. The Contractor shall provide a clean up area with a shower, soap, hot and cold potable pressurized water, a change area with a locker for clean clothes, etc., and a container for collection and disposing of hazardous waste at each work site. This facility shall be available for the Contractor's and the Administration's personnel.

The Contractor shall comply with SSPC - Guide 71 (DIS).

Each day the Contractor shall collect the clothing and other waste material in approved containers and seal them. When drums are used they shall be sealed 55 gal (210 L) open head type drums conforming to I.C.C. Specification 17-H. All containers shall be in new condition and approved for use by the Engineer. Containers shall be tagged with the bridge number, contract number, Contractor's name, contents, and the date.

Storage Site. At the end of each working day the Contractor shall haul the waste material away from the bridge site to an approved temporary storage site which has been obtained by the Contractor and approved by the Engineer. The storage site shall be capable of preventing the migration of the lead contaminated abrasive into the environment. The storage area shall provide protection from vandalism and unauthorized access by the general public. The waste shall not remain at the temporary storage site longer than 90 days from the date of accumulation.

Hazardous Waste. **T**he Contractor's industrial hygienist shall take a minimum of four samples of the accumulated residues collected at each bridge to be analyzed for TCLP as outlined in 40CFR261, Appendix II; the EPA Test Procedure Manual; and EP toxicity as outlined in COMAR 26.13.02.20 and 26.13.02.21 if required. Additional samples may be required if the average test results exceed 3.5 ppm. The disposal method employed shall be based on the results of these analyses.

Maryland law provides that when samples tested using TCLP exceed 5 ppm, they shall be considered hazardous waste and shall be either treated to lower the contamination below 5 ppm in a manner acceptable to the Department of the Environment and then disposed of as a nonhazardous waste, or removed under manifest by a licensed hazardous waste transporter to a permitted disposal facility. Waste containing less than 5 ppm by the TCLP test may be disposed of as an industrial waste at any landfill permitted to accept this material.

When tested waste material is determined to be hazardous waste, the Contractor shall obtain an EPA identification number as specified in COMAR 26.13.03.03.

The Contractor shall prepare a manifest for waste to be transported from the approved temporary storage site. The manifests shall be prepared and shall contain the information stipulated in COMAR 26.13.03.04.

All waste shall be weighed at the disposal site or at a certified weighing station. The Contractor shall furnish the Engineer with a certification or manifest identifying and indicating the weight of the waste to be disposed,

including solvents, rags, protective clothing, etc., and proof of its acceptance at an approved disposal site. All information required by state regulations shall be included.

COMAR 26.13.03.05 stipulates the "Pre-Transport" requirements and the amount of time permitted for the accumulation of hazardous waste. Waste shall be transported by a certified waste hauler to any landfill permitted to accept this material.

The Contractor can obtain the EPA I.D. numbers, a list of certified haulers, and other information regarding handling and disposal of blast waste by contacting the Department of Environment, Hazardous Waste Administration.

413.03.06 Surface Preparation. Surfaces shall be prepared as specified in the cited SSPC Specifications and the Contract Documents. Surface conditions shall conform to SSPC-Vis 1.

The Contractor shall furnish two 12 x 12 x 1/4 in (300 x 300 x6 mm) steel plates which shall be cleaned by the Contractor in conformance with the Contract Documents and used as a job sample standard for cleaning operations. These standard plates shall be given a clear protective coating. All cost shall be incidental to the other items specified in the Contract Documents.

(a) Solvent cleaning shall be used to remove foreign matter such as oil, grease, soil and other contaminants from steel or galvanized surfaces. Solvents, emulsions, cleaning compounds, steam cleaning or similar materials and methods approved by the Engineer shall be used as specified in SSPC-SP 1. Soap steam cleaning shall be used in cleaning steel open grid, decks and walkways and machinery areas of drawbridges. Contaminated solvent shall be removed before it evaporates by wiping or rinsing with clean solvents to prevent a film of contaminants from remaining on the surface. Solvent wiping may be required between coats. All solvent shall be approved by the paint manufacturer.

(b) Handtool cleaning shall be used to remove loose mill scale, loose

rust and loose paint from steel surfaces. Nonmechanical brushing, sanding, chipping, scraping or other hand impact methods conforming to SSPC-SP 2 shall be utilized as approved by the Engineer.

(c) Brush off blast or power tool cleaning conforming to SSPC-SP 7 shall be used to remove loose mill scale, loose rust and loose paint from steel surfaces. Powertools such as impact tools, grinders, sanders, or any combination of these tools used shall conform to SSPC-SP 3 and shall be approved by the Engineer.

(d) Abrasive blast cleaning shall be used to remove mill scale, rust, rust scale, paint or other foreign matter from steel surfaces. Steel grit propelled through nozzles or centrifugal wheels conforming to SSPC-SP 10 shall be utilized unless otherwise approved by the Bridge Inspection an Remedial Engineering Division. The end surface condition shall conform to near white. Abrasive shall be dry and free of oils, grease and other harmful materials such as lead dust, etc. at the time of use.

(e) Power tool cleaning to bare metal shall be used where abrasive blast cleaning is not permitted such as machinery areas, monotube piles etc. This method of cleaning shall conform to SSPC-SP 11.

(f) Shotblast cleaning shall be used to remove mill scale, rust, rust scale, paint or other foreign matter from steel surfaces. A sufficient amount of steel grit mixed with cast iron, malleable iron, steel or synthetic shot propelled through nozzles or centrifugal wheels conforming to SSPC-SP 10 shall be utilized and approved by the Engineer. The end surface condition shall produce an etched surface texture as opposed to the peened surface texture typical of shotblasting, and shall conform to near white. Shotblast cleaning shall not be permitted in the field.

(g) Power washing shall be used to remove dust, dirt, debris, and salt contaminants within 48 hours prior to blast cleaning or power tool cleaning. The pressure washer shall be capable of 2000 psi pressure at the nozzle using potable water.

413.03.07 Shop Cleaning. All new structural steel shall be cleaned in the shop. All oil, grease and other substances shall be removed from steel surfaces as specified in 413.03.06(a) prior to blast cleaning. The blast cleaning shall conform to 413.03.06(e). The following areas shall be blast cleaned after all shop fabrication is complete:

(a) Nonweathering Steel - All surfaces

(b) Weathering Steel

(1) The outside surfaces of the fascia stringers for bridges. For dual bridges this includes median fascia.

(2) At abutments, the end 10 ft (3.2 m) of all stringers and all other structural steel within the 10 ft (3.2 m) area, e.g., stiffeners, cross bracing, bearings, etc.

(3) At piers, 10 ft (3.2 m) in each direction from the center line of the pier giving a total length at each pier of 20 ft (6 m) and all other structural steel within the area, e.g., stiffeners, cross bracing, bearings, etc.

(4) At bolted field splices, 12 in. (305 mm) beyond the longest splice plate for each particular splice and all splice material.

413.03.08 Field Cleaning. Cleaning and painting shall proceed by sections, bays or other readily identifiable part of the work as may be approved by the Engineer. The work shall start at the top and proceed toward the bottom. The method of cleaning shall be either Brush Off Blast Cleaning or near White Blast Cleaning. Regardless of the method used for cleaning, the Contractor shall feather the edges of remaining old paint so that the repainted surface can have a reasonably smooth appearance.

Vegetation overhanging or fouling the structure shall be removed. Heavy rust and packed rust shall be removed by a combination of cleaning procedures such as hand chipping (using chipping hammers or scaling hammers), brush off blast cleaning, power tool cleaning, etc. without scarring good steel. All dust, pebbles, grease and debris on surfaces adjacent to those

being painted shall be removed. Oil and grease shall be removed by solvent cleaning. Portions of paint on previously painted surfaces which are chalky, powdered, cracked or otherwise unacceptable, including runs and sags, shall be removed.

Prior to blast cleaning all surfaces shall be washed as specified in 413.03.06 (g). Paint removed during washing operations shall be contained and collected in conformance with 413.03.03 through 413.03.05.

413.03.09 Paint Storage. Paints and thinners shall be stored in well ventilated areas and not subject to excessive heat, open flames, electrical discharge and direct rays of the sun. The Contractor shall adhere to all manufacturer's recommendations. Materials susceptible to damage by low temperatures shall be stored in heated areas when necessary. All materials shall be used on a rotating stock basis and remain closed until used. Paints which cannot be stirred to attain normal consistency shall not be used. Paint not in actual use shall be stored in tightly covered containers at not less than an ambient temperature of 45 F (7 C). Containers used for storage of coating shall be maintained in a clean condition, free of foreign materials and residue.

Thin skins formed in the container shall be cut loose and discarded. Material which has livered, gelled, thick skinned or become questionable shall not be used unless reapproved by the Engineer. Waste chemical solutions, oil rags and other waste shall be removed daily. All necessary precautionary measures shall be taken to ensure that workmen and work areas are adequately protected from fire hazards and health hazards resulting from handling, mixing and application of materials. Materials shall not be used beyond their pot life.

413.03.10 Painting Prerequisites. The Contractor shall adequately protect the environment, and be fully responsible for any damage resulting from wind or the cleaning and painting operations.

The Contractor shall submit in writing to the Engineer the proposed type and method of protection against paint spatters, spray, drippings, etc. while painting over roadways, waterways, machinery areas, and areas in the vi-

cinity of abutments and private properties. If at any time during the execution of the work the method of protection fails to function at the required level of efficiency, the Contractor shall immediately suspend all operations except those attendant to minimizing adverse impact to the environment. Operations shall not resume until modifications have been made to correct the cause of the failure.

Paint operations may be stopped by the Engineer during winds up to 20 mph (32 km/h). Paint operations shall stop if the wind velocity exceeds 20 mph (32 km/h) unless otherwise approved by the Engineer.

Paint shall not be applied in rain, snow, fog, mist or when the surface temperature is below the dew point.

All areas adjacent to machinery or mechanical components, etc. shall be painted by brush application unless approved by the Engineer. Areas not approved by the Engineer for spray painting shall be painted by brush application. All dry spray, runs and mud cracking shall be removed prior to the application of the succeeding coat.

The steel shall be kept dust free during painting operations, and care shall be taken to protect newly coated surfaces from cleaning operations. When an area which had previously been cleaned or painted becomes soiled, contaminated or rusted, the area shall be recleaned to the specified condition and completely recoated at no additional cost to the Administration.

All surfaces to be painted shall be sound, properly cleaned and thoroughly dry. Paint shall not be applied when the ambient air temperature in the shade is below 40 F (4 C), the surface temperature is less than 45 F (7 C), the surface temperature is expected to drop to 32 F (0 C) or below before the paint has dried, either temperature is less than 5 F (3 C) above the dew point, the relative humidity exceeds 85 percent, or the steel is hot enough to cause the paint to blister, produce a porous film or otherwise be detrimental to the life of the paint. The surfaces to be painted shall not be wet, damp or frosted.

If at any time it is suspected that moisture is condensing upon the surface the sling psychrometer shall be used to check dew point etc. The Engineer

may allow a well defined area of the surface to be lightly moistened with a damp cloth and observed. If the dampness evaporates and decreases in 15 minutes, the surface shall be considered satisfactory for the application of paint. If fresh paint is damaged by the elements, the paint shall be replaced or repaired by the Contractor at no additional cost to the Administration.

The Contractor shall schedule his operations so that all cleaned surfaces are painted within 24 hours. If rust bloom appears or the air or steel temperature falls below five degrees above the dew point after cleaning and prior to application of the primer coat, the Contractor shall reclean the affected areas to the satisfaction of the Engineer at no additional cost to the Administration.

Prior to the application of paint, the Contractor shall obtain approval from the Engineer that the surfaces to be painted during that day have been cleaned as specified.

After the primer coat has been applied, each subsequent coat shall be applied within 30 days after the previous coat unless otherwise approved in writing by the paint manufacturer.

413.03.11 Painting New Steel. The primer coat shall be applied in the shop as recommended by the manufacturer in a single application employing multiple spray passes. The specified dry film thickness shall be applied to all surfaces to be painted except a light dust coating shall be applied within the areas of field welding and to the top and both edges of the top flange where steel stud shear developers are to be attached.

Areas of structural steel to be painted, after blast cleaning is complete are:

Nonweathering Steel. The primer coat shall be applied to all structural steel surfaces. The vinyl coats shall be applied to all exposed structural steel surfaces in the completed structure.

Weathering Steel. The primer coat shall be applied to all structural steel surfaces listed below. The Vinyl coats shall be applied to all exposed structural steel surfaces in the completed structure listed below.

(a) If the structure is over a railroad or water, only the end 10 feet of all stringers at all abutments and the 20 feet section centered over the piers shall be painted (includes fascia stringers) and all other structural steel in these areas shall be painted.

(b) If the structure is over a highway or has curb openings, the end 10 feet of all interior stringers at all abutments, 20 ft section centered over the piers and all other structural steel in these areas shall be painted. In addition, the entire outside surfaces of the fascia stringers shall be painted (includes underside of the top flange, face of web, and the top, bottom and edges of bottom flange).

Bolts for field assembly shall not be shop coated. After field welding and prior to applying the intermediate or tie coat, these bolts, field weld areas, and rusted or damaged areas, shall be brush off blast or power tool cleaned as specified in 413.03.06(c), or abrasive blast cleaned as specified in 413.03.06(d) if required by the Engineer. The primer coat shall be applied on these areas the same day they are cleaned. Primer paint stained from rusted bolts shall be wiped before the intermediate coat is applied.

The primer shall be applied from agitated containers. All touch ups shall have the same dry film thickness as the coat being repaired but may be applied by brush. Organic zinc primer may be used to touch up the primer coat if required by the manufacturer or the Engineer.

Prior to field coating the surfaces of the steel shall be pressure water blasted with potable water in a pressure washer having 3000 to 5000 psi at the nozzle to remove dirt and contaminants. Scrubbing the surface or scraping off excess concrete, etc. may also be required.

Both vinyl coats shall be applied in the field after all field welding has been completed. All paint shall be applied in conformance with the manufacturer's recommendations. Unless otherwise specified in the Contract Documents, vinyl coats shall be sprayed.

413.03.12 Painting Existing Steel. All paint shall be properly mixed and applied as specified by the manufacturer except that all painting shall be by

brush or roller application unless otherwise approved by the Engineer. Spray painting will be permitted provided the location and method of application is approved by the Engineer. The Contractor shall adequately protect the environment and take full responsibility for any damage resulting from wind or the painting operations. All dry spray and runs shall be removed prior to the application of the succeeding coat. Surfaces inaccessible for painting by regular means shall have the paint applied by sheepskin daubers or by other means if necessary to ensure coverage of the proper coating thickness. Thinning of paint is prohibited unless authorized by the Engineer.

When alkyd paint is used, the Contractor shall allow each coat of paint to cure for a minimum of 36 hours and a maximum of 72 hours prior to the application of the succeeding coat of paint. Any exceptions shall be approved by the Engineer. Surfaces that have been brush off blast cleaned or power tool cleaned to tight paint on uncorroded steel shall be painted with coats II and III. Surfaces exposed to bare metal by brush off blast, power tool cleaning or blast cleaning shall be painted with coats I, II and III.

413.03.13 Restrictions. Except for shop coat touch-ups, steel that will be exposed to view in the completed structure shall not be painted until all concrete has been placed. Care shall be taken by the Contractor to protect concrete from being stained by painting operations. Damaged concrete surfaces shall be restored to originally intended color without damage to the concrete.

413.03.14 Defective Work. The Contractor shall be responsible for the satisfactory application of paint and neither conditions during application nor Laboratory acceptance of paint shall relieve the Contractor of responsibility of obtaining a satisfactory paint system. Painting shall be done in a neat and workmanlike manner. If rusting occurs or a paint coat lifts, blisters, wrinkles, or shows evidence of having been applied under unfavorable conditions, the workmanship is poor, impure or unauthorized paint has been used, or for any other reason the painting is unsatisfactory, the affected paint shall be removed and the steel thoroughly cleaned and repainted at no additional cost to the Administration. These area shall provide a uniform appearance throughout the structure.

413.03.15 Final Identification. When the final coat of paint is dry, the

Contractor shall stencil on the structure a legend indicating the type of paint used in each coat and the month and year in which each application was completed. The stencil shall be applied with black paint inside a fascia stringer near the abutment at a location selected by the Engineer. If more than one paint system is used, additional stencils shall be applied.

413.04 MEASUREMENT AND PAYMENT. The Contract unit price for the item specified in the Contract Documents will be full compensation for all material, labor, equipment (including test equipment), tools, and incidentals necessary to complete the work.

413.04.01 Cleaning and Painting Existing Structural Steel shall also include all tools, drums, permits, working drawings, and professional engineer's services used for containment, industrial hygienist services, collection and temporary storage, air monitoring, sampling and testing materials for lead content, including any revisions, resubmissions of the Containment Plan and Systems that may be required during the execution of the work, and all other incidentals necessary to complete all cleaning and painting operations including hauling and disposal at an approved industrial waste site or hazardous waste site.

413.04.02 Cleaning and Painting New Structural Steel will not be measured but the cost will be incidental to the pertinent Fabricated Structural Steel item.

413.04.03 Cleaning and Painting Existing Structural Steel will not be measured but will be paid for at the Contract lump sum price.

413.04.04 Cleaning Existing Structural Steel will be measured and paid for at the Contract unit price per square foot.

413.04.05 Painting Existing Structural Steel will not be measured but will be paid for at the Contract lump sum price.

413.04.06 Deleted

SECTION 414 — PORTLAND CEMENT CONCRETE STRUCTURES

414.01 DESCRIPTION. This work shall consist of constructing concrete structures or portions of structures including the furnishing, transporting, mixing, placing, curing, and finishing of the portland cement concrete and protecting the structures as specified in the Contract Documents or as directed by the Engineer.

414.02 MATERIALS.

Curing Materials	902.07
Form Release Compound	902.08
Concrete Mixes	902.10.03 and 414.02.04
Grout	902.11
Linseed Oil	902.12
Drains, Downspouts, Weepholes and Pipes	905
Reinforcement	908.01
Cast Iron Scuppers	909.04
Anchor Bolts	909.06
Steel Forms Which Remain In Place	909.10
Joint Sealer	911.01
Preformed Joint Fillers	911.02
Preformed Elastomeric Joint Seals	911.04
Flashing and Waterstops	913.04 and 911.08
Production Plants	915
Fusion Bonded Epoxy	917.02
Water	921.01
Epoxy Bonding Compound	921.04

414.02.01 Admixtures. Calcium chloride or any other admixture containing chloride salts shall not be used in bridge deck concrete including precast units.

414.02.02 Accessories in Deck Slabs. All accessories such as inserts and ties that will remain in completed superstructures within the top 5 in. (125 mm) of final deck slab concrete shall either be epoxy coated or made of material other than aluminum which will not rust. No inserts will be permitted in the top half of slabs exposed to vehicular traffic unless specified in the Contract Documents.

414.02.03 Precast Reinforced Concrete Box Sections. Precast reinforced concrete box sections for culverts shall conform to M 259 or M 273 including concrete design strength. All details shall be as shown in the Contract Documents. Construction joints between the walls and the bottom and top slabs will be optional.
Certification. The precast reinforced concrete box section manufacturer shall submit certificates showing the actual test results meeting these requirements.

414.02.04 Composition of Concrete Mixes for Slip Form. If the slip form method is used for constructing concrete parapets and concrete median barriers on bridges, the concrete shall meet the requirements of Mix No. 6 except that the slump shall be 1 in. (25 mm) maximum. The slump shall be measured at the placement point as the concrete is being charged into the slip form machine. The coarse aggregate shall be crushed stone conforming to M 43, size number 7, and shall not be less than 63 percent of the total aggregate in the mix. Other size coarse aggregate may be used provided the slip form results are approved by the Engineer.

414.03 CONSTRUCTION. Concrete shall be made at either the work site or away from the work site by an approved central mixing plant, or by approved truck mixing as specified in Section 915.

414.03.01 Equipment. The Contractor shall use equipment of sufficient capacity to complete any unit or section of concrete between construction joints, as specified in the Contract Documents, in one continuous operation consistent with placement operations as approved by the Engineer. Hand mixing may be permitted with written approval of the Engineer for small volumes of concrete. However, its intended use is for small isolated areas where structural integrity is not critical and the volume does not exceed 1 yd^3 (1 m^3).

414.03.02 Forms.

(a) Design Criteria.

(1) Design Loads. Design loads shall conform to AASHTO Standard Specifications for Highway Bridges, Temporary Works, Loads. The lumber in the forms shall be assumed to weigh 50 lb/ft^3 (800 kg/m^3).

(2) Design Stresses.

Timber Design. Timber design for form work shall conform to ACI Standard Recommended Practice for Concrete Formwork (ACI 347). Unit stresses stipulated in AASHTO for treated timber may be increased by 25 percent but shall not exceed the values listed below. Deflections for form members shall not exceed 1/270 of the span or 1/4 in. (6 mm).

Compression Perpendicular to Grain	450 psi (3.1 MPa)
Compression Parallel to Grain	1600 psi (11.0 MPa)
Flexural Stress	1800 psi (12.4 MPa)
Horizontal Shear	
Beams up to 6 in. (150 mm) deep	200 psi (1.4 MPa)
Beams over 6 in. (150 mm) deep	150 psi (1.0 MPa)
Axial Tension	1200 psi (8.3 MPa)

Plywood. The strength of plywood without backing shall be calculated on the basis of the grain of the face plys running parallel to its span. The plywood shall be installed in this manner.

Steel Members for Forms. Steel design for formwork shall conform to AASHTO Standard Specifications for Highway Bridges. For design where no dynamic loading is involved, the AISC Standard Manual of Steel Construction, Allowable Stress Design may be used as the accepted design code.

Steel Forms Which Remain in Place. The maximum deflection of steel deck forms which remain in place shall not exceed 1/180 of the span and not in excess of 1/2 in. (12 mm).

For steel deck forms which remain in place, camber shall not be used to compensate for deflection in excess of the above limits. The design spans of the form sheets shall be the clear distance between beam or girder flanges less 2 in. (50 mm).

For steel forms which remain in place, the unit working stress in the steel sheet and supporting members shall not be more than 0.725 of the specified minimum yield strength of the material furnished but not to exceed 36 000 psi (248 MPa). Physical design properties shall be computed in conformance with the American Iron and Steel Institute Specification for Design of Cold Formed Steel Structural Members.

(b) Working Drawing Approval. Detail, form, falsework and centering plans and design loads shall be submitted to the Engineer for approval except as specified otherwise in the Contract Documents. Working drawings for forms shall include all members proposed for use as well as form ties and bracing. Details for form ties shall not be submitted separately but shall be incorporated in the general working drawings submittal. The rate of placing concrete shall be noted on the working drawings. Approval of the working drawings will not relieve the Contractor of responsibility as specified in TC-4.01. The provisions of 408.03.28 also applied when working drawings are submitted for falsework and centering.

(c) Forms at Construction Joints and Corners. At construction joints in concrete, ties or bolts shall be provided 3 to 6 in. (75 to 150 mm) from each side of the joint for tightening the forms against the hardened adjacent concrete prior to placing fresh concrete. At joints where forms have been removed and reconstructed, the form surface shall extend over the concrete already in place; and the forms shall be drawn tightly against the previously placed concrete prior to placing the fresh concrete. Forms shall be filleted at all sharp corners, except when otherwise specified in the Contract Docu-

ments and shall be given a bevel or draft in the case of all projections. All exposed corners of concrete shall be chamfered with 3/4 x 3/4 in. (19 x 19 mm) milled chamfer strips, except on unexposed footings or where specified in the Contract Documents.

(d) Form Scaffolds and Platforms. Form scaffolds and platforms shall be built along the outside of bridge deck fascias during construction of forms for bridge decks. They shall be designed and constructed as an integral part of the form supports. Separate design calculations shall be furnished with the working drawing submission. Approval of the working drawings will not relieve the Contractor of responsibility as specified in TC-4.01.

(e) Forms for Unexposed Surfaces. All sheathing, studs and bracing shall be of sound material. Studs and wales shall be straight and true and surfaced on two edges to a uniform width. The inside face of the forms shall be of sufficiently smooth construction that the resulting concrete surfaces shall be accurately formed.

(f) Forms for Exposed Surfaces. Unless otherwise specified in the Contract Documents, steel forms which remain in place shall be used between stringers to support the bridge deck concrete, except in panels where a longitudinal deck construction joint is located between stringers. Forms to be used on the structure for widening and rehabilitation shall provide that the exposed finished concrete surfaces shall match the existing structure.

(1) Lined Forms for Exposed Surfaces. The contact surfaces of lined forms for surfaces exposed to weather or view shall be approved composition board, sanded plywood or metal. All studs shall be surfaced two edges to a uniform width and shall be of a grade of lumber that is solid, straight and free of defects that could impair its strength. The backing for form lining shall be constructed using a grade of form lumber that is solid, straight and free of defects that could impair its strength, but need not be of the quality used for contact forms for unexposed surfaces.

All sheathing for form backing shall be surfaced two sides to a uniform minimum of the thickness of at least the dimension approved on the working drawings. Form sheathing shall be built solidly, securely nailed to studs and placed to prevent any bulging of the lining.

(2) Unlined Forms for Exposed Surfaces. Unlined forms in contact with surfaces exposed to weather or view shall be constructed of five ply sanded plywood of the thickness specified in the Contract Documents. Plywood shall be manufactured especially for concrete form work using a waterproof glue. All studs and wales shall be surfaced two edges to a uniform width.

Full size sheets of plywood shall be used except where smaller pieces cover an entire area. All joints shall be backed solidly to prevent leakage and the edges of abutting sheets shall be nailed to the same stud or blocking with sixpenny nails not more than eight inches apart. Where rustication occurs, horizontal joints in the plywood shall be constructed behind a rustication strip. Otherwise, horizontal joints shall be placed at the same respective elevations in all portions of the structure. Where vertical rustication occurs, vertical joints in the lining shall be constructed behind a rustication strip. Otherwise, vertical joints shall be kept to a minimum and shall be butted tightly together and sealed with a crack filler specified in the Contract Documents, as the plywood is nailed in place.

(g) Steel Forms That Remain in Place.

(1) Installation. The surface of the steel forms in contact with concrete shall be smooth and free of surface irregularities. Working drawings for steel forms that remain in place shall specify the grade of steel, the physical and sectional properties for all permanent steel bridge deck form sheets and a clear indication of locations where the forms are supported by steel beam flanges subject to tensile stresses.

Form supports shall not be welded to flanges of steel that are

not considered weldable nor to portions of flanges that are subject to tensile stresses.

Welding and welds shall conform to the provisions of the latest AWS Bridge Welding Code pertaining to fillet welds except that 1/8 in. (3 mm) inlet welds will be permitted.

Unless otherwise specified in the Contract Documents, steel forms which remain in place shall be used between stringers to support bridge deck concrete, except in panels where a longitudinal deck construction joint is located between stringers.

(2) Procedure Check and Inspection. The Contractor shall remove at least one section of the forms at a location and time selected by the Engineer from each span of each bridge in the Contract. If the bridge has a longitudinal joint, a form on each side of the joint shall be removed from each span. This should be done as soon after placing the concrete as practical in order to provide visual evidence that the concrete mix and the Contractor's procedures are obtaining the desired results. An additional section shall be removed if the Engineer determines that there has been any change in the concrete mix or in the Contractor's procedures warranting additional inspection.

At locations 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. As soon as the form is removed, the concrete surfaces will be examined for cavities, honeycombing, and other defects. If irregularities are found and it is determined by the Engineer that these irregularities do not justify rejection of the work, the concrete shall be repaired as directed by the Engineer. The concrete shall be given an ordinary surface finish in conformance with 414.03.07(a). If the concrete where the form is removed is unsatisfactory, additional forms, as necessary, shall be removed to inspect and repair the slab. The Contractor's method of construction shall be modified as required to obtain satisfac-

tory concrete in the slab. All unsatisfactory concrete shall be removed and replaced or repaired as directed by the Engineer.

The Contractor shall provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedures.

(h) Steel Forms Which Do Not Remain in Place. The surface of the steel forms in contact with the concrete shall be smooth and free of bolts, bolt heads, nuts, rivet heads, welding seams and surface irregularities. Forms that produce unacceptable concrete surfaces will be rejected and shall not be reused.

(1) For Round Columns and Piers. Steel forms for round columns and piers shall have minimum number of horizontal joints and shall be column height. The minimum thickness of these steel forms shall be 10 gauge (3.42 mm).

(2) For Pier Caps and Crash Walls. Prefabricated girder type steel forms may be used for forming pier caps or crash walls. Each element of these forms, including side, bottom and end shall be in one piece where practical. Splices shall be arranged to provide a symmetrical pattern where forms are spliced.

(3) For Reinforced Concrete Box Culverts and Rigid Frames. Steel forms or forms constructed of wood or composition wood panel sheathing set in metal frames may be used. The minimum thickness of steel forms for box culverts and rigid frames shall be 10 gauge (3.42 mm).

(i) Fiber Column Forms. Fiber column forms shall only be used for round columns, and shall conform to these Specifications. The forms shall produce columns truly round and straight and shall be protected from dampness before concrete is placed. Fiber forms shall not be spliced.

(j) Release Agents. All forms shall be treated with form release compound immediately before placing concrete.

(k) Temporary Supports. Temporary supports used for centering and falsework shall be built on good firm foundations. Unless otherwise provided, they shall be founded to bear upon strata at or below the frost line unless rock is available, or piling shall be driven for support where required. The strength and bracing of the temporary supports shall insure that the completed structure will have the shape shown on the Contract Documents. The Contractor shall employ jacks or hardwood wedges in connection with the temporary supports in order to take up settlement either before or during placing of concrete. Temporary supports shall be set to give the structural camber specified on the Contract Documents, plus allowance for shrinkage and settlement. If during the construction any weakness, settlement or distortion develops, the work shall be stopped and any masonry affected thereby removed and the temporary structures strengthened before work is resumed. Centering shall be constructed to permit its gradual, uniform lowering.

(l) Defective Forms. Removal or modification of steel forms which remain in place shall be performed using a device approved by the Engineer. No burning will be permitted.

(m) Form Ties. Only form ties approved by the Engineer shall be used. Ties shall leave no metal closer than 2 in. (50 mm) from the surface. They shall not be fitted with lugs, cones, washers or other devices which act as spreaders within the form or for any purpose that leaves a hole larger than 7/8 in. (22 mm) diameter. When prefabricated steel girder forms are used, tapered ties up to 1½ in. (40 mm) maximum diameter shall be used. Ties shall be clean and free of rust. When ties are removed, the holes shall be pressure grouted with a nonshrink mortar mixed to match the color and texture of the concrete.

Portions of ties to be removed from the concrete shall be coated with a clear lubricant or other approved material to facilitate removal.

Care shall be exercised during removal of form ties to avoid stalling the concrete on the exposed surface. Cutting back from the face of the wall will not be permitted.

(n) Form Support Brackets or Devices. Devices attached to previously placed concrete may be used, provided all parts are acceptable to the Engineer. No metal part of an insert, threader or anchor that remains in place in the concrete shall be within 2½ in. (65 mm) of the surface. The concrete supporting the brackets or other devices shall be cured and shall have attained a minimum compressive strength of 3000 psi (20.7 MPa) before the brackets or other devices are attached. All voids left in the concrete after brackets or other devices have been removed shall be no greater than 2 in. (50 mm) diameter and shall be completely filled with mortar and the surface finished as specified in 414.03.07(a).

(o) Form Removal. For the purpose of determining the time when falsework and forms may be removed, backfill placed, and when loads may be applied to structures, an adequate number of concrete test specimens shall be made in addition to those required to check the quality of the concrete being produced. All forms for concrete work shall be removed and disposed of by the Contractor after form work requirements have been conformed to, except those that are specified to remain in place.

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and their support shall not be removed without the approval of the Engineer. Supports shall be removed in a manner that permits the concrete to uniformly and gradually take the stresses due to its own weight.

(p) Year Built Marking. The year of completion shall be cast into each structure, as determined by the Engineer. Forms or molds for casting the year built numerals in the structure shall be supplied by the Contractor. The year built numerals shall be the size specified in the Contract Documents.

(q) Survey Disk. A survey disk shall be placed in the concrete end post portion of bridge abutments and the headwall portions of box culverts as the concrete is being placed. Representatives from Baltimore County's Surveys Division will determine where to place the survey disks and will supply and place the disks in the plastic concrete.

The Contractor shall notify the Engineer at least seven working days prior to placing the concrete and the Engineer will contact Baltimore County's Surveys Division.

414.03.03 Anchor Bolt Placement. Anchor bolt placement shall conform to 408.03.31.

414.03.04 Concreting. Before placing concrete, forms shall be cleaned. Struts, stays and braces serving temporarily to hold the forms in correct shape and alignment shall not be buried in the concrete. If faces of completed or proposed excavated footing areas are disturbed prior to concreting, the footings shall be extended at the Contractor's expense, to bear on undisturbed faces acceptable to the Engineer. All concrete except tremie concrete shall be placed in the dry.

(a) Foundations. The Contractor shall be responsible for any reinforcement fabricated prior to approval of foundations. If bearing material varies more than assumed in design, footing may be lowered, raised, deepened, subfoundation placed, piles used or a combination of these methods used to best obtain bearing as directed by the Engineer. If planned footings are changed vertically, reinforcement steel shall be revised as required. Subfoundation concrete for bridges, retaining walls and wing walls of box culverts or rigid frames shall be constructed using plain Concrete Mix No. 1 (no reinforcement). The Concrete Mix No. 1 need not be vibrated, and the usual curing and cold weather requirements may be reduced to three days. Selected backfill using number 57 aggregate, protected with Geotextile against soil or as directed by the Engineer, may be used for subfoundation for box culvert barrels, headwalls and miscellaneous structures.

(b) Concrete Placement. Concrete shall be placed to avoid segregation of the material and the displacement of the reinforcement. The use of troughs, chutes and pipes for conveying concrete more than 15 ft (5 m) from the mixer to the forms will be permitted only when acceptable to the Engineer. Open troughs and chutes shall be metal or metal lined. Where segregation occurs due to steep slopes, chutes shall be equipped with baffles.

Where placing operations would involve dropping the concrete more than 5 ft (1.5 m), it shall be deposited through a tube made of sheet metal, canvas or other approved material. Aluminum hoppers or tubes shall not be used. Lower ends shall be kept as close as possible to the newly placed concrete and not more than 3 ft (1 m) above the concrete. All tubes shall have a minimum diameter of 6 in. (150 mm) unless otherwise directed by the Engineer. After initial set of the concrete, the form shall not be disturbed, and no strain shall be placed on the projecting ends of the reinforcement.

Concrete shall be placed in horizontal layers not more than 12 in. (300 mm) high except as provided herein. When less than the complete area of a layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and vibrated before the preceding layer has taken initial set to prevent injury to the concrete and avoid separation of joints between the layers.

Concrete in columns and walls shall be placed in one continuous operation unless otherwise directed. The concrete shall set at least 12 hours before the caps are placed.

Where walls, piers, columns, struts and posts have horizontal construction joints, succeeding lifts shall not be placed until the lower placement has set for 12 hours.

Prior to subsequent placement, all accumulations of mortar splashed upon the reinforcement shall be cleaned. Care shall be exercised not to injure or break the concrete seal bond near and at the surface of the concrete while cleaning the reinforcement steel.

(c) Superstructure Placement.

(1) Grade Controls for Bridge Deck Slabs. Bridge deck slabs supported by new stringers shall be placed in conformance with the specified line and grade. The Contractor shall take all necessary precautions, including a check on all new bridge seat elevations as the last order of work before setting stringers.

Any adjustments resulting from this check shall be completed before additional work is started. After the structural steel is set, a final check of elevations of all the steel stringers at points corresponding to those specified in the Contract Documents for dead load deflection and finished roadway elevations shall be made. Computations shall be made by the Contractor, reviewed by the Engineer, and controls set at proper elevations to produce finished tops of concrete bridge decks that will be true as to planned line and grade of the roadway surface.

Grade control for bridge deck slab replacements shall conform to 402.03.02.

(2) Superstructure Placement Restrictions. The superstructure shall not be erected until the substructure forms have been sufficiently stripped to determine the character of the concrete in the entire substructure, unless otherwise permitted by the Engineer. In all spans, the concrete bridge deck slabs outside of the stringers shall be cast using plywood forms.

The Contractor shall place all superstructure concrete in conformance with the following schedule:

SUPERSTRUCTURE CONCRETE PLACEMENT SCHEDULE

DATES	BEGIN CONCRETE PLACEMENT AFTER	FINISH BURLAP PLACEMENT BEFORE
May 15 - June 15	7:00 p.m.	11:00 a.m.
June 16 - Aug. 14	9:00 p.m.	7:00 a.m.
Aug. 15 - Sept. 15	7:00 p.m.	11:00 a.m.
Sept. 16 - May 14	No time restrictions	

Superstructure concrete shall not be placed or worked in any manner when the temperature in an unshaded location at the placement site is above 80 F (25 C). Floodlighting shall be used when existing light is less than 20 average horizontal ft-c (215 lx) over the construction area.

The Contractor shall submit a Situation Plan to the Engineer showing the locations and aiming of floodlights. After reviewing this plan, the Engineer will witness a test of the floodlighting system at the proposed construction area. The Contractor shall run the floodlighting test. The floodlighting system shall be capable of maintaining 20 ft-c (215 lx) without producing a glare on traffic. Floodlighting systems will be approved by the Engineer. When portable generators are used, an emergency backup system shall be available at all times on the job site.

(3) Rate of Concreting for Bridge Deck Slabs. Provisions shall be made by the Contractor to insure that the placement rate of concrete is 35 yd^3/hr (27 m^3/hr) minimum. Under special circumstances, the Engineer may give written approval to lower this requirement.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise directed by the Engineer.

Concrete shall not be mounded on concrete slab forms supported by beams, stringers, or girders. When placing, the concrete shall be distributed to a depth not exceeding the planned slab thickness plus 6 in. (150 mm) before spreading, consolidating and finishing.

The placing sequence shall be in the numerical order specified in the Contract Documents and shall not be modified. A minimum of 40 hours shall lapse between the completion of one placement and the start of the next numbered placement.

(d) Box Culverts. Box culverts shall be constructed by casting in place or using precast reinforced concrete box culvert sections. Whenever a particular method is indicated in the Contract Documents, the Contractor may elect to use the alternate method unless otherwise specified. However, all time constraints such as maintenance of traffic, curing, completion dates, etc., shall be met.

If the Contractor elects to use precast reinforced concrete box sections, at least 8 ft (2.4 m) of all box culvert ends and all footings, wing walls, headwalls and toe walls shall be cast in place. Additionally, the precast sections shall terminate a minimum of 1 ft (0.3 m) from all footings and toe walls. All lifting devices shall be indicated on the working drawings and all lifting holes shall be filled with nonshrink grout after the precast units are in place. The precast reinforced concrete box sections shall be set tightly together and the joints shall be sealed in conformance with the manufacturer's recommendations.

The bottom slabs of cast in place concrete box culverts shall be placed for their full depth in one mass or layer and permitted to set not less than 12 hours before any additional work is done.

Single cell box culverts spanning in excess of 10 ft (3 m) and multiple cell box culverts shall not have the top slabs placed until the concrete in the sidewalls has set for a minimum of 12 hours. Construction joints at the top side walls may be omitted in some cases provided the top slabs are placed as follows:

(1) For single cell box culverts spanning 10 ft (3 m) or less, the sidewall construction joint may be omitted and the top slab placed on the sidewalls, provided the concrete in the sidewalls is allowed to set for approximately two hours before starting to place the top slab.

(2) Regardless of size or number of cells, the Contractor may request in writing to place the top slab on the walls of box culverts in conformance with (1) above. The written proposed plan, including rate and method of placement, and type and size of equipment, shall be submitted to the Engineer for approval. If the Contractor receives initial written approval, the first section of the structure shall serve as a demonstration to confirm that there is no excessive cracking or any other detriment, and that satisfactory results will be obtained. After receiving written final approval, the Contractor may continue placing the remainder of the box culvert. If at any time the Engineer decides that

the results are no longer satisfactory, the Contractor shall revert to placing the concrete with the 12 hour delay as specified above at no additional compensation.

(e) Forming Concrete Parapets and Median Barriers on Bridges. The Contractor may construct concrete parapets and median barriers on bridges by either the slip form method or conventional fixed form method. The slip form method is prohibited on bridges maintaining traffic, and on parapets when bridge railings or fences are specified.

Contractors who elect to use the slip form method shall first demonstrate their ability to produce results acceptable to the Engineer. If a Contractor is unable to demonstrate that ability or fails to maintain acceptable results during production, the slip form operation shall be stopped, the unacceptable work shall be removed and the construction methods shall be modified. If construction modifications do not produce acceptable results, the Contractor shall use the fixed form method. No additional compensation will be permitted, and no increase will be allowed in any Contract price bid nor will any revisions be made to the amount of time to complete the Contract as a result of any required removals, modifications or changes in the method of placing parapets or barriers.

The Contractor shall notify the Engineer in writing of the proposed method of constructing the parapets and median barriers prior to beginning superstructure work. If slip forming is to be considered, then the following shall apply:

(1) The Contractor shall submit to the Engineer evidence of being capable of producing high quality slip form work. Prior to beginning any slip form construction, the Contractor shall submit a detailed work plan. The plan shall include the type of equipment, materials and procedures to be used, any subcontractors involved in the construction, key personnel who will be performing the work (names, training, experience, etc.), as well as detailed information on how the Contractor proposes to satisfactorily complete the work.

(2) When possible the work plan shall include reference to at least three other similar projects completed in the State of Maryland or surrounding states using the slip forming method for parapet or median barrier construction. As far as practical, these similar projects shall have been built using the same equipment, personnel, material, and procedures proposed for this project. The Engineer may elect to visit these completed projects to evaluate the acceptability of the finished product.

If the Engineer determines that the Contractor has satisfactorily slip formed parapets or median barriers at the locations submitted in the Contractor's work plan, the requirements of the off bridge test site specified below may be waived and the first 50 ft (15 m) of slip forming on the bridge will be considered the test section for the structure. This test section shall be completed and approved prior to placing the remaining portions of parapet or bridge median barrier.

(3) The work plan shall be approved in writing prior to beginning any slip forming operation.

Any proposed revisions or deviations to the approved work plan submitted by the Contractor shall be approved by the Engineer in writing prior to making the change.

If the Contractor does not conform to paragraph (2) above, an off bridge test section shall be completed and accepted prior to placing any portion of the parapet or bridge median barrier. The Contractor shall place the appropriate test section of parapet or median barrier using the same equipment, sensor line, support spacing, material, personnel and procedures as described in the work plan. This test section shall match the structure's horizontal curve as much as practical, be a minimum of 50 ft (15 m) long, and be placed at a location selected by the Contractor near the bridge site.

The off bridge test section shall be placed with vertical irregularities varying upward and downward at least 3/4 in. (19

mm). The Contractor shall then prove that the method of slip forming can compensate for this deviation and provide a top of parapet or median barrier that is true to the proposed line and grade and not necessarily parallel to top of bridge deck. This will necessitate that the equipment provide for variations in height of vertical face of parapet where it intersects the top of deck slab.

The sensor line shall be positioned, supported, and spaced in the same manner in the testing operation as will be used on the bridge decks with no stakes, holes, etc., used to support it. Sensor support spacing shall be as recommended by the slip form machine manufacturer and as necessary to maintain the planned line and grade. The rate of slip forming on the test section shall be the same as that proposed for the bridge. Joints shall be saw cut in the test section at the same approximate spacing and in the same manner as proposed for the finished bridge.

The Engineer will evaluate the procedure, material, equipment and appearance of the test section. The Contractor shall take three test cores from the test section at locations directed by the Engineer to determine the concrete quality. Honeycombing, sags, tears or other evidence of poor quality concrete will be cause for rejection of the test section. If the test section is rejected, the Contractor may place additional test sections until approved by the Engineer or may elect to use the fixed form method.

The accepted test section shall remain in place until all parapets or median barriers on the bridges are complete. The slip formed parapets and median barriers on the bridges will be compared to the approved test section to ensure that similar acceptable structures are being achieved on the bridges. Following completion and acceptance of all bridge parapets and median barriers, the Contractor shall remove and dispose of the off bridge test section.

The cost of the entire testing procedure, including removing and disposing of test units, regardless of whether the procedure is approved or rejected, will not be paid for, but shall be performed at the expense of the Contractor.

When dual bridges are separated by a joint, the Contractor shall construct in separate operations the two parapets which make up the median barrier. Constructing both sections of median barrier simultaneously is prohibited. The first median parapet section shall be allowed to cure for a minimum of 40 hours prior to constructing the second section of median parapet.

Additional reinforcement steel shall be placed to provide bracing for the reinforcement in the parapet to prevent displacement when subjected to the pressure developed in the slip form machine's extruding process. A detail will be included in the Contract Documents. The alignment and rigidity of the reinforcement steel will be strictly enforced by the Engineer to ensure that the minimum clearances shown on the Contract Documents for concrete cover are maintained.

The Contractor shall ensure that a continuous supply of concrete is available at the bridge site during slip forming operations, and that an uninterrupted flow of concrete is provided to the slip form machine. Once the slip form machine is set in motion, it shall keep advancing until it reaches the proposed stopping point. The Contractor shall organize and schedule the operations in a manner that the next concrete truck will be able to move into position at the slip form machine as soon as the previous truck pulls away without interrupting the machine's uniform advancement. Under no circumstances will the Contractor be allowed to operate the slip forming in a manner which requires a concrete truck to be removed from the bridge before another truck can move into place.

No vehicular traffic, except for the slip form machine and its concrete supply trucks, will be permitted on the bridge while slip forming operations are in progress.

When the slip form machine is set up and the sensor wire is placed, a dry run of the equipment shall be made in the presence of the Engineer to ensure that the parapet or median barrier will envelop preset obstacles which are to be embedded or meet with flush surfaces such as pull boxes, expansion joint plates, etc.

The concrete consistency shall maintain the shape of the structure without support after the extrusion. The surface shall be free of surface pits larger than 3/16 in. diameter. The concrete shall require no further finishing, other than light brushing with water only. Finishing with brush applications of grout will not be permitted.

If a tear occurs at the top of the parapet or median barrier during the slip forming operation, it shall be repaired immediately. The repair shall be made in a workmanlike manner in conformance with good concrete practices acceptable to the Engineer. The repair shall blend into the barrier to the extent that the naked eye cannot distinguish any difference in the wall face or top.

The rate at which the slip form machine is advanced is crucial to the quality of the finished parapet or median barrier. The Contractor shall ensure that the rate of advancement conforms to the equipment manufacturer's recommended value. The advancement of the slip forming machine on the bridges shall be the same rate as used on the approved test section. A higher or lower rate will not be permitted.

The shape of the finished parapet or median barrier shall conform to the dimensions shown on the Contract Documents. The vertical face at the bottom of the concrete safety shaped parapets or median barriers is 3 in. (75 mm) high, and will be unacceptable if this vertical face exceeds 3½ in. (89 mm). The finished parapet or median barrier shall show no deviation from the proposed grade and alignment in excess of 1/4 in. per 10 ft (6 mm per 3 m).

Joints shall be saw cut in the finished parapet or median barrier using a diamond blade. Cuts shall be 1/8 in. (3 mm) wide and 2 in. (50 mm) deep and shall be made in the top, outside and inside faces, stopping 3 in. (75 mm) above the top of deck slab in both faces except where it is impossible for the outside portion of the final placement of back to back median parapets. Joints shall be spaced as shown on the Contract Documents. Reinforcement steel in the parapets and median barriers shall be terminated at the joint locations. The deck shall be marked to insure that the saw cuts are made at these locations and do not conflict with the reinforcing steel pattern. The trapezoidal shaped control joints on the outside of parapets will not be required if slip forming is used. Slip form placements shall only be terminated at a parapet control joint. The joints shall be saw cut as soon as possible after initial concrete set and after the concrete has set sufficiently to preclude raveling during the sawing. The sawing shall be completed the same day the concrete is extruded and before any shrinkage cracking has occurred. Concrete shall not be left overnight without saw cutting the joints.

When portions of the bridges are in superelevation with varying rates of slope, the Contractor shall produce the exact configuration of parapets and median barriers as shown on the Contract Documents, i.e., level top surface, wall normal to deck surface, etc.

(f) Temperature Controls. Concrete temperatures shall be as specified in Section 902. Concrete below these temperatures shall be heated by one of the following methods:

(1) When the method of heated mixing water is used, the water shall not be above 170 F (77 C) when introduced into the mix.

(2) When the method of heated aggregates is used, aggregates containing frozen lumps shall be independently heated and no materials containing frozen lumps, ice, or snow shall be permitted to enter the mixer. Aggregates may be heated by steam coils or

other dry heat but not by discharging live steam or hot water into them. Heating by means of a flame thrower or any direct flame is prohibited.

When the ambient air temperature is below 40 F (4 C), the temperature of the air in contact with the reinforcement shall be raised to 40 F (4 C) prior to placing concrete. When the ambient air temperature is above 70 F (21 C) and the reinforcement is exposed to the direct rays of the sun, the reinforcement shall be cooled to 70 F (21 C) or less by means of a water spray prior to placing concrete. When the ambient air temperature is above 70 F (21 C) and the steel forms which remain in place are exposed to the direct rays of the sun, the forms shall be cooled by means of water spray prior to placing concrete.

When abnormal wind or storms are forecast locally by the National Weather Service, superstructure concrete shall not be placed during the period covered by the forecast.

(g) Pumping. Equipment shall be suitable and adequate in capacity for the work and will be acceptable to the Engineer. The equipment shall be arranged so that no vibrations result which might damage freshly placed concrete. No parts of the pump or discharge line shall be made of aluminum.

(h) Use of Conveyors. Concrete may be moved from the mixer to its final position by use of conveyors. Conveyors shall be in sections and concrete shall be deposited from one conveyor belt onto the next through a hopper. No individual section of the conveyor train shall rise more than 30 degrees from the horizontal. The belt travel speed shall not exceed 900 ft/min (270 m/min) for concrete slumps not exceeding 2 in. (50 mm). This speed shall be decreased for slumps exceeding 2 in. (50 mm). Conveyors used for placement of decks shall be supported by main load carrying members. Polyethylene or other material acceptable to the Engineer shall be placed under the conveyor line to contain any spillage from the belts onto the deck.

414.03.05 Depositing Concrete Under Water. Concrete shall not be deposited in water or exposed to the action of water before setting, unless specified in the Contract Documents or approved by the Engineer in writing. Concrete deposited under water shall be placed by means of a tremie pipe. The tremie pipe shall not be less than 10 in. (250 mm) diameter and shall be equipped with a watertight plug.

The bottom of the pipe shall be equipped with a baffle or deflector plate. The number and location of pipes will be dependent on the size of the pour. After tremie concrete has been placed, it shall not be disturbed nor shall successive layers be placed on top until the previously placed concrete has developed the necessary strength as determined by the Engineer. Concrete shall not be deposited in water where the temperature is less than 35 F (2 C). When concrete is deposited in water between 36 (2 C) to 45 F (7 C), the concrete shall be heated and placed at a temperature between 60 (15 C) and 80 F (27 C). No pumping of water will be permitted while concrete is being placed. The consistency of the concrete shall be carefully regulated to prevent segregation. Tremie concrete which projects more than 6 in. (150 mm) above the top of the as-planned tremie concrete shall be cut down at the Contractor's expense until no portion is more than 6 in. (150 mm) above the as-planned elevation.

(a) Cofferdams. Where cofferdams are used, separate forms shall be constructed within the cofferdams except where footing concrete is to be placed against a base of undisturbed material and where the cofferdam is to remain in place and act as the concrete form. The water level in the space between form and cofferdam shall be kept below the bottom elevation of concrete for at least 12 hours.

(b) Concrete Seals. When feasible, concrete seals for parts of structures under water shall be placed continuously from start to finish so as to avoid horizontal construction joints. The surface of the concrete shall be kept as nearly horizontal as practicable at all times to insure thorough bonding. In these cases, each succeeding layer of the seal shall be placed before the preceding layer has taken its initial set. The slump of tremie concrete shall be maintained between 4 and 8 in. (100 and 200 mm) and maintained as close to 4 in. (100 mm) as possible. After dewatering and prior to placing

any succeeding layers of concrete, the top of the foundation seal (tremie concrete) shall be thoroughly cleaned.

(c) Concrete Exposed to Saline Water. Saline water shall not come in direct contact with the concrete until it has been permitted to harden as required in the following table:

CONCRETE IN SALINE WATER	
SALINE CONTENT OF WATER BY WEIGHT IN PARTS PER THOUSAND	SALINE WATER SHALL NOT CONTACT CONCRETE UNTIL FOLLOWING MINIMUM TIME IN DAYS HAS ELAPSED AFTER INITIAL SET*
0 - 10	0
10+ - 15	7
15+ - 20	14
20+ - 25	21
OVER 25	30
** The Engineer may approve a waiver in writing.*	

Unless otherwise specified, the concrete shall be wet cured for at least 7 days while being maintained at a temperature of 50 F (10 C) or above.

414.03.06 Consolidation. All concrete except concrete deposited under water shall be consolidated by means of internal vibrators unless otherwise directed by the Engineer. These provisions shall also apply to precast members or units.

Vibration shall be applied at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.

(a) Internal Vibration. Internal vibrators shall be of a type and design approved by the Engineer. The intensity of application shall visibly

affect a mass of concrete of 1 in. (25 mm) slump over a radius of at least 18 in. (460 mm) and have frequency of vibration not less than 4500 impulses per minute.

(b) External Vibration. External vibrators shall be of a type and design approved by the Engineer. External vibration shall be used as directed by the Engineer for the following sections: very thin, very heavily reinforced, numerous inserts or where form surfaces are sharply inclined or battered. Filler concrete for steel grid floors shall be consolidated using external vibrators to the steel grid.

414.03.07 Finishing Concrete Surfaces. Concrete faces shall be finished with one of the following types. All concrete work shall have an ordinary surface finish as described in paragraph (a) below unless otherwise specified.

(a) Ordinary Surface. Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or not to be waterproofed. On all surfaces, broken corners or edges and any cavities shall be thoroughly cleaned and, after having been kept moist, shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the grade of the concrete being finished. Any excess mortar at the surface of the concrete shall be removed. The mortar patches shall be cured as specified in 414.03.09. Construction and expansion joints in the completed work shall be carefully tooled and cleaned. Joint filler shall be exposed for its full length with clean and true edges. Resulting surfaces shall be true and uniform. Surfaces which cannot be repaired in a manner acceptable to the Engineer shall be completed as special surface finishes.

(b) Special Surface. Fins and projections shall be removed. The surface of the concrete shall then be saturated with water and kept wet for a minimum of two hours. A grout mix of the same proportions as the concrete shall be thoroughly rubbed onto the surface by section using burlap pads or cork floats completely filling all voids, pits, and irregularities. After this grout has dried sufficiently, the excess

shall be wiped off with dry, clean burlap. The surface shall then be cured as specified in 414.03.09(f), except that only colorless liquid curing compound shall be used in this method. The exterior faces of cast-in-place superstructures for bridges over highways shall receive this type of finish.

(c) Horizontal Surfaces. All upper horizontal surfaces such as the tops of parapets, copings, and bridge seats shall be finished by placing an excess of concrete material in the forms and striking off even with a wood template. Tops of handrail (posts and caps), headwalls, parapets, wing walls, and barriers shall be steel troweled to a smooth, dense surface.

The bridge seat bearing areas of the substructure masonry shall be finished to the elevations shown on the Contract Documents. The Contractor shall check the elevation of each bearing area prior to finishing to assure conformance. Each area shall be checked for level in all directions using a spirit level and adjustments made prior to the setting of the concrete. The area shall be steel troweled to a dense flat surface. Bearing areas which are not flat after final finishing shall be ground to achieve an acceptable surface.

Under no condition will the bearing area be acceptable at an elevation below that of the surrounding masonry.

(d) Bridge Deck Slabs. After the concrete has been placed, it shall be screeded with a power operated finishing machine approved by the Engineer. The finishing machine and all transverse construction joints shall be set parallel to the abutment and pier support lines on all bridge deck slabs.

Under no circumstances shall the finishing machine span a length greater than the manufacturer's recommendation. The Contractor may combine machines or use two machines of which both may use a common rail and any additional rail. The proposed method and the location and anchorage of accessories that will remain in the completed superstructures as a result of this requirement shall be subject to the approval of the Engineer and conform to 414.02.02.

After the concrete has been struck off, the surface shall be checked with a 10 ft (3 m) straightedge operated in a position parallel to the center line of the structure by means of long handles.

This straightedge shall progress longitudinally in overlapping 5 ft (1.5 m) increments and transversely in 2 ft (0.6 m) increments to locate any irregularities in the surface. The width of the working face shall not be greater than 2 in. (50 mm) and the straightedge shall be as light weight as possible to avoid distortion of the slab surface.

The concrete surface shall be finished with a full width strip of burlap mechanically or manually dragged across the surface.

(1) Grooved Slabs. The grooving operation shall start after the bridge deck slab has been cured in conformance with 414.03.10 and attained a minimum compressive strength specified in 414.03.15. The bridge deck shall be grooved perpendicular to the center line.

The grooves shall be cut using a mechanical saw device which leaves grooves 1/8 in. (3 cm) wide, 3/16 in. (5 mm) +/-1/16 in. (1.5 mm) deep, and variably spaced from 5/8 in. (16 mm) to 7/8 in. (22mm) apart. The grooves shall extend across the slab to within 1 ft. (300 mm) of the gutter lines. The transverse grooving shall not cut across armored joints or any joint in which an existing joint seal may be damaged, but shall stay clear by 2 in. (50 mm) +/- 1 in. (25 mm) on each side. On joints skewed 70 degrees or less, one pass shall be made parallel to the armored joint unless otherwise directed by the Engineer. The residue resulting from grooving operations shall be removed from all surfaces in a manner acceptable to the Engineer. All surfaces shall be left in a washed, clean condition.

(2) Deck Slab Tolerances. Slab thickness shall not be reduced. Any slabs which are found to have deficient thickness may be rejected. The surface shall not deviate in a transverse or longitudinal direction more than 1/8 in./10 ft (3 mm/3 m) from a straight line. For vertical curves the deviation (from the curve

specified) shall not exceed 1/8 in./10 ft (3 mm/3 m) in a longitudinal direction. The corrective work shall be done prior to grooving at the Contractor's expense.

(e) Sidewalks and Safety Curbs. The concrete shall be struck off with an approved screed to the elevation and slope specified in the Contract Documents. It shall be wood floated to give a uniformly gritty surface free from depressions or high spots. The joints shall then be edged with the appropriate edging tool. Curbs shall be stripped and finished as soon as possible.

(f) Culvert Slabs. The tops of culvert slabs when they are not part of the roadway, and invert slabs shall be screeded either by hand or machine and have a float finish. The allowable surface tolerance shall be within 1/4 in. (6 mm) of the grade specified in the Contract Documents.

Inverts of culverts having a span less than 10 ft (3 m) need not be straightedged.

414.03.08 Curing. These requirements shall apply to curing of all concrete surfaces except bridge deck slabs or top surfaces of culverts with integral wearing surfaces. Curing for bridge deck slabs and top surfaces of culverts with integral wearing surfaces shall be as specified in 414.03.10.

Curing shall start as soon as the concrete has set sufficiently.

The requirement for keeping the surfaces wet shall be met even in areas where there is no ready water supply.

(a) Culvert invert slabs and all footings shall be cured for five days using the method specified in 414.03.09(a),(b),(c), or (d).

(b) Vertical surfaces shall be cured in the forms for seven days. However, the forms may be removed after 24 hours for structural elements 6 ft (2 m) or less in height, or after 48 hours for structural elements greater than 6 ft (2 m) high, with the following provisions. The surface shall be cured as specified in 414.03.09(d) for the

remainder of the seven day curing period. The forms shall not be removed when cold weather protection is required. Forms, falsework, centering, etc., carrying loads shall remain in place for a minimum of seven days and until the concrete has attained a compressive strength of 3000 psi (20.7 MPa). Internal bulkheads used for forming construction joints, etc. may be removed after the concrete has been in place for 24 hours if it is necessary to do so to continue the work without interruption. When a higher strength concrete than specified is used, forms, false-work, centering, etc., carrying loads shall remain in place for three and a half days and until the concrete has attained a compressive strength of 3000 psi (20.7 MPa).

Fiber column forms may be removed at times specified above, but no later than 10 days after placing concrete.

When parapets or median barriers on structures are formed by the slip form method, curing shall begin with method (f) using a fugitive dye liquid membrane-forming compound immediately after the concrete is finished. Immediately after each joint is saw cut, the concrete surfaces shall be cured for the remainder of the seven days of cure using method (d).

(c) Tops of end walls, end support walls, headwalls, etc., shall be cured for three days with burlap or cotton mats as specified in 414.03.09(b) or (d), respectively.

(d) Horizontal surfaces shall be cured for seven days as specified in 414.03.09 using method (b),(c),(d), or (e).

414.03.09 Curing Methods.

(a) Flooding. Units of structures that will be below water in the completed structure, ie., bottom slabs of culverts, footings, struts, etc., may be gradually flooded when approved by the Engineer after the concrete is 12 hours old, provided the curing water conforms to 921.01. The temperature of this water shall be maintained at 35 F (2 C) or above for the specified curing time.

(b) Burlap. Two layers of burlap shall be used. Successive strips of burlap shall be overlapped a minimum of 6 in. (150 mm). The second burlap layer shall be placed not less than 45 degrees (0.8 rad) to the first layer, or in lieu of this, the 6 in. (150 mm) overlap of the second layer may be placed midway between the first layer. This material shall be thoroughly saturated by immersion in curing water for at least 24 hours prior to placement and shall be kept saturated throughout the time specified for curing.

(c) White Opaque Polyethylene Backed Nonwoven Fabric. One layer of white opaque polyethylene backed fabric shall be used. Successive strips shall be overlapped a minimum of 6 in. (150 mm). This material shall be thoroughly saturated by immersion in curing water for at least 24 hours prior to placement and shall be kept saturated throughout the time specified for curing.

(d) Cotton Mats. One layer of cotton mat material shall be used and shall be kept thoroughly saturated with curing water prior to placement and throughout the time specified for curing. The material shall be kept in tight contact with the concrete.

(e) White Opaque Burlap Polyethylene or White Opaque Polyethylene Film. The white opaque burlap polyethylene sheeting shall be placed on no less than one layer of wet burlap with the burlap side of the sheeting facing down. White opaque polyethylene film, if used, shall be placed on no less than two layers of wet burlap. Only one layer of cotton mats is required in any usage. These materials may only be used atop the wet burlap or cotton mats on unobstructed flat and reasonably level surfaces.

Adjacent mats or sheets shall be lapped no less than 1 ft (0.3 m). The ends shall be brought down around the sides of the concrete being cured and securely fastened to make an air-tight seal.

The white opaque burlap polyethylene sheeting or the white opaque polyethylene film shall remain in place for the same length of time as required for burlap or cotton mats. These protective coverings

need not be wetted down, however, the covered burlap or cotton mats shall be kept wet for the time interval specified.

(f) Liquid Membrane. Liquid membrane forming compound shall be applied in conformance with manufacturer's recommendation or as directed by the Engineer. The material shall be applied by sprayers and shall be thoroughly agitated before and during use.

414.03.10 Bridge Deck Slabs. Bridge deck slabs and top slabs of culverts with integral wearing surfaces, including sidewalks, shall be cured as follows:

The Contractor shall have misting equipment available. Prior to placement of any concrete, operation of the misting equipment shall be verified by the Engineer to insure that the equipment and procedure are capable of misting the entire placement area without damaging the fresh concrete. This shall be done at the location of proposed use each day that a deck placement is to be made. Ample spare parts, water, fuel, etc. shall be readily available. A back-up tested unit shall also be available.

The Contractor shall cover the finished concrete with wet burlap as specified in 414.03.09(b). The concrete covering shall progress immediately after the concrete has been finished but no portion of the concrete shall remain uncovered for more than 45 minutes after placement. Mist spraying shall be used when directed by the Engineer, and when the concrete is not covered with wet burlap within 30 minutes after placement. Once misting is started it shall continue until wet burlap is complete in place.

Use of the mist spray shall not relieve the Contractor of the responsibility for covering the concrete within the 45 minutes after placement.

After the concrete is covered with wet burlap it shall be cured in conformance with 414.03.09(b) for the remainder of the seven day period. The two layers of burlap shall be kept continuously and uniformly saturated throughout the curing period. White opaque burlap polyethylene sheeting and white opaque polyethylene film or clear polyethylene film shall not be placed over wet burlap except when approved by the Engineer in writing for cold weather protection. A sufficient quantity of soaker hoses shall be

used to meet these requirements. The Contractor shall take immediate action to remedy improper saturation of any area throughout the entire curing period.

The Contractor shall provide a sufficient number of experienced personnel and necessary equipment to ensure proper placement, protection and curing of the concrete in conformance with these Specifications.

The Contractor shall also provide temporary troughs, dams, etc., necessary to prohibit the runoff water from reaching any traveled roadway, shoulder or sidewalk. The proposed methods of controlling runoff water in these areas shall be submitted to the Engineer for approval before use. The plan shall include locations of all troughs and dams, as well as the proposed methods of attaching them to any portions of the structure. There shall be no welding or drilling holes in any portion of a permanent member of the structure.

After the procedure is underway, it shall be evaluated, and any areas not functioning in a manner acceptable to the Engineer shall be modified by the Contractor to satisfy the requirements for retaining and directing the flow of water.

In rehabilitation construction, where the full use of temporary troughs, dams, etc., is not practical, modifications to the provisions for controlling the runoff water shall be made by the Contractor and approved by the Engineer.

414.03.11 Construction Joints. Construction joints shall be kept to a minimum and will be permitted only where specified in the Contract Documents, or authorized by the Engineer in writing.

The surface of the hardened concrete shall be cleaned and kept moistened until the additional concrete is placed. The top surface of concrete shall be leveled using a grade strip, unless otherwise specified. At chamfers the top surface of the concrete shall be steel troweled adjacent to the chamfer using the top surface for the chamfer strip as a guide.

Where a feather edge might be produced at a construction joint, as in the sloped top surface of a wing wall, an inset form shall be used to produce a blocked in addition to the preceding placement which shall produce an edge thickness of concrete of a minimum 6 in. (150 mm) succeeding placement.

The Contractor shall place an epoxy bonding compound on the surface areas of existing concrete (concrete that existed prior to the beginning of the Contract) which will be in contact with new concrete. Epoxy bonding compound shall also be applied to the entire face of all bridge deck slab construction joints. The surfaces to be coated shall be clean, sound, and dry and bonding compound shall be mixed and applied in conformance with the manufacturer's recommendations.

414.03.12 Linseed Oil Protective Coating. Linseed oil protective coating shall be applied to the integral concrete bridge deck slabs, box culvert wearing surfaces and sidewalks on bridges and box culverts when the pertinent Linseed Oil Protective Coating item appears in the Contract Documents.

Permanent paint or tape lane markings required on the structures shall be placed prior to the application of the linseed oil protective coating. The concrete surfaces to be treated shall also be cured, dried and thoroughly cleaned of all dust, dirt, and deleterious material prior to placing the first linseed oil protective coating.

If the concrete is wet, it shall be allowed to dry for one to two days at a minimum temperature of 60 F (15 C) minimum. If the concrete surfaces are extremely dry, the Contractor shall either wet the concrete thoroughly and allow it to dry for one or two days or apply a third protective coating at the same rate per gallon as the second coat, as directed by the Engineer. The ambient temperature at the time of application shall be 50 F (10 C) minimum. Following the second application, the ambient temperature shall be 40 F (5 C) minimum. Two coats shall be applied on all top surfaces that are not grooved. The first coat shall be applied at a rate of 1 gal/40 yd^2 (4 liter/33 m^2). The second coat shall be applied at a rate of 1 gal/67 yd^2 (4 liter/56 m^2). On bridge decks and top slabs of box culverts that are grooved, the first coat shall be applied at a rate of 1 gal/25 yd^2 (4 liter/21 m^2). The

second coat shall be applied at a rate of 1 gal/45 yd^2 (4 liter/38 m^2). The second coat shall not be applied until the first coat is dry. If additional coats are required, there shall be a minimum of 24 hours between them. The drying time may be increased as the ambient temperature falls below 70 F (21 C).

414.03.13 Cold Weather Protection. Concrete shall be protected and heated after it has been placed when the air temperature in the shade and away from artificial heat drops to 40 F (5 C) or lower at the time of placing or at any time within the number of days specified herein. Protection and heating shall be as follows:

(a) Ordinary concrete shall be protected and kept continuously at a temperature not less than 50 F (10 C) for at least 7 days following placement.

(b) In no case shall concrete be heated to more than 100 F (38 C). At the end of the heating period, the concrete surfaces shall be cooled to the temperature of the outside air by slowly reducing the artificial heat at a uniform rate until the temperature of the outside air is reached within a 24 hour period.

The Contractor shall have tarpaulins, insulating devices, and other suitable materials at the site to enclose or protect all portions of the concrete requiring protection. Materials shall be installed as close as possible before placing the concrete, and it shall be installed as rapidly as possible to keep exposure to cold weather to a minimum. Where heating is required, the spaces to be heated shall be completely enclosed and the temperature kept at required levels by the use of heaters approved by the Engineer.

The Contractor shall provide a sufficient number of maximum/ minimum recording thermometers to record temperatures in each concrete placement undergoing cold weather protection.

The curing period for all structure concrete requiring cold weather protection shall conform to the cold weather protection period except when the normal curing period is longer.

414.03.14 Underpinning Old Foundations. If underpinning is required, the Contractor shall perform the required work as directed by the Engineer. The operation shall consist of the restoring or lowering of the old foundations with concrete. The concrete shall be Mix No. 6. Excavation and the underpinning operations shall be done in part section, so as not to remove more than 10 percent of the supporting area under the old foundation at one time. The concrete shall have a maximum slump of 1½ in. (40 mm). When directed by the Engineer, underpinning shall be installed by hand, pneumatic or pumping processes. The usual curing and cold weather requirements will be deleted for the underpinning with other provisions for curing and protection improvised on the job as may be directed.

414.03.15 Loads on Concrete Structures. The erection of structural steel or concrete superstructures on concrete substructures shall start when the Contractor has completed curing, removed forms and substructure concrete has reached a minimum compressive strength of 3000 psi (20.7 MPa).

No loads may be applied to the concrete superstructure (including loads of stored materials, equipment, concrete safety parapets, sidewalks, median curbs, etc., placed upon the concrete slab) until the concrete in that portion of the deck has attained a minimum compressive strength of 3000 psi (20.7 MPa).

No traffic including the Contractor's vehicles and equipment shall be routed onto any new portion of bridge deck until the concrete cylinder breaks for the final section of that unit of the deck has attained a minimum compressive strength of 4500 psi (31.0 MPa) and curing of concrete is completed.

414.03.16 Prevention and Removal of Stains on Concrete. The Contractor shall prevent rust from structural steel, staining by bituminous materials or any other substance from discoloring any portion of the concrete. The Contractor shall use construction procedures that prevent staining of any of the concrete. Where unpainted structural steel has been specified, the Contractor shall protect the pier caps, columns and abutments with a wrapping of reinforced polyethylene or similar material which shall be left in place to prevent staining until after the structure has been completed. If any portion of the concrete is stained, the stains shall be removed and concrete restored to its original color without damage to the concrete. The work

shall be done at the Contractor's expense as directed by the Engineer. Chemical solvents shall not be used to remove stains unless approved by the Engineer.

414.03.17 Safety Hazards. The Contractor shall be responsible for gas detection in and ventilation of confined spaces as specified in TC-3.06.

414.03.18 Defective Work. Defective work exposed upon removal of the forms shall be entirely removed or repaired within 24 hours, as directed by the Engineer.

(a) Edges of material remaining in place shall be cut perpendicular to the finished surface to the full depth of the material removed, but not less than 1 in. (25 mm). If the removal of defective concrete affects the structural requirements, the member also shall be removed and replaced as directed by the Engineer.

(b) Defective areas shall be cleaned.

(c) Defective areas shall be coated with an epoxy bonding compound.

(d) Defective areas shall be patched with concrete mortar or epoxy. The color, contour, and texture of surrounding concrete shall be matched as close as possible.

414.04 MEASUREMENT AND PAYMENT. Portland cement concrete structures will be measured and paid for as specified. The payment will be full compensation for all material, labor, equipment (including safety equipment), tools, forms and form removal, reinforcement steel, curing and misting, scuppers, mechanical and electrical work, all cost incidental to the conducting of tests for oxygen content and presence of gases and applying mechanical ventilation to confined spaces, year built markings, and incidentals necessary to complete the work.

The construction of drainage and weep holes, any pipe necessary, expansion material, flashing, dampproofing, membrane waterproofing, epoxy bonding compound, joints and their placement will not be measured but the cost will be incidental to the concrete item. No deduction in concrete quantities

will be made for pipes or conduits having diameters less than 8 in. (200 mm) nor for reinforcement steel, anchors or any other appurtenances.

414.04.01 Portland cement concrete for Footing Concrete and Subfoundation Concrete will be measured and paid for at the Contract unit price per cubic yard.

414.04.02 Portland cement concrete for Substructure Concrete for Bridge, Superstructure Concrete for Bridge, Reinforced Concrete Box Culverts and Retaining Walls will not be measured but will be paid for at the Contract lump sum price. The cost of the epoxy coated reinforcement steel shall be excluded from the Contract lump sum price for Superstructure Concrete for Bridge.

414.04.03 Wing walls and footings for reinforced concrete box culverts will not be measured but the cost will be incidental to the Reinforced Concrete Box Culvert item.

414.04.04 Parapets on bridges, wing walls, reinforced concrete box culverts and retaining walls, or concrete median barriers on bridges and top slabs of reinforced concrete box culverts will be paid for at the Contract lump sum price for the pertinent Concrete Parapet or Concrete Median Barrier items.

414.04.05 Deleted

414.04.06 Floodlighting will be measured and paid for at the Contract unit price per each night used, including fuel, backup generator, setup, relocation and removal.

414.04.07 Linseed oil protective coating will be measured and paid for at the Contract unit price per square yard for the pertinent Linseed Oil Protective Coating item. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

414.04.08 Temporary supports or piling will not be measured but the cost will be incidental to the formwork.

SECTION 415 — LIGHTWEIGHT SUPERSTRUCTURE CONCRETE

415.01 DESCRIPTION. This work shall consist of constructing the lightweight concrete portions of the structure as specified in the Contract Documents.

415.02 MATERIALS. Materials shall conform to 414.02 except as modified herein.

Control testing for Compression Test and Unit Weight of Cured Concrete shall be two companion cylinders for each 100 yd^3 (80 m^3), or fraction thereof, as specified in M 195.

Lightweight concrete shall have a minimum compressive strength of 4500 psi (31.0 MPa).

Aggregate shall conform to Section 901.

Linseed oil protective coating shall conform to 902.12.

Lightweight concrete shall be composed of Type I portland cement, an approved air entraining admixture, Type A or D chemical admixture, water, lightweight coarse aggregate, fine aggregates and shall be proportioned as specified in 211.2 of the ACI's Recommended Practices for Selection Proportions for Structural Lightweight Concrete. Fly ash or ground iron blast furnace slag may be substituted for portland cement as specified in 902.06.

Minimum cement content shall be 700 lb/yd^3 (415 kg/m^3). The maximum average unit weight of the cured concrete shall be 118 lb/ft^3 (1840 kg/m^3). Air entrainment shall be determined by volumetric method as specified in T 196, and shall be 6 to 9 percent (entrapped plus entrained). Slump shall be 3 in. (75 mm) maximum. Water added to the mix using saturated aggregates shall not exceed a water/cement ratio of 0.45. Net water including the absorbed water shall not exceed a water/cement ratio of 0.75.

415.03 CONSTRUCTION. Construction shall conform to 414.03 and the following:

Handling of lightweight aggregates shall be arranged to provide a thorough sprinkling of the aggregates during the stockpiling to produce damp aggregate. Sprinkling shall be done to obtain uniform distribution of moisture. Aggregates shall then be allowed to drain as long as necessary to produce a uniform moisture content, and the moisture content shall be maintained as much as practical until the aggregate is used. The admixtures shall be added to the mix as specified in the manufacturer's recommendations.

415.03.01 Existing Structures. Bridges shall not have hot mix asphalt wearing surfaces and the top of the concrete slab bridge deck shall be the riding surface of the bridge. To place the top of the concrete bridge deck slabs to the planned line and grade of the roadway, the Contractor shall take elevations along the bottom of the bottom flange or top of top flange (remove small sections of slab over stringers or use pilot holes, etc.) at the center and quarter points of all stringers, and at other points if necessary to provide a maximum spacing of 25 ft (7.6 m) between elevations, (points to correspond as close as possible to the locations of the finish roadway elevations provided in the Contract Documents) prior to removing the existing slabs. After removing the decks, the Contractor shall take a new set of elevations at the exact same points and ascertain the rebounds. The Contractor is cautioned that the deck replacement material may be lighter than the existing deck and the deflection caused by lighter material will be less than the material removed. The Contractor shall compute modified rebound figures to be used in lieu of dead load deflections to establish grade controls to produce finished tops of concrete bridge decks that will be true to as planned line and grade.

415.04 MEASUREMENT AND PAYMENT. Lightweight concrete structures will be measured and paid for as specified. The payment will be full compensation for all material, labor, equipment (including safety equipment), tools, forms and form removal, reinforcement steel, curing and misting, scuppers, mechanical and electrical work, all cost incidental to the conducting of tests for oxygen content and presence of gases and applying mechanical ventilation to confined spaces, year built markings, and incidentals necessary to complete the work.

The construction of drainage and weep holes, any pipe necessary, expansion material, flashing, dampproofing, membrane waterproofing, epoxy bonding compound, joints and their placement will not be paid for but the cost will be incidental to the lightweight concrete item. No deduction in lightweight concrete quantities will be made for pipes or conduits having diameters less than 8 in. nor for reinforcement steel, anchors or any other appurtenances.

415.04.01 Lightweight Superstructure Concrete will not be measured but will be paid for at the Contract lump sum price unless other-wise specified in the Contract Documents.

415.04.02 Lightweight concrete parapets and median barriers will not be measured but will be paid for at the Contract lump sum price for the pertinent Lightweight Concrete Parapet or Lightweight Concrete Median Barrier items.

415.04.03 Deleted

415.04.04 Floodlighting will be measured and paid for as specified in 414.04.06.

415.04.05 Linseed Oil Protective Coating will be measured and paid for as specified in 414.04.07.

SECTION 416 - REINFORCEMENT FOR CONCRETE STRUCTURES

416.01 DESCRIPTION. This work shall consist of furnishing and placing reinforcement, including deformed steel bars, wire mesh and plain round steel spiral bars, as specified in the Contract Documents or as directed by the Engineer. Reinforcement shall be uncoated or epoxy coated as specified in the Contract Documents.

416.02 MATERIALS.

Grout	902.11(c)
Deformed Steel Bars	908.01
Plain Round Steel Bars for Column Spirals	908.02
Wire Mesh	908.05 and 908.06
Fusion Bonded Epoxy Powder Coating for Steel	917.02
Galvanizing	A 153

416.02.01 Supports. Material for all supports shall be approved coated metal, plastic, plastic tipped or galvanized. Aluminum shall not be used. All materials shall be acceptable to the Engineer.

The wire supports for epoxy coated steel bars shall be completely covered with 1.5 to 9.0 mils (0.04 to 0.23 mm) of adherent epoxy coating except for minimum necessary contact marks. The reinforcement steel shall be held in place with plastic coated tie wires fabricated for this purpose.

Steel bars used as supports for epoxy coated steel bars shall be epoxy coated in the same manner as reinforcement steel.

416.03 CONSTRUCTION.

416.03.01 Working Drawings. When the Contract Documents do not include reinforcement steel details, the Contractor shall submit working drawings to be approved by the Engineer prior to the start of any fabrication unless otherwise specified. Details shall conform to the Administration's Reinforcing Bar Detailing Manual and TC-4.01.

416.03.02 Plan Dimensions. All dimensions related to reinforcement steel are out to out measurement except the spacing is measured center to center.

416.03.03 Cutting and Bending. Reinforcement bars shall be cut and bent at the mill or shop to the shapes specified in the Contract Documents before shipment to the job site. Reinforcement bars shall not be bent in the field except to correct errors, damage by handling and shipping, or minor omissions in shop bending.

Epoxy coated reinforcement bars on skewed bridges and in other locations that are specified to be cut in the field shall be either sawed or sheared but shall not be flame cut.

All bending shall conform to the American Concrete Institute (ACI) Specifications tolerances modified to cover requirements as specified in the Contract Documents.

416.03.04 Shipping, Handling, and Protection of Material. Reinforcement steel bars shall be shipped in standard bundles and tagged and marked in conformance with the provisions of the Code of Standard Practice of the Concrete Reinforcing Steel Institute. Bundles shall be kept intact and material undamaged and properly identified until ready for use.

Coated steel shall be bundled together for shipment using excelsior or other materials as approved by the Engineer and banded using plastic or padded metal bands.

Bundles shall be stored at the site on suitable blocking or platforms at least 4 in. (100 mm) above the ground or vegetation. They shall be kept free from vegetation growth, accumulations of dirt, oil, or other foreign material. Blocking shall be sufficiently close to avoid bending and distortion of the bars. Any distortion of the bars or damage to epoxy coating shall be corrected as directed by the Engineer at the expense of the Contractor.

416.03.05 Placing and Fastening. All reinforcement steel, including dowel bars, shall be accurately placed in the position specified in the Contract Documents or working drawings, and firmly held during the depositing and setting of the concrete. Reinforcement steel or dowel bars shall not be inserted into plastic concrete.

Bars shall be tied at all intersections except alternate intersections need not be tied where spacing is less than 1 ft (0.3 m) in each direction. On bridge decks and the top slabs of box culverts all intersections shall be tied in the top mat of reinforcement. Reinforcement steel bars embedded in concrete shall not be bent after they are in place.

Before any concrete is placed, all mortar shall be cleaned from the rein-

forcement. No concrete shall be deposited until the placing of the reinforcement bars is inspected and is acceptable to the Engineer. This shall not relieve the Contractor of the responsibility for any shifting of the bars during the placement of concrete.

Reinforcement bars shall be supported and their distances from faces of forms shall be maintained by means of approved templates, blocks, ties, hangers or other supports. Bars in the bottom of footings shall be supported on approved precast concrete blocks with embedded tie wires or suspended in place. Bars in the tops of footings shall be supported by supports that are approved by the Engineer.

Metal, metal with plastic tipped legs, or plastic chairs shall not be used against formed surfaces that will be exposed in the finished structure.

A final visual inspection of epoxy coated steel at the construction site will be made by the Engineer after the steel is in place and immediately prior to placing the concrete. Any areas designated by the Engineer which require repair shall be patched with epoxy. No concrete shall be placed on a patched area until the patching material is cured for one hour. The Contractor shall allow the Engineer four hours of normal working time after the reinforcement and forms are in place to conduct the inspection.

416.03.06 Splicing. Bars shall be furnished in the lengths and spliced as specified in the Contract Documents and approved shop drawings. There shall be no additional splicing of bars without written approval of the Engineer. Lap splices shall be made with the bars in contact and wired together.
Welding of reinforcement steel or attachments thereto shall not take place without written authorization by the Engineer.

416.03.07 Tying New Concrete into Existing Concrete. On all projects where portions of existing structures are to be used in the finished structure and existing concrete is to be removed, the existing reinforcement steel to be incorporated in the final structure shall be straightened and cleaned. Care shall be taken not to damage these bars.

Any exposed existing reinforcement steel, which is to be incorporated into the final structure:

(a) And in the opinion of the Engineer has lost 20 percent or more of its original cross sectional area, shall be cut out. A new bar of the same diameter shall be provided and placed so as to have the minimum required lap at each end of the new bar, or modified as per (c).

(b) Where the required bar lap length is available, it shall be used as a dowel.

(c) Where the required bar lap is not available or limits of concrete removal to achieve bar lap are too great, a welded or approved mechanical splice shall be provided.

All existing reinforcement steel extending into an area in which epoxy coated reinforcement steel is required shall be sandblast cleaned and epoxy coated.

If expected reinforcement steel is missing, or a pattern differing from that shown on the existing Contract Documents is uncovered, then the Office of Bridge Development shall be contacted for evaluation.

Where dowel bars are required to tie new concrete into an existing structure, the dowel holes shall be at least the diameter of the dowel bar plus 1/2 in. (13 mm).

416.03.08 Substitution. Substitution of different size bars will be permitted only when approved by the Engineer. No additional compensation will be allowed for substituting larger size bars in lieu of the bars specified.

416.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for all material, labor, equipment, tools, cleaning, coating, and incidentals necessary to complete the work.

416.04.01 Reinforcement steel bars or epoxy coated reinforcement steel bars will not be measured but the cost will be incidental to other pertinent items specified unless an item for reinforcement steel bars appears in the Contract Documents.

416.04.02 Reinforcement Steel Bars or Epoxy Coated Reinforcement Steel

Bars will not be measured but will be paid for at the pertinent Contract lump sum price.

416.04.03 Reinforcement Steel Bars or Epoxy Coated Reinforcement Steel Bars will be measured and paid for at the Contract unit price per pound based on the original approved overall lengths of bars computed on the basis of the nominal unit weights per linear foot.

416.04.04 Deleted

SECTION 417 - DAMPPROOFING AND MEMBRANE WATERPROOFING

417.01 DESCRIPTION. This work shall consist of dampproofing and waterproofing of concrete surfaces. The type of system will be specified in the Contract Documents.

417.02 MATERIALS.

Asphaltic Materials	913.01
Asphalt Primer	913.02
Fabric for Use with Asphalt	913.03
Membrane Waterproofing and Dampproofing	921.12

417.03 CONSTRUCTION.

417.03.01 Storage. Waterproofing fabrics and membranes shall be stored in a dry protected place. Asphalt materials in containers shall be kept closed when not in use.

417.03.02 Surface Preparation. Dampproofing or membrane waterproofing shall not be applied until curing has been completed and surfaces are protected against cold. All surfaces shall be dry, smooth and free from projections and holes.

When dampproofing and membrane waterproofing are specified for joint application, the membrane waterproofing shall be applied first. Dampproofing or membrane waterproofing shall not be done when the temperature is less than 40 F (4 C).

417.03.03 Coating for Dampproofing. The coating for dampproofing shall consist of two prime coats and one seal coat applied to the following concrete surfaces that will be in contact with backfill.

(a) Abutments and abutment wing walls, except that portion which is placed against undisturbed material.

(b) Top of top slabs, rear faces of headwalls, slope walls, and wing walls of all reinforced concrete box culverts, and the bottom of bottom slabs of precast reinforced concrete box culverts.

(c) Rear face of retaining walls.

417.03.04 Coating for Membrane Waterproofing. The coating for membrane waterproofing shall consist of a prime coat, three mop coats, and two layers of fabric.

Membrane waterproofing as described above shall be applied to the face of all construction joints for a width of 16 in. (406 mm) minimum centered on the joint for concrete structures next to backfill above normal water surface, with backfill on one side and atmosphere on the other side.

417.03.05 Application of Dampproofing. Care shall be taken to confine all coatings to the areas to be covered to prevent coating of parts of the structure that will be exposed to view in the completed structure. Dampproofing shall be applied to the full face of all contraction joints.

The dampproofing material shall be applied following the manufacturer's recommendations. When no recommendations are provided, the dampproofing material shall be applied to the cured, cleaned, and dry surfaces as follows:

(a) Paint with two coats of primer for absorptive treatment at a rate of

1/8 gal/yd^2 (0.57 l/m^2) per coat. The second coat shall not be applied until the first coat has thoroughly dried. The material shall not be heated.

(b) After the second prime coat has thoroughly dried, one seal coat shall be applied by brush or roller at a rate of 1/8 gal/yd^2 (0.57 l/m^2) of surface. When necessary, this material may be heated, but not in excess of 150 F (66 C).

417.03.06 Application of Membrane Waterproofing. When membrane waterproofing is applied, the cured, cleaned and dry surfaces shall be coated with a prime coat and covered with mop coats and layers of fabric.

417.03.07 Roll or Sheet Waterproofing Membrane. An alternate system of waterproofing or dampproofing consisting of rolls or sheets of membrane material may be used in lieu of the above coatings. The rolls or sheets shall be applied in conformance with the manufacturer's recommendations. For dampproofing, one ply shall be required. For waterproofing, a two ply shall be required, with the outer ply protected by a factory-applied synthetic textile protection, which shall be approved by the Engineer.

Coating Procedure. The surfaces shall first be coated with a primer at a rate of 1/8 gal/yd^2 (0.57 l/m^2) of surface. The prime coat shall be applied 24 hours in advance of applying any mop coats and shall be dry before the first mopping is applied. The primer shall not be heated.

Asphalt for mop coats shall be heated to a temperature between 300 and 350 F (149 and 177 C), with frequent stirring to avoid local overheating. The heating kettles shall be equipped with thermometers.

The waterproofing shall begin at the low point of the surface to be waterproofed, so that water will run over and not against or along the laps.

The first strip of fabric shall be half width. The second shall be full width, lapped the full width of the first sheet. The third and each succeeding strip thereafter shall be full width and lapped so that there will be two layers of fabric at all points and three layers with laps not less than 2 in. (50 mm) wide at edges of strips. All laps at ends of strips shall be 12 in. (300 mm) wide.

Beginning at the low point of the surface to be waterproofed, a section 20 in. (500 mm) wide and the full length of the surface shall be mopped with the hot asphalt. Immediately following the mopping, the first strip of fabric shall be pressed into place eliminating all air bubbles. This strip and an adjacent section of the surface of a width equal to slightly more than half the width of the fabric being used shall then be mopped with hot asphalt and a full strip and a full width of the fabric shall be pressed into place as before. The forward or upgrade half of this second strip and an adjacent section of the concrete surface shall then be mopped with hot asphalt and the third strip of fabric shingled on so as to lap the first strip not less than 2 in. (50 mm). This process shall be continued until the entire surface is covered. The entire surface shall then be given a final mopping of hot asphalt. There shall be a complete coating of asphalt between all layers of fabric.

In all cases, the mopping on concrete shall cover the surface so that no gray spots appear, and on cloth it shall be sufficiently heavy to completely conceal the weave. Asphalt shall be applied at the rates of 1.2 gal/yd^2 (5.42 l/m^2) on horizontal surfaces and 1.4 gal/yd^2 (6.32 l/m^2) on vertical surfaces. The work shall be regulated so that at the close of a day's work, all cloth that was laid shall have received as many coatings as was required for that stage of completion. Special care shall be taken at all laps to see that the cloth is thoroughly sealed down.

Membrane Care. At the edges of the membrane and any points where it is punctured by appurtenances such as drains or pipes, it shall be flashed in a manner acceptable to the Engineer to prevent water from getting between the waterproofing and the waterproofed surface. Damage to the membrane shall be repaired. Repairs shall extend beyond the outermost damaged portion, and the second ply shall extend at least 3 in. (75 mm) beyond the first.

417.04 MEASUREMENT AND PAYMENT. Dampproofing and Membrane Waterproofing will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

SECTION 418— PNEUMATICALLY APPLIED MORTAR

418.01 DESCRIPTION. This work shall consist of furnishing and placing

pneumatically applied mortar as specified in the Contract Documents or as directed by the Engineer.

418.02 MATERIALS.

Fine Aggregate/Sand	901, Table 901 A
Cement	902.03
Curing Materials	902.07
Reinforcement Bars	908.01, 908.02, and 908.08
Anchor Bolts	909.06
Water	921.01

Cement shall be Type I furnished in paper sacks weighing 94 lb (43 kg). Sand shall not contain more than 6 percent moisture by weight. Pneumatically applied mortar shall have a minimum 28 day compressive strength of 3500 to 5000 psi (24.1 to 34.5 MPa).

All mixes shall be approved by the Engineer prior to starting work.

418.02.01 Test Panels. When specified in the Contract Documents, test panels of various mix combinations, admixtures, and materials shall be prepared and cured by the Contractor. One test panel shall be prepared for every 100 ft^3 (3 m^3) of mortar in place. Additional test panels shall be prepared as directed by the Engineer. Each panel shall be 36 in. (910 mm) square and 8 in. (200 mm) deep. At least one half of each panel shall contain the same reinforcement as the structure. A separate panel shall be fabricated by each application crew using the equipment for each mix design, and in each shooting position encountered.

The Contractor shall be responsible for the preparation and curing of all test panels. The Contractor shall core each test panel and the cores shall be delivered to the Laboratory for testing. Cores shall have a minimum diameter of 4 in. (100 mm) and a minimum length of 8 in. (200 mm). Each core will be tested in compression at 7, 14, and 28 days. Core strength correction will conform to T 24.

The cut surface of each specimen will be examined by the Engineer. Additional surfaces shall be exposed by sawing or breaking the panel when this

is considered necessary to check soundness and uniformity of the material. All cut or broken surfaces shall be dense and free from lamination and sand pockets.

418.03 CONSTRUCTION. The Contractor shall provide safe access to all areas of the existing structure to be repaired. Prior to the start of any repair work, the Contractor, in the presence of the Engineer, shall conduct a full and thorough inspection of the areas to be repaired. The purpose of this inspection will be to identify the location and extent of each area of concrete deterioration and repair. The extent of removal and the determination of when sound concrete is encountered shall be as established by the Engineer.

If at any time an area is identified as having deteriorated concrete exceeding a depth of 6 in. (150 mm) behind the original finish surface, all concrete removal in the immediate area shall stop and the Engineer shall be notified. The Contractor shall not resume work until directed to do so by the Engineer.

418.03.01 Equipment. All equipment shall be capable of thoroughly mixing all material used and shall be calibrated.

The mixer shall be self cleaning and capable of discharging all mixed material without any carry over from one batch to the next. Mixing equipment shall be cleaned at least once a day.

The air compressor shall be of ample capacity to maintain a supply of clean, dry air adequate to provide the required nozzle velocity for all parts of the work, while simultaneously operating a blow pipe for cleaning away rebound. The air and water pressure shall be constant and not pulsate.

418.03.02 Storage. Storage and handling of cement shall conform to 902.01. Sand shall be stored to prevent segregation or contamination of the material.

Reinforcement shall be stored on blocking racks or platforms which will keep them off the ground, and they shall be kept free of dirt, oil, grease, paint, and other foreign matter.

418.03.03 Surface Preparation. The deteriorated areas of concrete shall be removed to sound concrete with a 30 lb (14 kg) maximum chipping hammer to a minimum depth of 1 in. (25 mm) behind the reinforcement steel.

After the Engineer has determined that the cavity surface is sound, it shall be sandblasted. Just prior to mortar application, all surfaces shall be thoroughly cleaned, followed by wetting and damp drying.

The Contractor shall contain all blast waste and loose concrete and promptly remove it to an approved disposal site. Blast waste and loose concrete shall be kept out of waterways.

418.03.04 Reinforcement. If sound concrete is encountered before the reinforcement steel is exposed, then sound concrete shall be removed to a depth of 1 in. (25 mm) behind the existing reinforcement steel. If sound concrete is found within 3½ in. (90 mm) of the proposed finished surface, the removal shall stop and additional No. 4 reinforcement bars shall be dowelled and installed at 12 in. (300 mm) center to center horizontally and vertically, 2 in. (50 mm) clear of proposed finished surface. Dowelling details shall be as directed by the Engineer.

All exposed existing reinforcement steel that will be incorporated in the new work shall be sandblasted to a near white finish to remove all rust, dirt, scale and loose concrete. All deteriorated reinforcement bars that have lost 20 percent or more of their original dimension shall be cut out and new bars welded in their place. Dual bars of equivalent or greater section may be used. New reinforcement steel shall be welded to existing reinforcement steel as specified in the Contract Documents. The Engineer will establish if reinforcement steel is to be reused or replaced.

All areas to be repaired shall be reinforced with wire mesh in addition to the reinforcement steel.

For anchoring reinforcement to masonry surfaces, expansion bolts not less than 3/8 in. (10 mm) in diameter shall be set in drilled holes, or plain round No. 4 bars shall be set in approved dry packed mortar tightly driven in drilled holes. Drilled holes shall not be less than 3 in. (75 mm) deep. All

bolts or bars shall be set in solid masonry (not in mortar, joints, or cracks) and shall have heads or hooks on their outer ends. Where approved by the Engineer, wire mesh reinforcement shall be wired to existing reinforcement without the use of expansion bolts.

Mesh shall be cut in sheets of proper size, and the separate sheets shall be bent over templates so as to follow closely the outlines of the member or surface to be covered. It shall be securely held in a uniform position by being tied with 14 gauge (2 mm) black annealed wire to the bolts or bars. Ties shall be spaced at 12 in. (300 mm) maximum.

Where adjacent sheets of mesh join, they shall overlap at least two squares of the mesh and be tied together at intervals not exceeding 18 in. (460 mm) with 14 gauge (2 mm) black annealed wire.

418.03.05 Guides. Sufficient guides shall be provided to obtain the full thickness of mortar specified to insure uniform and straight lines.

418.03.06 Mixing and Screening. The cement and sand shall be uniformly dry mixed in a batch mixing machine. Mixed materials which are not applied as mortar within one hour after being mixed shall be discarded. After the materials are dry mixed and before being charged into the placing machine, the mixture shall be passed through a 3/8 in. (10 mm) screen.

418.03.07 Application. Each layer shall be built up by several passes of the nozzle over the working area. The mixture shall emerge from the nozzle in a steady, uninterrupted flow. Should the flow become intermittent for any cause, it shall be directed away from the work until it becomes constant. The distance of the nozzle from the work shall be as required to give best results for the conditions, and shall be held perpendicular to the application surface. When shooting through reinforcement, the nozzle shall be held at a slight angle from perpendicular to permit better encasement.

The application of the mixture to vertical surfaces shall begin at the bottom. The first layer shall at least completely embed the reinforcement.

Rebound shall not be worked back into the construction, nor shall rebound be salvaged and included in later batches.

Rebound and overspray shall not be allowed to fall into waterways and shall become the property of the Contractor, who shall dispose of this material at the Contractor's own expense in an approved disposal site.

When a layer of pneumatically applied mortar is to be covered by a succeeding layer, it shall first be allowed to take its initial set. Then all laitenance, loose material and rebound shall be removed by brooming. Any laitenance which has been allowed to take final set shall be removed by sandblasting and the surface cleaned with an air water jet. In addition, the surface will be sounded by the Engineer with a hammer for hollow sounding areas resulting from rebound pockets or lack of bond.

418.03.08 Curing and Cold Weather Protection. Curing and cold weather protection shall conform to Section 414. Mortar shall be kept continuously wet for at least seven days after application. The use of a liquid membrane forming compound will be permitted with prior approval of the Engineer.

418.03.09 Finishing. The area of repair on existing structures shall be finished to match the existing structure.

418.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for all cement, sand, water, test panels, cores, storage, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

418.04.01 Pneumatically Applied Mortar will be measured and paid for at the Contract unit price per each bag of cement used in preparing the pneumatically applied mortar used in the work.

At the conclusion of each day's work, the Engineer and Contractor will agree on the number of bags of cement used during that work period in the application of pneumatically applied mortar. Each bag counted shall be suitably marked to indicate that measurement has been provided.

418.04.02 Pneumatically Applied Mortar will be measured and paid for at the Contract unit price per cubic foot of mortar in place when specified in the Contract Documents,

418.04.03 Additional reinforcement will be measured and paid for at the Contract unit price per pound.

418.04.04 Drilled Holes will be measured and paid for at the Contract unit price per linear foot.

418.04.05 Wire mesh, dry packed mortar and expansion bolts will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

SECTION 419 - CONCRETE OVERLAY FOR BRIDGE DECKS

419.01 DESCRIPTION. This work shall consist of removing only existing bridge wearing surface, grinding 1/4 in. (6 mm) minimum thickness from the existing concrete bridge deck, cleaning all surface areas to be overlaid free from materials detrimental to achieving bond, replacing deteriorated steel, and placing latex modified concrete or other material, all as specified in the Contract Documents.

419.02 MATERIALS.

Fine Aggregate	901, Table 901 A
Coarse Aggregate	901, Size No. 7
Portland Cement Type I	902.03
Concrete for Patching	902.10
Linseed Oil	902.12
Latex Modified Concrete	902.13
Reinforcement	908
Water	921.01

419.03 CONSTRUCTION.

419.03.01 Equipment. Equipment is subject to the approval of the Engineer and shall conform to the following:

Surface Preparation Equipment.

(a) Sawing equipment capable of sawing concrete to the specified depth.

(b) Scarifying equipment shall be capable of removing 1/4 in. (6 mm) minimum from the existing concrete surface. The scarifier shall be a power operated mechanical type or a high pressure water jet type capable of controlling the scarifying depth. Insufficient means of controlling runoff water may be cause for rejection of the high pressure water jet scarifier.

(c) Sandblasting equipment capable of removing rust scale and old concrete from reinforcement bars and of removing small chips of concrete partially loosened by the grinding or chipping operation.

(d) Power driven hand tools for removal of unsound concrete will be permitted with the following restrictions:

(1) Pavement breakers heavier than nominal 30 lb (14 kg) class are prohibited.

(2) Pavement breakers or mechanical chipping tools shall not be operated at an angle in excess of 45 degrees measured from the surface of the deck.

(3) Chipping hammers heavier than a nominal 15 lb (7 kg) class shall not be used to remove concrete from beneath any reinforcement bars.

(e) Hand tools such as hammers and chisels shall be provided for removal of remaining particles of unsound concrete from beneath any reinforcement bar or to achieve the required depth.

Latex Modified Concrete Proportioning and Mixing Equipment. Equipment used for mixing shall be self-contained, mobile, continuous mixing and subject to the following:

(a) The mixer shall be self-propelled and be capable of carrying sufficient unmixed dry bulk cement, sand, coarse aggregate, latex modifier and water to produce on the site not less than 6 yd^3 (4.6 m^3) of concrete. Storing aggregate in the mixing equipment overnight is prohibited.

(b) The mixer shall be capable of positive measurement of cement being introduced into the mix, have a recording meter visible at all times, and be equipped with a ticket printout which shall indicate the quantities being mixed.

(c) The mixer shall be calibrated to accurately proportion the mix. Certification of the calibration by an approved testing authority will be accepted as evidence of the accuracy if the yield is shown to be true within a tolerance of 1.0 percent in conformance with MSMT 558.

(d) The mixer shall provide positive control of the flow of water and latex emulsion into the mixing chamber. Water flow shall be indicated by flow meter and be readily adjustable to provide for minor variations in aggregate moisture.

(e) The mixer shall be capable of being calibrated to automatically proportion and blend all components of indicated composition on a continuous or intermittent basis as required by the finishing operation, and shall discharge mixed material through a conventional chute directly in front of the finishing machine.

(f) The mixer shall be capable of spraying water over the entire placement width as it moves ahead to insure that the surface to be overlaid is wetted to receive the latex modified concrete.

Placing and Finishing Equipment.

(a) Placing and finishing equipment shall include hand tools for placement and brushing in freshly mixed modified mortar and for distributing it to approximately the correct level for striking off with the screed. Approved hand operated vibrators and screeds may be used to place and finish small areas of work.

(b) An approved finishing machine shall be used for finishing all large areas of work. The finishing machine shall be self propelled and capable of forward and reverse movement under positive control. Provisions shall be made for raising all screeds to clear the screeded surface for traveling in reverse. A rotating cylinder type finishing machine shall be used. It shall be equipped with one or more rotating steel cylinders, augers, and vibratory pans and span the placement transversely.

(c) The finishing machine shall be designed so that, when concrete is being mixed and placed under normal operating conditions at the minimum rate, the elapsed time between depositing the concrete on the concrete deck and final screeding shall not exceed 10 minutes.

(d) The construction shall be supervised by a representative of the manufacturer of the latex modified mixture or as directed by the Engineer.

419.03.02 Rate of Overlay. The combination of labor and equipment for proportioning, mixing, placing and finishing latex concrete shall conform to the following minimum requirements except when otherwise specified in the Contract Documents:

TOTAL OVERLAY AREA PER BRIDGE yd^2 (m^2)	MINIMUM OVERLAY RATE PER HR yd^3 (m^3)
0-328 (0-274)	1.0 (0.8)
329-492 (275-411)	1.5 (1.2)
493-656 (412-548)	2.0 (1.7)
over 656 (548)	2.5 (2.1)

419.03.03 Existing Wearing Surface. When the existing bridge contains a hot mix asphalt wearing surface, it shall be removed in the area that is to receive the concrete overlay.

The Contractor shall not damage the existing concrete surfaces. Pavement breakers with broad faced chisel blades shall be used. The chisel shall

be operated at a slight angle with the horizontal to peel the old wearing surface off without damaging the deck surface.

The Engineer will determine any damage to the existing bridge caused by the Contractor's operations. Damaged portions shall be repaired by the Contractor to the satisfaction of the Engineer at the Contractor's expense.

All removed material shall become the Contractor's property and shall be disposed of at approved spoil areas.

419.03.04 Deck Repairs. When the Contract Documents specify a 1/4 in. (6 mm) minimum scarification, structural cracks will be located and marked by the Engineer prior to scarifying the existing bridge deck slabs. A saw cut approximately 3/4 in. (19 mm) deep shall be made on each side of these cracks and approximately parallel to them. The concrete between the saw cuts shall be removed by chipping and by use of hand tools to a depth of at least 2 in. (50 mm). Where reinforcement steel is exposed, the concrete shall be removed as specified in 419.03.05. In areas which cannot be reached by scarifying, in areas of deep stalling, and where reinforcement is exposed, the concrete shall be removed down to sound material by chipping and by use of hand tools as directed by the Engineer. The Contractor may use the high pressure water jet for removal of this material if approved by the Engineer.

After completion of removal of deteriorated concrete, remove all rust, oil or other foreign materials detrimental to achieving bond, followed by sandblasting and air blast or vacuum as determined by the Engineer.

If the scarification is specified to be greater than 1/4 in. (6 mm), the scarification shall be performed to the limits shown in the Contract Documents prior to the Engineer's inspection for deteriorated areas. After scarification the Engineer will inspect the entire exposed portion of the deck and indicate if any repairs are required including the type and extent of the repair. Deteriorated areas of deck shall be removed down to sound concrete. The removal shall be as specified for 1/4 in. (6 mm) scarifying except that the saw cutting may be omitted.

Spalled concrete, voids and other defects which are located within the proposed concrete overlay area shall then be patched in conformance with the following:

(a) For cavities less than 1 in. (25 mm) deep, no special treatment of cavity is required.

(b) For cavities 1 to 3 in. (25 to 75 mm) deep, the Contractor has the option of patching with Mix No. 5 concrete or filling the void with concrete overlay while applying the overlay. Wire fabric shall be placed as specified in 418.03.04 except that where approved by the Engineer the fabric may be wired to existing reinforcement without the use of expansion bolts, etc. Wire fabric will not be required for patch areas less than 2 ft^2 (0.6 m^2). The Contractor may use one or more of the patching materials specified, provided that each total depth of a patch is made with only one type of patch material.

(c) In areas where the depth of deck removal is over 3 in. (75 mm) deep, the Contractor may opt to patch with Mix No. 6 concrete or fill the void with concrete overlay while applying the overlay. If the repair is staged, a 1½ x 3 in. (39 x 75 mm) keyway shall be provided at the vertical joint.

When the depth of removal reaches half of the original concrete deck thickness and deeper removal is anticipated, the Contractor shall furnish and erect temporary protective shields as specified in 402.03.01.

In large areas of full depth deck repair, forms supplied to enable placement of the concrete shall be supported by blocking erected from the stringers. In small areas of full depth deck repair, forms supplied to enable placement of the concrete may be suspended from existing reinforcement bars by wire ties. The Engineer will determine the method used.

The top surface of all patch areas shall be the top of the as planned scarified surface. The top surface of all patch areas shall be given a final textured finish consisting of 1/8 in. (3 mm) wide by 1/8 in. (3 mm) deep transverse corrugations spaced approximately 1/4 in. (6 mm) apart. The method of texturing shall be approved by the Engineer prior to placing the material in

the patch. The patched areas shall be covered with wet burlap or wet cotton mats and shall be kept continuously wet for 120 hours.

419.03.05 Surface Preparation. After curing the repair areas shall be surface dried, sandblasted and cleaned prior to the application of the overlay system.

Areas where the surface has been removed shall not be left exposed during the close of the project's overlay construction season due to weather conditions prohibiting the placement of the latex modified concrete overlay. If the latex modified concrete cannot be placed, the Contractor shall furnish all necessary materials and labor to cover the area with a traffic bearing surface as directed by the Engineer. When the latex modified concrete overlay operations resume, the Contractor shall remove the temporary surface and repair any damage to the satisfaction of the Engineer at no additional cost to the Administration.

Existing reinforcement steel to be utilized in the finished deck shall conform to 416.03.07 except all bars shall be thoroughly cleaned by sandblasting. Where the bond between existing concrete and reinforcement steel has been destroyed, or where more than half the diameter of the steel is exposed, the concrete adjacent to the bar shall be removed to a depth that will permit concrete bond to the entire periphery of the exposed bar. This clearance shall be a minimum of 1 in. (25 mm) unless lower bar mats make it impractical. Care shall be exercised to prevent cutting, stretching or damaging any exposed reinforcement steel.

Areas from which unsound concrete has been removed shall be kept free of slurry produced by additional wet sawing of concrete. Work shall be planned so that this slurry will drain away from all open areas. All slurry shall be removed from prepared areas before proceeding with the surface preparation.

The entire surface shall be thoroughly cleaned and sandblasted before placing the overlay. The sandblasting shall clean all reinforcement of visible rust and clinging concrete detached from the deck and all areas of concrete against which the overlay is to be placed. Sandblasting may be required on the day the overlay is to be placed so that reinforcement is free of visible

rust. Sand-blasting shall not be performed more than 24 hours prior to placing the overlay.

The surface shall be further cleaned by air blast followed by flushing with water. Prior to placing the overlay, the surface shall be wetted and kept wet for at least one hour and puddles of free water shall be removed.

The concrete overlay shall be the riding surface of the bridges. In order to place the top of the overlay to true as planned line and grade of the roadways, the Contractor shall take all necessary precautions to produce a finished top of concrete overlay that shall be smooth riding by placing the concrete overlay in a manner that meets the grade of the proposed adjoining portions of the new bridge decks and adjoining roadways.

419.03.06 Proportioning and Mixing of Concrete Materials. Mixers shall be clean and the ingredients accurately proportioned.

Latex modified concrete materials shall be mixed at the site in conformance with the specified requirements for the equipment used. The latex modified concrete discharged from the mixer shall be uniform in composition and consistency. Mixing shall be capable of permitting finishing operations to proceed at a steady pace with final finishing completed before the formation of the plastic surface film.

419.03.07 Placing and Finishing Concrete. Screed rails shall be placed and fastened in position to insure 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 any compound to facilitate their removal.

The location of longitudinal joints may be shown in the Contract Documents. If not shown, the locations shall be as directed by the Engineer based on avoiding joints in the vehicular wheel path as much as practical.

The Contractor shall take every reasonable precaution to secure a smooth riding bridge deck in conformance with 414.03.07(d). Prior to placement operations, he shall review his equipment, procedures, personnel and previous results with the Engineer, and the inspection procedures will be re-

viewed to assure coordination. Precautions shall include the following:

(a) All surfaces shall be completely cleaned as approved by the Engineer prior to placing the overlay.

(b) The overlay mixture shall be brushed onto the wetted, prepared surface. Care shall be exercised to insure that all vertical and horizontal surfaces receive a thorough, even coating and that the rate of progress is limited so that the brushed material does not become dry before it is covered with additional materials required for the final grade.

(c) The overlay mixture shall be placed to approximately 1/4 in. (6 mm) above grade and then screeded with an approved power operated finishing machine to the line and grade specified in the Contract Documents. A suitable portable lightweight or wheeled work bridge shall be used behind the finishing operation. Hand finishing may be required along the edge of placements. Joints shall be edge tooled except next to metal expansion dams, curbs and previously placed lanes.

(d) Screed rails and construction bulkheads shall be separated from the newly placed material by passing a pointing trowel along their inside face. The trowel cut shall be for the entire depth and length of screed rails and bulkheads after the mixture has stiffened sufficiently. Metal expansion dams shall not be separated from the overlayment.

419.03.08 Curing. The surface of the latex modified concrete overlay shall be covered with a single layer of clean, wet burlap or wet cotton mat as soon as the surface will support it without deformation. Immediately following covering with wet burlap or wet cotton mat, a 4 mil (0.10 mm) layer of polyethylene film shall be placed on the burlap or cotton mat and the surface cured for 24 hours. After 24 hours, the curing material shall be removed and the latex modified concrete air cured for an additional 72 hours. White opaque burlap polyethylene sheeting may be substituted for the polyethylene film with approval of the Engineer, but shall not replace the wet burlap or wet cotton mat.

All other concrete overlays shall be cured in conformance with 414.03.10.

419.03.09 Grooving. The operation shall be in conformance with the applicable portions of 414.03.07(d)(1), but shall start after the overlay has been cured in conformance with 419.03.08.

No linseed oil shall be placed on latex modified concrete finished deck surfaces.

419.03.10 Limitation of Operations. Deck placement restrictions shall be as specified in the applicable provisions of 414.03.04.

All traffic (Contractor's or public) is prohibited on the concrete overlay until the curing of the material is completed and the compressive strength test has reached 3000 psi (20.7 MPa).

Concrete shall not be placed adjacent to a surface course less than 96 hours old. This restriction does not apply to a continuation of placement in a lane or strip beyond a joint in the same lane or strip.

Grinding or chipping the existing concrete pavement within 6 ft (2 m) of the latex modified concrete is prohibited until the latex modified concrete has cured for a minimum of 48 hours.

Latex modified mixtures shall not be placed at temperatures lower than 45 F (7 C). The mixture may be placed at 45 F (7 C), if rising temperature is predicted, and anticipated for at least 8 hours.

At temperatures below 55 F (13 C), the Engineer will require a longer curing period and conformance with applicable portions of 414.03.15.

Latex modified concrete that is unsatisfactory shall be removed and replaced at no additional cost to the Administration. Any day during which the curing temperature falls below 50 F (13 C) shall not be counted as a curing day. When during the curing period the curing temperature falls below 35 F (2 C), the work may be considered as being unsatisfactory and rejected.

During minor delays of one hour or less, the end of the placement may be protected from drying with several layers of wet burlap. A construction dam or bulkhead shall be installed when the delay exceeds one hour in duration. Placement operations may proceed after a period of not less than 12 hours. This restriction does not prohibit continuation of placement provided a gap is left in the lane or strip. The gap shall be of sufficient length for the finishing machine to clear the previously placed concrete.

Adequate precautions shall be taken to protect freshly placed concrete overlays from sudden or unexpected rain. All placing operations shall stop when it starts to rain. The Engineer may order the removal and replacement, at the Contractor's expense, of any material damaged by rainfall. The Engineer will determine what material has been damaged.

419.03.11 Linseed Oil Protective Coating. No oil protective coating shall be placed on the latex modified concrete finished deck surfaces. Linseed oil protective coating shall be placed on all other concrete overlay finished deck surfaces as specified in 414.03.12.

419.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for all chipping, scarifying and removal of hot mix asphalt pavement, cleaning, sandblasting, air blasting, flushing with water, curing, all saw cuts, disposal of material removed, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

419.04.01 Removal of Existing Wearing Surface From Bridge will be measured and paid for at the Contract unit price per square yard for the actual surface area removed from the bridge deck.

419.04.02 Scarified surfaces will be measured and paid for at the Contract unit price per square yard for the pertinent Scarifying Existing Bridge Deck item.

419.04.03 Hand Chipping Existing Bridge Deck areas of structural cracks and areas of unsound concrete that are not over 1 inch deep will be measured and paid for at the Contract unit price per square yard for the actual surface area hand chipped on the bridge deck.

419.04.04 Deck repairs over 1 inch deep will be measured and paid for at the Contract unit price per square foot for the pertinent Deck Repairs 1 to 3 Inches Deep, Deck Repairs Over 3 Inches But Not Full Depth, and Deck Repair Full Depth item. The payment will be full compensation for furnishing and placing concrete or latex modified concrete to fill the voids.

419.04.05 Overlay will be measured and paid for at the Contract unit price per cubic yard for the pertinent Concrete Overlay item. The volume of concrete used will be determined from the theoretical yield of the design mix. If the Contractor elects to fill the patching voids with the concrete overlay, the volume of the voids will be deducted from the cubic yard measurement for the Concrete Overlay item.

419.04.06 Placing, finishing and curing of the overlay, including forms, equipment, labor and materials necessary to accomplish the overlay will be measured and paid for at the Contract unit price per square yard on the pertinent Placing, Finishing and Curing Concrete Overlay item. The actual areas placed, finished and cured will be measured, exclusive of areas of metal expansion dams exposed on the finished surface.

419.04.07 Repair Bar for Deck Reinforcement will be measured and paid for at the Contract unit price per linear foot.

419.04.08 Linseed Oil Protective Coating for nonlatex modified concrete overlays will be measured and paid for as specified in 414.04.07.

SECTION 420 - PRESTRESSED CONCRETE BEAMS

420.01 DESCRIPTION. This work consists of furnishing and placing all prestressed concrete beams, elastomeric bearing pads, bearing plates and embedded items, all steel strands and wires, jacks and other devices required to provide in place the finished beam in conformance with the Contract Documents.

420.02 MATERIALS.

420.02.01 Portland Cement Concrete. The required cylinder strength of

the concrete at transfer of the tensioning load and the minimum required cylinder strength of the concrete at 28 days will be specified in the Contract Documents. The concrete mix shall contain an approved air entraining admixture and an approved Type D or G admixture conforming to 902.06. **Calcium Chloride or any other admixture containing chloride salts shall not be used in prestressed beams.**

High range water reducing admixtures may only be used if the Engineer determines that the producer can design and show by trial mix that the concrete with the high range water reducer will not have a slump of more than 6 in. (125 mm) and air entrainment of 4 to 7 percent with a minimum cement factor of 700 lb/yd^3 (415 kg/m3) and a water/cement ratio of less than 0.39. If a high range water reducing admixture is permitted, it shall conform to 902.06.03 Type G. The Engineer will be the sole judge of the design adequacy and trial mix evaluation. The approved mix shall conform to the strength requirements specified in the Contract Documents. The Engineer may reject an admixture when the performance shows that after actual usage the required results are not achieved.

The Engineer shall be allowed to take six test cylinders from each beam or beams cast and cured as a unit for the purpose of checking the quality of concrete being produced, for determining the time when forms may be removed and for determining the time when pre-stressing forces may be applied to a beam. These cylinders shall be made in metal molds and cured with the beams. At least three test cylinders shall be made and cured under laboratory conditions as specified in T 126. Test cylinders shall be made and tested at the manufacturing site, by the manufacturer, in conformance with T 22 under the supervision of the Engineer.

420.02.02 Reinforcement and Steel Strand. Reinforcement steel shall conform to 908.01. All reinforcement steel to extend into the roadway slab shall be epoxy coated.

Steel strand for pretensioning shall be 1/2 in. (13 mm) diameter, seven wire steel strands with a nominal area of 0.153 in.^{2} (3.89 mm^2). Steel strands shall conform to 908.11.

Material used for debonding of pretensioning steel strands shall be solid or split plastic sheathing having a minimum thickness of 0.025 in. (0.6 mm).

The manufacturer shall submit typical load/elongation curves for each individual shipment of prestressing steel strand. For each lot of 10 tons (9 Mg) or fractions thereof, certified copies of the manufacturer's test reports shall be forwarded to the Engineer.

420.02.03 Elastomeric Bearing Pads. The elastomeric bearing pads shall conform to 910.02.

420.03 CONSTRUCTION.

420.03.01 Working Drawings. If the Contractor elects to use methods other than specified in the Contract Documents, the Contractor shall provide working drawings to the Engineer for approval. The drawings shall include reinforcement, anchorages, steel strand profiles, lifting inserts and all other pertinent information required. The Engineer may accept or reject any changes proposed by the Contractor. All proposed changes shall be at the Contractor's expense.

420.03.02 Prestressed Concrete Plants. The prestressed concrete manufacturing plant shall conform to 421.03.02.

420.03.03 Beds and Forms. Casting beds shall be supported on unyielding foundations. Beds and forms shall be cleaned after each use. Accumulation of coatings used for bond breakers shall be prevented.

Prior to stringing steel strands, the bottom of forms shall be inspected for cleanliness and accuracy of alignment. The contact surfaces of forms shall be coated with a bond breaker that dries to a surface hardness. The coating shall be dry before the steel strand comes in contact with it to prevent contamination of the steel strand.

420.03.04 Meetings. A representative of the concrete plant shall attend the Administration's preconstruction meeting and all subsequent preerection field meetings.

420.03.05 Steel Strand Tensioning. In all methods of tensioning, the stress induced in the steel strands shall be measured both by jacking gauges and by elongations of the steel strands. All jacks and gauges shall be calibrated by an independent laboratory at the Contractor's expense and documentation forwarded to the Engineer. If any jack or gauge appears to be giving erratic results, or gauge pressures and elongations indicate materially different stresses during manufacturing, recalibration will be required. Means shall be provided for measuring the elongation of the steel strands to at least the nearest 1/32 in. (1 mm).

A difference in indicated stress between jack pressure and elongation of up to five percent may occur. In this event, the difference shall be placed so that the discrepancy will be on the side of a slight overstress rather than understress. In an apparent discrepancy between gauge pressure and elongation in excess of five percent, the entire operation shall be carefully checked and the source of discrepancy determined before proceeding further.

Elongations and jacking pressures shall make appropriate allowance for friction and all possible slippage or relaxation of the anchorage. For pretensioned beams, 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 steel strands.

In all stressing operations, the stressing force shall be kept symmetrical about the vertical axis of the beam.

Split plastic sheathing for debonded steel strands shall be thoroughly sealed with tape prior to placing concrete.

The amount of stress to be given each steel strand will be specified in the Contract Documents. All steel strands to be prestressed in a group shall be brought to a uniform initial tension prior to being given their full pretensioning. The uniform initial tension of approximately 500 to 1000 lb (225 to 450 kg) shall be measured by a dynamometer or other approved means. The results will be used as a check against elongation computed and measured. The group shall then be stressed until the required elongation and jacking pressure are attained and reconciled within the limits specified.

After the steel strands are stressed as specified and with all other reinforcement in place, the concrete beams shall be cast to the specified lengths. Steel strand stress shall be maintained between anchorages until the concrete has reached the compressive strength specified in the Contract Documents.

All pretensioned steel strands shall be cut flush with the end of the beam. Where the end of the beam will not be covered by concrete, the exposed ends of the steel strands and the concrete face at the end of the beam shall be cleaned and coated with a protective coating as specified in the Contract Documents. Cleaning shall be by wire brushing or abrasive blast cleaning to remove all dirt and residue which is not firmly bonded to the metal or concrete surfaces. Care shall be taken to work the protective coating into all voids in the prestressing steel strands.

420.03.06 Camber. During the beam fabrication period, the Contractor shall select a representative number of beams to be known as "Camber Control Beams," subject to the Engineer's approval. They shall be clearly and permanently identified so that the camber readings taken as indicated below can be associated with the proper beam.

(a) Camber readings shall be taken as follows:

(1) Just prior to prestressing.

(2) Immediately after prestressing.

(3) At weekly intervals thereafter within the three months after casting.

(4) At biweekly intervals, after the three month period expires.

(5) Just prior to shipment from the casting yard to the job site.

(6) Camber determinations shall be continued at these intervals if the beams are stored or stockpiled at the job site.

(b) Two copies of the camber records shall be furnished to the Engineer prior to erection of the beam.

420.03.07 Detensioning Beams. The schedule for detensioning of beams having deflected steel strands shall incorporate the following:

(a) The manufacturer's sequence of releasing deflected steel strands and uplift points shall be approved by the Engineer.

(b) All hold down devices for deflected steel strands shall be disengaged and all hold down bolts removed from the beams.

(c) The manufacturer's sequence of releasing the remaining straight steel strands shall be approved by the Engineer.

All hold down devices may be released prior to release of tension in deflected steel strands if:

(1) The weight of the prestressed beam is more than twice the total of the forces required to hold the steel strands in the low position, or

(2) If weights or other approved vertical restraints are applied directly over the hold down points to counteract the uplifting forces, at least until the release of deflected steel strands has proceeded to a point that the residual uplifting forces are less than half the weight of the beam.

All procedures for releasing prestressing forces of deflected steel strands shall be followed carefully. Failure to follow these procedures may result in rejection of the beams.

All beams shall be adequately separated in storage immediately following removal from the bed to facilitate the repair of surface blemishes and to allow inspection of the finished surfaces.

420.03.08 Tolerances. The following tolerances shall apply to each beam unless otherwise specified in the Contract Documents:

PRESTRESSED CONCRETE BEAM	TOLERANCE
Depth (overall)	±1/4 in. (6 mm)
Width (flanges & fillets)	±1/4 in. (6 mm)
Width (web)	±1/4 in. (6 mm)
Length of Beam	±1/8 in. per 10 ft or 1/2 in. (3 mm per 3 m or 13 mm) whichever is greater
Exposed Beam Ends (deviation from square or designated skew)	Horizontal ±1/4 in. (6 mm) Vertical ±1/8 in. per ft (3 mm per 0.3 m) of beam height
Side Inserts (spacing between center of inserts and from the centers of inserts to the ends of the beams)	±1/2 in. (13 mm)
Bearing Plate (spacing from the centers of bearing plates to the ends of the beams)	±1/2 in. (13 mm)
Stirrup Bars Average of all bars Individual bar longitudinal spacing	 ±1/2 in. (13 mm) ±1 in. (25 mm)
Horizontal Alignment (deviation from a straight line parallel to the center line of beam)	1/8 in. (3 mm) max per 10 ft (3 m)
Camber Differential between adjacent beams of same type and steel strand pattern	1/8 in. per 10 ft (3 mm per 3 m) at time of erection or 1/2 in. (13 mm) max
Center of Gravity of steel strand group	±1/4 in. (6 mm)
Center of Gravity of depressed group steel strand at end of beam	±1/2 in. (13 mm)
Position of hold down points for depressed strand	±6 in. (150 mm)

420.03.09 Marking, Shipping, Storage, and Erection. Each beam shall be marked with an erection mark for identification, weight marks for beams 6000 lb (2.7 Mg) or more, and inspection stamps.

The Contractor shall furnish the Engineer with an erection diagram clearly indicating erection marks that show the position of the beam in the structure.

Erection mark numbers, weights and inspection stamps shall be painted on the top surface of the top flange of the beams. No marks shall be placed elsewhere on the beam.

The cast in place lifting devices, and a sufficient amount of cranes and spreader beams shall be utilized whenever the prestressed concrete beams are lifted during loading, unloading, storage, erection, etc.

The Contractor shall furnish the Engineer copies of material orders and shipping statements. The weights of each individual beam shall be shown on the statements.

When shipping beams, blocking shall be placed at intervals that will prevent sag and distortion. All beams shall be shipped in an upright position. Beams too long to fit inside of a truck or trailer shall not cantilever beyond the bed more than 1/4 of its length. Beams too long to comply with this requirement shall be supported on dollies, additional vehicles or other vehicles that shall fully support the long pieces, as approved by the Engineer.

Beams shall be stored off the ground in an upright position, shall be protected as far as practical from surface deterioration, and be kept free of accumulations of dirt, oil or other deleterious material.

Erection shall conform to 408.03.27, .28, .29, .31, .32, and .33.

420.03.10 Bearings. Bearing pad delivery and installation shall be as specified in 421.03.19.

420.04 MEASUREMENT AND PAYMENT. Prestressed Concrete Beams will not be measured but will be paid for at the Contract lump sum price. The payment will be full compensation for all concrete, forms, reinforcement, bearing pads, steel strands, steel components, testing, transporting, storage, erection, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

SECTION 421 - PRESTRESSED CONCRETE SLABS

421.01 DESCRIPTION. This work consists of furnishing and placing all prestressed concrete slabs, elastomeric bearing pads, bearing plates and embedded items, and all steel strands, wires, jacks or other devices re-

quired to provide in place the finished slabs in conformance with the Contract Documents.

421.02 MATERIALS.

421.02.01 Portland Cement Concrete. The mix shall be as specified in ACI 211.1 and shall contain a Type D or G admixture conforming to 902.06. The required cylinder strength of the concrete at transfer of the pretensioning load and the minimum required cylinder strength of the concrete at 28 days will be specified in the Contract Documents. The water/cement ratio shall be 0.35 to 0.45. If Type G admixtures are used they shall provide a maximum slump of 6 in. (150 mm) and air entrainment of 6 ± 2 percent. The Engineer shall be allowed to take six test cylinders from each slab or slabs cast and cured as a unit for the purpose of checking the quality of the concrete being produced, for determining the time when forms may be removed and for determining the time when prestressing forces may be applied to a slab. These cylinders shall be made in metal molds and cured with the slabs. At least three test cylinders shall be made and cured under laboratory conditions as specified in T 126. Test cylinders shall be made and tested under the supervision of the Engineer, by the manufacturer at the manufacturing site in conformance with T 22. Calcium chloride or any other admixture containing chloride salts shall not be used in prestressed slabs.

421.02.02 Reinforcement, Rods and Steel Strand. Reinforcement steel shall conform to 908.01 and shall be epoxy coated.

Anchor rod dowel bars shall conform to A 242.

Tie rods shall be threaded bars conforming to A 663, Grades 45 through 60.

Tie rod tubes shall consist of corrugated, rigid or semi-rigid type, galvanized steel sheathing or rigid plastic sheathing.

Steel strands shall be seven-wire uncoated low relaxation strands conforming to M 203, Grade 270, Supplement 1, except the actual yield strength at one percent extension shall fall between the following two strength limits. The lower limit is 85 percent of the breaking strength. The upper limit is 95

percent of the actual breaking strength, measured at 3½ percent extension.

The manufacturer shall submit typical load/elongation curves for each individual shipment of prestressing steel strand. For each lot of 10 ton (9 Mg) or fraction thereof, certified copies of the manufacturer's test reports shall be submitted to the Engineer.

Material used for debonding of pretensioning steel strands shall be solid or split plastic sheathing having a minimum thickness of 0.025 in. (0.62 mm)

421.02.03 Elastomeric Bearing Pads. Elastomeric bearing pads shall conform to 910.02 except that the bearing pads shall be of 50 durometer hardness. Bearing pads dimensions will be specified in the Contract Documents.

421.02.04 Joint Sealers. Joint sealers shall conform to the manufacturer's recommendations.

421.02.05 Grout shall conform to 902.11.

421.02.06 Closed cell neoprene sponge elastomer shall conform to 911.10.

421.02.07 Epoxy adhesive material shall conform to 921.04

421.03 CONSTRUCTION.

421.03.01 Working Drawings. Working drawings shall conform to 420.03.01.

421.03.02 Prestressed Concrete Plants. The prestressed concrete manufacturing plant shall be registered and certified under the Prestressed Concrete Institute Program and a valid certificate shall be submitted to the Engineer prior to the start of production.

421.03.03 Beds and Forms. Beds and forms shall conform to 420.03.03.

421.03.04 Meetings. Meetings shall conform to 420.03.04.

421.03.05 Protection of Prestressing Steel Strand. Prestressing steel strand shall be stored under shelter and kept free of deleterious material, such as grease, oil, wax, dirt, paint, loose rust, or other similar contaminants. Steel showing corrosion, etching, pitting or scaling of the surfaces shall not be used. A light coating of surface rust is acceptable if it can be removed completely from the steel by wiping with a cloth.

Prestressing steel strand shall not be stored on a surface which contributes to galvanic or battery action. Steel strand shall not be used as a ground for electric welding and shall be protected from electric welding sparks.

421.03.06 Reinforcement, Inserts, and Chairs. Reinforcement shall be placed within the specified tolerances. Reinforcement shall be secured to beds and forms using chairs, blocking or ties. Cages of bars shall be fabricated by tying only. Cages shall not be supported by tensioned strands. Tie wire ends shall be bent into the slab. The type and placement of inserts shall be shown on the shop drawings.

Form ties, chairs, and inserts shall be recessed in the concrete by at least 1 in. (25 mm) or stainless steel accessories shall be used.

421.03.07 Methods of Force Measurement. Forces shall be measured using one of the following methods as the primary measuring system and checked using one of the other methods as the secondary measuring system. Methods of force measurement are:

(a) Curves. Current stress-strain or load elongation curves furnished by the strand manufacturer may be used. An average modulus may be used if acceptable to the Engineer. Means shall be provided for measuring the elongation of the strands to at least the nearest1/ 32 in. (1 mm).

(b) Pressure Gauges. Gauges shall be used to measure force by the pressure applied to hydraulic jacks. These gauges shall be furnished with dials calibrated with the jacking system.

(c) Dynamometers. Dynamometers connected in tension to the stressing system for the initial force application may be used.

Gauging System. Tensioning systems shall be equipped with accurately calibrated hydraulic gauges, dynamometers, load cells, or other devices for measuring the stressing load to an accuracy of reading within two percent. A qualified testing laboratory shall calibrate and issue a certified calibration curve with each gauge. A gauging system shall be recalibrated when it shows erratic results, when directed by the Engineer and at intervals not greater than three months. Gauges for single strand jacks may be calibrated by an acceptable and calibrated load cell. Calibrate gauges for large multiple strand jacks, acting singly or in parallel, by proving rings or by load cells placed on either side of the movable end carriage.

Pressure gauges and dynamometers shall be provided preferably with full pressure and load capacities of approximately twice their normal working range. Loads shall be limited to a minimum of 25 percent and a maximum of 75 percent of the total graduated capacity, unless calibration data establishes consistent accuracy over a wider range.

Each gauge shall indicate loads directly in pounds or shall be accompanied by a chart with which the dial reading can be converted into pounds.

Tensioning systems employing hydraulic gauges shall be equipped with appropriate bypass pipes, valves, and fittings so the gauge reading remains steady until the jacking load is released.

Gauge readings, elongation measurements, and calculations for elongation shall include appropriate allowances for operational losses in the tensioning system due to strand slippage, movement of anchorages and abutments, elongation of abutment anchorage rods, strand rotation, temperature variation, friction, bed shortening and other forces and influences acting on the strands. Calculations for elongation shall be available for inspection.

Friction in Jacking System. Rams used in jacks for single strand tensioning are small, thus, friction losses in the jacking system may be ignored, provided gauge pressure is verified by elongation or load cells. In multiple strand tensioning systems, the sliding surfaces shall be cleaned and lubricated to minimize friction. A force override (compensatory operational loss correction) shall be established for standard strand pattern series.

Thermal Effects. The design prestress force shall be increased by 1/2 percent for each 5 F (3 C) ambient temperature below 80 F (27 C). No adjustment is required when the ambient temperature is above 80 F (27 C). Steel strands shall not be stressed when the ambient temperature is below 40 F (4 C). After the steel strands are tensioned, the temperature of the air surrounding the steel strands shall be maintained at 40 F (4 C) or more until the prestress force is transferred to the concrete.

Control of Jacking Force. Either manual or automatic pressure cutoff valves may be used for stopping the jacks at the required load. Automatic cutoffs capable of adjustment shall be used to ensure that the jacking load corresponds to the required load. The setting accuracy for automatic cutoff valves shall be verified whenever there is reason to suspect improper results and at the beginning of each day's operation.

421.03.08 Stringing Steel Strands. Steel strands containing former vise grip points shall not be reused unless the points are outside the new steel strand vise locations. Steel strands that have been draped shall not be reused. All steel strands shall have the same lay or direction of twist. The ends shall be cut using shears or abrasive cutting wheels. Steel strands shall be positioned over chairs to eliminate sagging of steel strands in the bottom rows.

421.03.09 Steel Strand Splices. There shall be only one splice per steel strand. For single steel strand tensioning, the number of steel strands that may be spliced in each bed is not restricted. For multiple steel strand tensioning, either all steel strands shall be spliced and the elongation shall be adjusted for average slippage, or no splices are permitted.

421.03.10 Steel Strand Vises. Steel strand vises shall be capable of anchoring stressing loads positively with a minimum of slippage, and shall be cleaned, lubricated and inspected between each use. Grips that become visibly worn or distorted, or that allow slippage in excess of 1/4 in. (6 mm) shall not be used. A full set of steel strand vises shall be cleaned and inspected before starting each stressing operation.

The maximum permissible time for holding tensioned steel strands in the bed before placing concrete shall be 72 hours.

Split plastic sheathing for debonded steel strands shall be thoroughly sealed with tape prior to placing concrete.

421.03.11 Wire Failure in Steel Strands. Seven wire steel strand with any broken wire shall be removed and replaced. All steel strands shall be checked for wire breaks before placement of concrete.

421.03.12 Pretensioning. The total load to be applied to each strand shall be as specified in the Contract Documents. The load shall be applied as a total of two loading stages. The initial load shall straighten the steel strand, eliminate slack and provide a starting or reference point for measuring elongation. All steel strands shall then be stressed to the final total load. The elongation of steel strands shall be computed or measured for the final load applied.

The initial load shall not exceed 10 percent of the specified tensioning force or 2000 lb (910 kg), whichever is greater. The initial load shall be measured within a tolerance of ± 100 lb (45 kg). The initial elongation measurement shall not be used to determine the initial force.

Initial tensioning may be accomplished using fence stretchers in conjunction with a dynamometer. Initial tensioning for a single strand may be provided by a pressure jack equipped with a proper gauging system. Other methods that provide a measurable and uniform load shall be acceptable if approved by the Engineer in writing prior to use.

In all stressing operations, the stressing force shall be kept symmetrical about the vertical axis; however, in tensioning single steel strands, the initial and final loads may be applied in immediate succession to each steel strand.

Jack mounted pressure gauges shall be the primary system of force measurement for the final tensioning of straight single steel strands. Elongation shall be checked against pressure gauge readings on all steel strands. Slippage shall be checked at steel strand vises. The computed elongation, including operational losses and equivalent elongation for the initial tensioning force shall agree with the pressure gauge reading within three percent.

Jack mounted pressure gauges shall be the primary system of force mea-

surement for the final tensioning of multiple steel strands. For uniform application of load to the steel strands, the position of the face of the anchorage at final load shall be parallel to its position under initial load. Parallel movement shall be verified by measurement of equal movement on opposite anchorage sides and by checking the plumb position of the anchorage before and after final load application. Slippage shall be checked at steel strand vises.

After the steel strands are stressed as specified and with all other reinforcement in place, the concrete slabs shall be cast to the specified lengths. Strand stress shall be maintained between anchorages until the concrete has reached the compressive strength specified in the Contract Documents.

421.03.13 Detensioning. The tension force shall not be transferred to the slabs until the concrete strength, as indicated by cylinder tests, equals or exceeds the specified transfer strength.

Forms, ties, inserts, hold downs, or other devices that restrict the member's longitudinal movement along the bed shall be removed or loosened prior to detensioning or a method and sequence to minimize longitudinal movement shall be used. Prestressing forces shall be released using a method to minimize sudden or shock loading.

Single steel strand detensioning may be accomplished by heat cutting the steel strands. The single steel strand detensioning sequence shall maintain prestressing forces nearly symmetrical around the slab's vertical axis. Eccentricity around the vertical axis shall be limited to one steel strand. The steel strand cutting pattern shall be approved by the Engineer prior to its use. Multiple steel strand detensioning may be accomplished by gradually reducing the force applied to each steel strand equally and simultaneously.

All pretensioned prestressing steel shall be cut off flush with the end of the slab. Where the end of the slab will not be covered by concrete, the exposed ends of the prestressing steel and the concrete face at the end of the slab shall be cleaned and coated with a protective coating specified in the Contract Documents. Cleaning shall be by wire brushing or abrasive blast cleaning. Care shall be taken to work the coating into any voids in the prestressing steel strands.

421.03.14 Tolerances. The following tolerances shall apply to each slab unless otherwise specified in the Contact Documents. If the deviations from tolerance can be effectively corrected, those slabs accepted in writing by the Engineer may be used.

PRESTRESSED CONCRETE SLAB	TOLERANCE
Depth (overall)	+ 1/2 in. - 1/4 in. (13 mm - 6 mm)
Width (overall)	±1/4 in. (6 mm)
Slab length @ center line (based on design length specified)	±1/2 in. (13 mm)
Horizontal alignment (deviation from a straight line parallel to the slab center line)	1/4 in. (6 mm)
Horizontal misalignment of adjacent form sections	3/16 in. (5 mm) max
Camber deviation from specified camber, as measured at prestress transfer or at the beginning of slab storage at the fabrication plant	±1/2 in. (13 mm)
Camber differential between adjacent slabs	1/4 in. per 10 ft (6 mm per 3 m) 1/2 in. (13 mm) max
Location of each strand	±1/8 in. (3 mm)
Center of gravity of strand group	±1/4 in. (6 mm)
Stirrup bars (longitudinal spacing)	±1 in. (25 mm)
Longitudinal position of handling devices	±3 in. (75 mm)
Concrete bearing area (variation from plane surface when tested with a straightedge through middle half of slab	±1/8 in. (3 mm)
Tie rod tubes (spacing between the tube centers and from tube centers to slab ends)	±1/2 in. (13 mm)
Tie rod tubes (spacing from tube center to slab bottom)	±3/8 in. (9 mm)
Threaded inserts (spacing between the center of inserts and from center of inserts to ends of slabs)	±1/2 in. (13 mm)
Skew ends (deviation from designated skew)	±1/2 in. (13 mm)
Vertical ends (deviation from specified dimension)	±3/8 in. (9 mm)

421.03.15 Test Loading. Test loading shall consist of subjecting the slab to a load which is one and a half times the design load without evidence of distress or cracking in the slab. Test loads shall be exerted for not less than a 24 hour period. The slab selected for test loading shall be placed in a level position on solid nonyielding supports, with the bottom approximately 36 in. (1 m) above the ground to permit inspection of the bottom. Loads shall be applied to permit a close, safe inspection of the slab in the presence of the Engineer.

After fabrication and acceptance at the plant, one slab of the first bed of slabs will be selected by the Engineer and test loaded. Final acceptance of the manufacturing process will be based upon the results of the test load.

If any slab fails to conform to the strength requirements based upon the 28 day cylinder test, the slab may be accepted if the Contractor performs a load test, at his expense, subjecting the apparent weak slab to test loading.

421.03.16 Handling and Storage. Slabs may be handled immediately after completion of stress transfer. If transfer is not done in a continuous operation, slabs shall not be handled before they are sufficiently stressed to sustain forces and bending moments due to handling.

When air temperatures are below 40 F (4 C), only surface dry slabs shall be removed from the beds. Slabs shall not be placed outside the bed if the differential between slab and air temperature is more than 50 F (10 C).

The cast in place lifting devices, and a sufficient amount of cranes and spreader beams shall be utilized whenever the prestressed concrete beams are lifted during loading, unloading, storage, erection, etc.

All slabs shall be adequately separated in storage immediately following removal from the bed to facilitate the repair of surface blemishes and to make inspection of the finish surfaces possible. Slabs shall be stored in suitable areas until the 28 day compressive strength is attained and shall remain in horizontal and upright positions at all times.

Slabs may be stacked as long as they are separated and adequately supported across the full width at each bearing point. Slabs shall be stacked so

that lifting devices are accessible and undamaged. The upper slabs of a stack shall not be used as storage areas.

421.03.17 Shear Keys and Sleeves for Tie Rods. Shear keys shall be formed along all slab top edges except the outside edge of fascia slabs which shall be plain. The top of the shear key shall provide a minimum total opening between adjacent slabs of 1/2 in. (13 mm) after tightening the tie rods. Prior to shipping, the entire shear key area shall be sandblasted to provide a rough texture and to completely remove all dirt, oil, grease or foreign substance that would prevent bonding.

Sleeves for tie rods shall be cast in the slabs at locations specified in the Contract Documents.

421.03.18 Marking and Shipping. Prior to shipment each slab shall be marked with an individual, consecutive identification mark at a permanently exposed location. The identification mark shall match that shown on the approved working drawings to allow erection as specified in the Contract Documents.

Load restrictions shall be as specified in GP-5.10. Slabs shall not be shipped until approved in writing by the Engineer and they have attained the minimum 28 day compressive strength, but in no case in less than five days following prestress transfer.

The method of transport and shipment from each plant is subject to acceptance by the Engineer. When transporting slabs by truck, barge, or railroad car they shall be supported as shown on the working drawings, using adequate bracing to maintain the vertical position. The supports, bracing, and shipment methods shall dampen vibrations.

Adequate padding material shall be provided between tie chains or cables to prevent concrete chipping.

421.03.19 Bearing pads delivered to the bridge site shall be stored under cover on a platform above the ground surface. Pads shall be protected from damage at all times and shall be kept dry, clean and free of dirt, oil, grease and foreign substances.

The surfaces of the concrete bearing areas that will be in contact with the bearing pads and the full contact area of the bearing pads shall be coated with an epoxy adhesive. The Contractor shall strictly adhere to the manufacturer's recommendations for mixing and applying epoxy adhesive material. The surface temperatures when applying epoxy adhesive shall be a minimum of 50 F (10 C) with a predicted ambient temperature for the next four hours of 50 F (10 C) or above. The surfaces to be coated shall be clean, dry and sound. The Contractor shall be prepared to use water jets, sandblasting, air blasting etc. for cleaning the surfaces to the satisfaction of the Engineer.

The bearing pads shall be accurately set in the epoxy adhesive and secured in place by blocking or other mechanical means until the adhesive sets.

421.03.20 Erection and Field Tightening. Erection shall conform to 408.03.27, .28, .29, .31, .32, and .33. Immediately prior to erection, the sandblasted shear key surfaces shall be cleaned with compressed air, stiff bristle fiber brushes, or vacuumed. Slabs shall be pulled together and field tightened in the transverse direction by tie rods. Field tightening shall be performed with approved impact wrenches. After tightening, all tie rod holes shall be grouted.

421.03.21 Filling Joints Between Slabs. After field tightening all slabs, the joint below the shear keys shall be sealed using a method approved by the Engineer. Shear keys shall then be grouted by overfilling the joints. Grout shall be driven or tamped compactly into the keyways and not vibrated. After a half hour the excess grout shall be struck off flush with the top of the slabs. The manufacturer's recommendations shall be followed for grouting in cold or hot weather.

421.04 MEASUREMENT AND PAYMENT. Prestressed Concrete Slabs will not be measured but will be paid for at the Contract lump sum price. The payment will be full compensation for all concrete, forms, reinforcement, epoxy coating, steel strands, sheathing, steel rods, inserts, grout, bearing pads, epoxy adhesive, testing, shipping, storage, erection, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

SECTION 422 - METAL RAILING

422.01 DESCRIPTION. This work shall consist of furnishing, fabricating, coating, and erecting of all metal railings as specified in the Contract Documents.

422.02 MATERIALS. Materials shall be as specified in the Contract Documents.

422.03 CONSTRUCTION. All railings shall be fabricated and erected as specified in the Contract Documents.

The Contractor shall furnish working drawings for approval by the Engineer.

422.03.01 Production, Handling and Shipment. Metal railings and incidental parts shall be carefully handled and stored on blocking, racks, or platforms to prohibit contact with the ground and shall be protected from corrosion or damage. Materials shall be kept free from dirt, oil, grease, and other foreign matter. Surfaces to be painted shall be carefully protected both in the shop and in the field. Damaged material shall be repaired or replaced as directed by the Engineer at the Contractor's expense.

422.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

422.04.01 Metal Railing will be measured and paid for at the Contract unit price per linear foot.

422.04.02 Metal Railing will not be measured but will be paid for at the Contract lump sum price.

422.04.03 Metal Railing will not be measured but the cost will be incidental to other pertinent items included in the Contract Documents.

SECTION 423 - TIMBER STRUCTURES

423.01 DESCRIPTION. This work shall consist of constructing structures or portions of structures using timber, including fabrication, erecting, treating and coating of the timber elements as specified in the Contract Documents or as directed by the Engineer.

For timber piling refer to Section 407. For structural steel refer to Section 408. For concrete refer to Section 414.

423.02 MATERIALS.

Asphalt Cement	904.01
Structural Steel	909.01
Gray Cast Iron	909.04
Bolts and Hardware	909.09
Structural Timber	921.05
Preservative Treatments for Timber	921.06
Metal Timber Connectors	Per manufacturer & approved by the Engineer
Galvanizing	A 153
Fire Stops and Galvanized Sheet Metal	A 525, Coating Designation G 90

423.03 CONSTRUCTION.

423.03.01 Storage and Handling. Timber shall be open stacked in piles at least 12 in. (300 mm) above the ground surface in a manner to shed water and prevent warping. It shall be protected from weather by a suitable covering. The storage site shall be cleared of weeds and rubbish before placing material and throughout the storage period. The site selected shall not be subject to flooding. Timber shall be handled with rope or nylon slings to prevent the breaking of outer fibers, bruising, or penetrating the surface.

423.03.02 Cutting and Boring. When practical, cutting and boring of treated timbers shall be done before treatment. All cuts in treated timbers and all abrasions (after having been carefully trimmed) shall be brush coated with two applications of an approved wood preservative before installing the timber in the structure. Whenever forms or temporary braces are attached to treated timber with nails or spikes, the holes shall be filled by driving galvanized nails or spikes flush with the surface, as directed by the Engineer.

423.03.03 Bolt Holes. Bolt holes bored after treatment shall be filled with asphalt cement applied with a caulking gun or as directed by the Engineer before inserting bolts. Holes that are not to receive bolts shall be plugged with asphalt cement coated plugs.

423.03.04 Coating Untreated Surfaces. In untreated timber structures, all contact surfaces between any members (except adjacent flooring members) shall be coated with two coats of an approved preservative before assembling. The back faces of bulkheads and all surfaces of timber that will come in contact with earth, metal or other timber shall be similarly coated. The ends of timber members shall be coated in the same manner.

423.03.05 Protection of Ends of Caps, Wales and Planks. The ends of all caps, wales and planks shall be covered with resin glass composite shields as approved by the Engineer. The shields shall be applied as follows:

(a) Remove all dirt and other loose material from area to be capped.

(b) Apply the first coat of resin to the top and 4 in. (100 mm) down the side of the member.

(c) Apply precut glass cloth, using a 3 in. (75 mm) grooved aluminum roller to achieve "wet-out" and brass staples for anchorage.

(d) When the initial coat of resin has taken a tack free set, apply a second coat of resin to seal the entire application.

423.03.06 Diameter of Holes. Holes bored in timber structures shall conform to the following:

a) Round drift bolts, spikes, and dowels - 1/16 in. (1.5 mm) less than the diameter of the device.

(b) Square drift bolts, spikes, and dowels - equal to the smallest dimension of the device.

(c) Machine bolts - same as the diameter of the bolts.

(d) Rods - 1/16 in. (1.5 mm) larger than the diameter of the rods.

e) Lag screws - equal to the diameter of the screw at the base of the thread.

(f) Connector bolts - 1/16 in. (1.5 mm) larger than the diameter of the connector bolts.

423.03.07 Bolt Assemblies. Bolt heads or nuts which come in contact with the timber shall be fitted with a washer of the size and type specified. After all nuts are adequately tightened, the bolt shall be deburred.

423.03.08 Countersinking. Countersinking shall be done wherever smooth faces are required. In treated timber, recesses formed in horizontal surfaces for countersinking shall be painted with an approved preservative. After the bolt or screw is in place, recesses shall be filled with an approved asphalt coating.

423.03.09 Connectors. Connector holes shall be bored through members to be connected. The bolt hole shall be kept perpendicular to the face of the timber. When spike grids or split ring connectors are specified in the Contract Documents, they shall be installed in conformance with the manufacturer's recommendations.

423.03.10 Framing. All timber shall be accurately cut and framed to provide even bearing over the entire contact surface. When making joints, there shall be no shimming and there shall be no open joints.

423.03.11 Sills. Sills shall have true and even bearing on mud sills or concrete pedestals. All earth shall be removed from contact with sills.

423.03.12 Caps. Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps shall be secured by drift bolts or as specified in the Contract Documents. The drift bolts shall be in the center of the post or pile.

423.03.13. Bracing. The ends of bracing shall be bolted through the pile, post, or cap. Intermediate intersections shall also be bolted. Spikes or nails shall be used in addition to bolts. When bracing intersects, filler blocks shall be used with a bolted connection.

423.03.14 Stringers. Stringers shall be placed in position so that knots near edges will be in the top portions of the stringers. Bottom edges of stringers shall be sized to provide uniform depth at bearings.

Outside stringers may have butt joints with the ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. The lapped ends of untreated stringers shall be separated a minimum 1/2 in. (13 mm) and shall be securely fastened by drift bolts where specified. When stringers are two panels long, the joints shall be staggered.

Cross bridging between stringers shall be toenailed with at least two nails in each end. The lower ends of all bridging and one side of each diaphragm shall be left disconnected and free to move until after the deck above it has been securely fastened to the stringers.

423.03.15 Floor Planking. Floor planking shall, unless otherwise specified, be SIS and SIE, hit or miss, and the planks shall be of uniform thickness with a maximum tolerance of 1/8 in. (3 mm). Where necessary to maintain traffic, planks shall be laid in half-of-bridge width sections. Timber plank floors shall always be accompanied with suitable hold down devices. Planks shall be spiked to every stringer or joist or nailer using not less than two spikes, and the length of the spikes shall be at least equal to twice the thickness or depth of the plank. Where planks will be under wheel guards or hold down devices, care shall be taken while selecting planks of as near equal thickness as possible. Before any hold down or wheel guard is bolted, treated shims or wedges shall be firmly driven between low planks and hold

down and low planks and wheel guard so that all planks shall be held down with equal pressure. The shims shall occupy at least 50 percent of the area between the bottom of the hold down and the top of the plank and between the bottom of the wheel guard and the top of the plank.

423.03.16 Wheel Guards. Wheel guards shall be installed in sections not less than 12 ft (3.6 m) long. Splices shall be shiplapped with the lap equal to 8 in. (3 mm) or the greater side of the piece, whichever is larger.

423.04 MEASUREMENT AND PAYMENT. Piles are excluded. The payment will be full compensation for all timber (treated or untreated) storage and handling, preservative, composite shields, asphalt cement, metal components, drilling holes, and for all material, labor, equipment, tools, and incidentals necessary to complete the work.

423.04.01 Timber structures will be measured and paid for at the Contract unit price per 1000 board feet (MBM). The computation of quantities will be based on the nominal sizes specified in the Contract Documents and the exact overall net length of pieces remaining in the completed structure. No allowance will be made for waste.

423.04.02 Timber structures will not be measured but will be paid for at the Contract lump sum price.

SECTION 424 - BRICK MASONRY

424.01 DESCRIPTION. This work shall consist of brick laid in full beds of mortar and built to the shapes and dimensions and at the locations specified in the Contract Documents or as directed by the Engineer.

424.02 MATERIALS.

Curing Compound	902.07.03
Brick	903
Mortar	903.06

424.03 CONSTRUCTION. All brick masonry shall be laid in level courses with faces plumb, square and true to the dimensions specified. All exposed surfaces shall be smooth.

Brick facing shall be constructed as specified in the Contract Documents.

424.03.01 Bond. Unless otherwise specified, brick masonry shall be laid in common bond having at least one course in every seven composed entirely of headers. Adjoining courses shall be laid to break joints by half brick as nearly as practical.

424.03.02 Bricklaying. All brick shall be sprayed with water to dampen the surface prior to laying. Only fresh plastic mortar shall be used, and it shall be soft and workable when placed on the wall. A layer of mortar shall be spread on the beds and not more than a shallow furrow which can be readily closed by the laying of the brick shall be made in it. All bed and head joints shall be filled solid with mortar. End joints of stretchers and side or cross joints of headers shall be fully buttered with mortar and a shoved joint made so that mortar is squeezed out at the top of the joint. No brick shall be jarred or moved after it has been fully bedded in the mortar. Bricks loosened after the mortar has taken its set shall be removed, cleaned and relaid with fresh mortar. No broken or chipped brick shall be used in the face. No spalls or bats shall be used except where necessary to shape around irregular openings or edges. Full bricks shall be placed at ends or corners where possible and the bats used in the interior of the course. In making closures, bricks shorter than the width of a whole brick shall not be used. Whole brick shall be used as headers.

424.03.03 Joints. All joints shall be slushed with mortar at every course, but slushing alone will not be considered adequate for making an acceptable joint. Exterior faces shall be laid up in advance of backing. Exterior faces shall be back plastered or parged with a coat of mortar not less than 3/8 in. (10 mm) thick before the backing is laid up. Prior to parging, all joints on the back of face courses shall be cut flush. Joints shall not be less than 1/4 in. (6 mm) nor more than 1/2 in. (13 mm) wide. Whatever width is adopted shall be maintained uniformly throughout the work.

424.03.04 Pointing. All exterior head and bed joints shall be tooled with a

round tool, slightly larger than the joint, pressed tight against the still plastic mortar so as to provide a concave finish. When nails or line pins are used, the holes shall be immediately plugged with mortar and pointed as soon as the nail or pin is removed.

424.03.05 Cleaning. Upon completion of the work, all exterior surfaces shall be cleaned by scrubbing and washing down with water, or if necessary, cleaning shall be done with a 5 percent solution of muriatic acid which shall then be rinsed off with liberal quantities of clean fresh water.

424.03.06 Curing. After the work has been laid up and pointed, the exposed surfaces of brick masonry shall be cured by one of the following methods:

(a) Brick shall be covered with two layers of burlap and kept wet for three days.

(b) A nonbituminous colorless liquid curing compound shall be applied by means of an approved hand or motor driven spray operated at a pressure between 40 and 60 psi (276 MPa and 414 MPa). The liquid compound shall be uniformly applied at a rate of 0.034 to 0.040 gal/yd^2 (1.58 l/m^2 to 1.81 l/m^2). The material shall be applied so that the exposed surface is completely coated and sealed in one application. At points where the work shows evidence of insufficient coating, additional material shall be added as directed by the Engineer.

424.03.07 Cold Weather Protection. No brick masonry work or pointing shall be done when there is frost in the brick or when the air temperature is below 50 F (10 C), unless the Contractor provides suitable housing, covering and tarpaulins, and heating devices necessary to keep the atmosphere surrounding the masonry at a temperature of not less than 50 F (10 C) for the curing period.

424.03.08 Backfill. Brick masonry shall not be backfilled before seven days after completion of the section.

424.04 MEASUREMENT AND PAYMENT. The payment will be full

compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

424.04.01 Brick Masonry for Structures will be measured and paid for at the Contract unit price per square foot. The Engineer may permit the backfilling of masonry structures sooner than specified if traffic or other conditions warrant this. In no case, however, will this operation be permitted until the third day after the completion of all work.

424.04.02 Brick Masonry for Structures will be measured and paid for at the Contract unit price per cubic yard.

424.04.03 Brick Masonry for Structures will not be measured but will be paid for at the Contract lump sum price.

424.04.04 Brick Masonry Facing will be measured and paid for at the Contract unit price per square foot.

424.04.05 Brick Masonry Facing will not be measured but will be paid for at the Contract lump sum price.

SECTION 425 - EPOXY PROTECTIVE COATINGS FOR CONCRETE

425.01 DESCRIPTION. This work shall consist of furnishing, and applying of epoxy protective coatings as specified in the Contract Documents or as directed by the Engineer.

425.02 MATERIALS.

Sand	901, Table 901 A
Epoxy Protective Coatings	917

425.03 CONSTRUCTION. The epoxy protective coating shall not be applied until at least 30 days after forms are removed. All surfaces to be

coated shall be blasted. The surface shall be clean, sound, thoroughly dry and free of oil, grease, curing compound and other foreign matter before applying the first epoxy protective coating. Two coats shall be applied to the specified areas of the structure. The application of each epoxy protective coating shall follow a dry weather period of at least two consecutive days. Adjacent areas not to be coated shall be masked or otherwise protected to prevent staining.

425.03.01 Mixing and Application. Mixing and application shall conform to the manufacturer's recommendations. Epoxy coatings shall be applied by brush or roller. Epoxy coatings shall not be applied to concrete piers and abutments until after structural steel masonry plates have been placed.

425.03.02 Coating Requirements. The second coat of epoxy coating on the top surfaces of the pier caps and abutment bridge seat areas between beams pads shall be sprinkled with an excess of sand while the film is still wet. When the film has hardened sufficiently to resist marring, the excess sand not adhering to the coatings shall be removed. Areas to be coated are:

(a) Abutments and piers that are under an expansion device in the deck shall be coated.

(b) For abutments, coatings shall be applied to the entire horizontal surface of the abutment bridge seat areas (between and around the beam pads) and all exposed surfaces of the beam pads, and the entire contiguous vertical faces of the backwalls and cheek walls.

(c) For piers, coatings shall be applied to the entire horizontal surface of pier bridge seat areas (between and around the beam pads), and all exposed surfaces of the beam pads.

425.03.03 Material Precautions. The manufacturer's Material Safety Data shall be used in handling and use of the material.

425.03.04 Repairs. Any portion of the structures damaged by the Contractor's operations in applying the protective coatings shall be repaired as directed by the Engineer, at the Contractor's expense.

425.04 MEASUREMENT AND PAYMENT. The payment will be full compensation for both coats and all material, labor, equipment, tools, and incidentals necessary to complete the work.

425.04.01 Epoxy protective coatings for concrete will not be measured but the cost will be incidental to other pertinent items specified in the Contract Documents.

425.04.02 Epoxy protective coatings for concrete will not be measured but will be paid for at the Contract lump sum price for the pertinent Epoxy Protective Coating item.

425.04.03 Epoxy protective coatings for concrete will be measured and paid for at the Contract unit price per square foot for the pertinent Epoxy Protective Coating item.

SECTION 426 - EPOXY PROTECTIVE COATING FOR METAL

426.01 DESCRIPTION. This work shall consist of furnishing and applying an electrostatically applied fusion bonded epoxy on metal surfaces as specified in the Contract Documents.

426.02 MATERIALS. Refer to 917.02

426.03 CONSTRUCTION. The coating shall be applied in an environmentally controlled plant that is fully enclosed. The coating system shall have the capabilities of preheating and post baking.

All metal surfaces shall be free of oil or any mill coating.

All metal surfaces shall be grit blasted to white metal as specified in SSPC-SP 5 using a mixture of steel shot and grit. Cleaned surfaces shall be protected from conditions of high humidity, rainfall or surface moisture. The metal surfaces shall not flash rust before coating. Blast profile shall be a uniform, angular anchor profile with a height of 2 to 5 mils (0.05 mm to 0.13

mm). Anchor pattern shall be checked with an approved surface profile gauge.

The coating material shall be applied and cured as specified by the epoxy coating manufacturer. The metal surfaces and oven temperatures shall not exceed 500 F (260 C) during any part of the curing process. The cured coating shall be of uniform color, gloss, and thickness, and shall be free of blisters, fish eyes, sags, runs and any other irregularities.

The finished coating thickness shall be 10 ±2 mils (0.25 mm ±0.05 mm) when tested as specified in SSPC PA-2 except the balls and sockets on steel sheet piling may have a lesser thickness of coating.

New bolts, nuts and washers shall be similarly coated with a thickness of 4 to 7 mils (0.10 mm to 0.18 mm). The nuts shall have oversize threads and shall fit the bolts after both are coated. The bolt heads shall be restrained from turning during torquing operations.

The coater shall be responsible for all quality control checking including visual inspection and thickness measurements and shall keep the results of each inspection in a form suitable to the Administration's representative.

The Administration's representative shall have access to each part of the process and shall have the right and opportunity to witness or perform any of the quality control tests on a random sampling basis.

A compatible touch up system shall be provided for repair of defects, all areas damaged during erection, and all visible open areas. Touch up shall be applied by the Contractor as specified below.

(a) Surface Preparation. The coating shall be applied directly to the metal surface which shall be clean, dry and free of rust and scale. Blast clean to National Association of Corrosion Engineers (NACE) near white where possible. Grease, oil, etc., shall be removed with suitable solvents. The cleaned surface shall be coated before oxidation occurs.

(b) Mixing. Mix ratio of Part A to Part B shall be as recommended by the manufacturer. The two parts shall be thoroughly mixed until a

uniform color is achieved. If thinning is required, each part shall be thinned separately with thinner recommended by the manufacturer. Material not used within the pot life recommended by the manufacturer shall be discarded.

426.03.01 Material Precautions. The manufacturer's Material Safety Data shall be used in handling and use of this material.

426.04 MEASUREMENT AND PAYMENT. Epoxy protective coating for metal will not be measured but the cost will be incidental to the pertinent items specified in the Contract Documents.

SECTIONS 427 through 494 RESERVED

SECTION 495 - APPLICATION OF BRIDGE/ STRUCTURE NUMBERS

495.01 DESCRIPTION. This work shall consist of applying Bridge/Structure numbers to all completed structures that include Bridge Standard No. BR-MAINT (0.01)-79-99 in the Contract Documents.

495.02 MATERIALS. The paint shall be suitable for the particular application and shall be selected by the Contractor subject to the approval of the Engineer.

495.03 CONSTRUCTION. The bridge/Structure Number shall be applied to the bridge/structure as a last order of work. The size, location, etc. shall conform to BR-MAINT (0.01)-79-99. All work shall be done in a neat, workmanlike manner with sharp edges differentiating between all coatings and the previous substrate. Surfaces shall be properly prepared in conformance with the paint manufacturer's recommendations. Paint shall not be applied to wet or moist surfaces.
On rehabilitation projects the Bridge/Structure Number shall be repainted if it is faded, removed or otherwise deemed necessary by the Engineer.

495.04 MEASUREMENT AND PAYMENT. Applications of Bridge/ Structure Numbers will not be measured but the cost will be incidental to the pertinent items specified in the Contract Documents.