

## Section 706. STRUCTURAL CONCRETE CONSTRUCTION

**706.01 Description.** This work consists of constructing Portland cement concrete portions of bridges, box and slab culverts, headwalls, retaining walls, and other structures. This work also consists of furnishing and installing the required items for electrical grounding systems.

When covered by the Department's Concrete Quality Assurance program this work will be accepted and paid for according to this section and the procedures described in section 605. Superstructure and substructure concrete items are treated as critical concrete QA items as defined in section 605 except, Grade T concrete items will be treated as non-critical concrete QA items. Section 604 applies to all concrete construction.

**706.02 Materials.** The materials shall meet the following requirements:

Concrete, Grades S2, T, D .....	701
Mortar and Grout .....	702
Mortar and Concrete Patching and Granular Material .....	902
Curing Materials .....	903
Insulating Blankets .....	903
Polystyrene Insulation .....	903
Steel Reinforcement .....	905
Bar Chairs and Wire Ties .....	905
Miscellaneous Metals .....	908
Geosynthetics .....	910
Premolded Fiber Joint Filler .....	914
Joint Sealants for Concrete Construction .....	914
Neoprene Joint Seals .....	914
Electrical Conduit .....	918
Electrical Grounding System .....	918
Water .....	911

For bridges, concrete placed under water shall be Grade T. All other structure concrete shall be Grade S2 unless otherwise designated.

Concrete designated as Substructure Concrete shall be Grade S2. Concrete designated as superstructure concrete and superstructure concrete, night casting shall be Grade D using 6AA natural aggregate with a maximum of 2.50 percent absorption according to ASTM C 127. No slag aggregate will be allowed.

Expansion joint devices and penetrating water repellent material must be selected from the Qualified Products List.

### 706.03 Construction.

#### A. Equipment.

- 1. Placing Equipment.** Equipment used for placing concrete shall be of such capacity and so arranged that concrete may be placed as specified in subsection 706.03.H. The

necessary equipment for concreting operations shall be available for inspection, testing, and approval prior to its anticipated use.

A tremie, pump, or other approved equipment shall be used for placing concrete under water.

The tremie shall consist of a hopper of at least 7 cubic feet capacity with a watertight discharge tube not less than 10 inches in diameter and of sufficient strength to perform the work. The lower end of the tremie shall be equipped with a suitable valve or device which shall be tightly closed while the tremie is being charged and lowered into position and which can be fully opened in the lowered position.

The pump discharge, pipe, and fittings for pumping concrete shall have a minimum inside diameter of 4 inches. Aluminum pipe will not be permitted for conveying or placing the concrete.

2. **Bridge Deck Finishing Equipment.** The self-propelled transverse finishing machine shall have sufficient width and length to finish the concrete within the specified limits, from curb to curb or from curb to bulkhead. Bridge deck finishing machines shall be equipped with rotating finishing cylinder(s), auger, drag float and other structural and mechanical requirements needed to finish the concrete within the specified tolerances. The machine or supporting frame shall transversely span the section being cast and travel in the direction of concrete placement. Equipment shall be capable of finishing concrete placed in transverse strips progressing from end to end of the span being cast. This machine shall be mounted on wheels. The wheels shall operate on longitudinal rails capable of carrying the loads between supports with a deflection of not more than  $\frac{1}{16}$  inch. The rail sections used shall be straight within  $\frac{1}{8}$  inch per foot and such that the rail grade shall not differ from the required screed grade by more than  $\frac{1}{16}$  inch. The rail shall be installed at a height above the surface being finished to allow hand floating under the rails. Each rail shall be mounted on adjustable supports that will not deflect under machine load. All rail supports shall be located over a beam. Portable, lightweight or wheeled work bridges capable of transversely spanning the section being cast for transverse finishing will be required for all machine finished deck sections.

A 3-foot lightweight, metal float and a lightweight, rigid 10-foot straightedge, each equipped with a suitable handle, will be required. Truss type vibrating screeds will be allowed when conditions (safety, configuration) warrant and when authorized by the Engineer.

3. **Concrete Saws.** The saw shall be self-propelled and capable of cutting hardened concrete neatly to the depth and line required.
4. **Other Equipment.** Pumping equipment, air compressors, vibrators, joint sealing equipment, straightedges, finishing tools, and other tools necessary for the proper placing and finishing of the concrete shall meet the approval of the Engineer.
5. **Texturing Equipment.** Texturing equipment shall be capable of producing uniform transverse grooves of the specified width, depth, and spacing.

6. **Equipment for Applying Penetrating Water Repellent Material.** Penetrating water repellent material shall be applied with low pressure (15 to 40 psi) airless-type spray equipment or with long-nap rollers.

B. **False Decking.** False decking will be constructed to the limits shown on the plans.

The materials used to construct the false deck shall be of sufficient strength to support any material or debris falling from the deck. The flooring pieces shall tightly abut each other to prevent material or debris from falling through. The flooring system shall not damage the beams and must meet the approval of the Engineer.

The false decking shall be installed following the erection of the structural steel or precast concrete beams or prior to beginning any deck removal, repair, or construction activities. No portion of the false decking system shall project below any beam bottom flange. The false decking shall be maintained in such a condition that it does not create a hazard to vehicular, pedestrian, or waterway traffic. Material or debris on the flooring outside the fascia shall be removed at least daily. The false decking shall remain in place until completion of the construction activity as directed by the Engineer.

For bridges over waterways a barge may be used in the waterway in the place of constructing a false decking system over the waterway. The barge shall be positioned appropriately in the waterway following the erection of the structural steel or precast concrete beams or prior to beginning any deck removal, deck repair, or bridge construction activities. The barge shall be maintained in such a condition that it does not create a hazard to, or impede, waterway traffic. The barge shall be of sufficient size and strength to support any material or debris falling from the deck. The barge shall remain in place until completion of the bridge construction activity as directed by the Engineer. The Engineer will judge the effectiveness of the barge in containing any material or debris falling from the deck. Should the Engineer determine that the barge is ineffective in keeping falling material and debris from entering the waterway, the Engineer shall have the right to shut down the operation and require the Contractor to construct a conventional false decking system at no additional cost to the Department.

C. **Falsework.** Falsework shall consist of designing, constructing, placing and removing temporary supports required for the construction of the permanent structure. All materials used in falsework shall be in good condition and free from defects which might impair its strength.

Submittal of working drawings and design calculations for falsework shall be in accordance with subsection 104.02. Review of the falsework and forms by the Engineer is required before any concrete is placed. Such review will not relieve the Contractor of responsibility for the adequacy and safety of the design. Welding of form supports shall be according to subsection 707.03.D.8.

Means shall be provided by the Contractor for accurately measuring and correcting any settlement in the falsework while it is being placed under load.

#### D. Forming.

1. **General.** All forms shall be built mortar-tight and sufficiently strong and rigid to allow placing, vibrating, and curing the concrete. They shall be built true to the lines designated and shall be maintained until the concrete has sufficiently hardened to permit their removal. Forms shall have net sections adequate for the weight to be sustained plus an allowance for impact. Falsework for forms shall be used according to subsection 706.03.C.
2. **Vertical Clearance.** The minimum clearance is defined as the minimum vertical distance between any point on the pavement, including 24 inches either side of the pavement, to the structure.

Every effort will be made to keep all form work above the bottom of all beams. If it is required to extend the form work below the bottom of the beam, the Contractor shall furnish and place advance warning signs at locations required by the Engineer before making any change in the existing underclearance of any structure. A period of up to 10 days shall be provided to enable the Engineer to determine the locations where the advance warning signs are to be placed.

3. **Removable Forms.** For the purpose of specifying removable forming material, surfaces to be formed are designated as Type A and Type B.

Type A surfaces shall include the exposed surfaces of piers, abutments, wing walls and retaining walls; the outside faces of girders, T-beams, slabs, columns, brackets, curbs, headwalls, barriers, railings, arch rings, spandrel walls and parapets; but excludes the bottoms of floor slabs and sidewalks, the sides of interior beams and girders, and backwalls above bridge seat.

Type B surfaces shall include all formed concrete surfaces which will not be exposed in the finished work and all exposed surfaces not included in Type A surfaces.

- a. **Type A Surface.** Face forming material for Type A surfaces shall be 5-ply structural grade western fir plywood. If the grain of 3 plies run perpendicular to the studs, the  $\frac{25}{32}$  inch thickness will be considered 1-inch nominal thickness.

In lieu of structural plywood, form lumber may be used, consisting of dressed shiplap or square edged lumber, sized 4 sides, with a minimum of  $\frac{3}{4}$  inch actual thickness covered by form lining. Form lining for either shiplap or square edge lumber shall be metal, composition or plywood. Composition or plywood linings shall be not less than  $\frac{1}{4}$  inch thick.

Forms constructed of metal, composition or special plywoods shall conform to these requirements to the extent practical. Sizing, spacing and dimensions of members of such systems are subject to the prior approval of the Engineer and continued use will be based upon satisfactory performance.

For curved Type A surfaces, the above requirements for pattern and minimum thickness of lumber may be modified by the Engineer. The inside faces of forms for Type A surfaces shall be free of holes, irregularities, or unevenness in the surface.

- b. **Type B Surface.** Face forming material for Type B surfaces shall be a minimum of  $\frac{3}{4}$  inch thick, except material may be of any type allowed for Type A surfaces. Form lining shall not be required for shiplap and square edge lumber. Square edge lumber will not be allowed for forming horizontal surfaces.
- c. **Type A and B Surfaces.** For both types of formed surfaces, used forms, or face form material, having defects which may produce work inferior to that resulting from new material shall not be used.

Studs shall be spaced not more than 12 inches, center to center, for Type A surfaces or 24 inches, center to center, for Type B surfaces and shall be nominal 2 by 6 inches or nominal 4 by 4 inches in section, except that nominal 2 by 4 inch studs may be used for pours not exceeding 3 feet 6 inches in height. They shall be capped at the top with a plate of not less than the size of the approved studs, carefully selected as to straightness.

All joints in plates shall be scabbed 4 feet each way to provide continuity.

Forms shall be of such thickness and so constructed that the forms will remain true to shape. All bolt and rivet heads occurring in the inside face of the forms shall be countersunk so that a plane smooth surface of the desired contour is obtained.

Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or which do not line up properly shall not be used. Special care shall be exercised to keep metal forms free from rust, grease, or other foreign material which will tend to discolor the concrete.

All wales shall be securely scabbed to prevent distortion during the placing and curing of concrete. A row of wales shall be placed within 6 inches of the bottom of each pour unless studding can be extended below the bottom of the pour and secured by wales fastened to rods in the previous pour.

- d. **Construction.** Forms shall be securely braced to prevent movement while placing concrete. Forms shall not be secured to concrete bridge decks or concrete pavements by mechanical or adhesive methods that will be exposed in the completed structure. All corners shall be finished square without moldings and, for exposed faces of concrete, the edges of forms at corners shall be sawed square and straight and placed to a tight fit. Chamfered corners shall be formed with dimensions measured on the sides. For Type A surfaces, the forms shall be arranged as to present a neat geometric pattern of form marks. No offset or shifting of patterns will be permitted. The forms shall be constructed such that they can be removed without damage to concrete.

Where special architectural treatment is indicated for exposed faces of retaining walls and abutments, the following shall apply. Any resulting grain marks shall run in a horizontal direction. The panels are to be 4 feet by 4 feet with double ½ inch "V" grooves along the panel edges. The use of partial size panels will not be permitted except as required to complete non-modular sized pours. Used face form lumber having defects which may produce work inferior to that resulting from new material shall not be used.

Welding to structural steel beams to support concrete deck forms shall be according to subsection 707.03.D.8.

- e. **Ties and Spreaders.** All metal appliances used inside the forms to hold them to correct alignment and location shall be constructed to permit the removal of the end portions after the removal of the forms. The ends shall be removed to a depth of at least 1 inch from the surface of the concrete and shall not create an opening greater than 1½ inches in diameter. Wire ties and pipe spreaders will not be permitted. Metal or wooden spreaders which are separate from form ties shall be entirely removed as concrete is being placed.
- f. **Form Surface Treatment.** The inside of all forms for concrete surfaces shall be treated with a release agent which will not discolor or adversely affect the concrete. The release agent shall not come in contact with steel reinforcement and existing concrete surfaces.

#### 4. Permanent Metal Deck Forms

- a. **Materials.** Fabricate permanent deck forms and supports from steel conforming to ASTM A 653 coating designation G210, any grade except Grade 50, Class 3. Galvanize fasteners according to AASHTO M 232. Fabrication of permanent metal deck forms, supports, and accessories shall meet the requirements of section 707.
- b. **Design and Fabrication.** Select sheet size for permanent metal deck forms based on the manufacturer's recommendations. The unit working stress in the steel sheet must not exceed 0.725 of the specified yield strength of the steel or 36,000 psi whichever is less.

In addition to the dead load of the form, plastic concrete, and steel reinforcement, include construction loads of 50 psf. If not required to fill corrugations with styrofoam, add to these loads the concrete which will fill the corrugations. See contract documents for details. Consider the full slab thickness, as shown on the plans, to be above the corrugations.

Design all form supports and attachments to carry the dead loads and resultant horizontal loads due to forming of cantilever overhangs. The design of the form sheets must consider the clear span of the form plus 2 inches measured parallel to the form flutes. Design for deflections, due to forms, plastic concrete, and steel reinforcement, of ¼ inch or 1/180 of the form span length, whichever is less. Do not use form camber to compensate for deflection greater than these limits.

Verify all dimensions of superstructure beams before fabrication of the permanent metal deck forms.

- c. **Construction.** Do not use metal forms below longitudinal or transverse open joints or expansion type joints.

Do not allow form sheets to rest directly on top of the beam flanges. Center each sheet in the bay and ensure a minimum bearing length of one inch at each end. Attach sheets promptly to avoid hazards that can result from lateral movement or sudden uplift of the forms. Provide safety stops where necessary.

All attachments will be made by welds, bolts, clips, or other approved means. All sheets will be attached using sheet metal screws from the top side where practical. Bolting and welding of attachments will only be allowed in top flange compression areas. Do not flame cut metal deck forms or supports. Repairing galvanized areas at welds or unbolted edges resulting from shearing or punching is not necessary.

Field drill  $\frac{1}{4}$  inch diameter weep holes, at 12 inch maximum spacing, along transverse and longitudinal construction joints.

If required, place styrofoam in corrugations and secure it so that the concrete will not displace it. Place concrete onto forms from a height no greater than 15 inches above the top of the form.

#### E. **Placing Steel Reinforcement.**

1. **Storage and Protection.** Steel reinforcement shall be stored above the ground on platforms, skids, or other supports. It shall be stored in an orderly manner and plainly marked to facilitate inspection and checking. Storage sites at river locations shall be located at elevations above the extreme high water elevation shown on the plans.
2. **Handling and Storage of Epoxy-Coated Reinforcement.** All systems for handling coated bars shall have padded contact areas. All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. All bundles of coated bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion from sags in the bundles of coated bars. The bars or bundles shall not be dropped or dragged. Coated bars shall be stored on padded wood or steel cribbing, and covered to prevent exposure to the sun's ultraviolet rays.
3. **Field Bending.** Bending of reinforcing bars shall not be done in the field except as provided on the plans or to correct minor errors or omissions in shop bending. Field bending shall be done cold. Field bends shall be made as specified for shop bending in subsection 905.03. Damage to epoxy coating as a result of field bending shall be repaired according to subsection 706.03.E.8.
4. **Placing and Fastening.** All steel reinforcement shall be accurately placed and firmly held during concrete placement. When placed in the work, it shall be free from dirt and reasonably free from excessive rust, loose mill scale, or other foreign material. Bars

shall be placed with a variation in spacing between adjacent bars of not more than  $\frac{1}{6}$  of the spacing shown on the plans, except as may be needed to permit placing of anchor bolts and position dowels. Bars shall be securely wire tied at all intersections, except that where spacing in other than top mat of deck reinforcement is such that the product of the length and width of spacing is less than 120 square inches, only alternate intersections need be tied. Welding will not be permitted. Bar laps shall be securely tied near each end of the lap. Except for deck reinforcement, the clear distance from the reinforcement to the surface of the concrete shall not be less than the dimension shown on the plans nor exceed this dimension by more than 25 percent. For deck reinforcement, the distance from the top transverse reinforcement to the bottom of the concrete slab shall not vary more than  $\frac{3}{8}$  inch from the plan dimension. The concrete clear cover over the top transverse reinforcement shall not be less than the dimension shown on the plans.

Except in bridge superstructures, the specified distances of the reinforcement from the forms shall be maintained by means of stays, ties, hangers, bar chairs, or other approved supports. Supports for holding reinforcement shall be approved plastic or coated metal chairs. Chairs supported on the forms shall have sufficient bearing area to prevent undue penetration into the forming material. Commercial grade concrete brick will be permitted in footings only.

For bridge decks, place the bar chairs parallel to the beam and space with the lines of supports (measured between beam centers) at approximately the  $\frac{1}{4}$  and  $\frac{3}{4}$  points for beam spacings less than 9 feet and at approximately the  $\frac{1}{6}$ ,  $\frac{1}{2}$  and  $\frac{5}{6}$  points for beam spacings 9 feet and over. Additional bar chairs are required outside the fascia beam to support the reinforcing steel along and near the fascia. On concrete box beam bridges without slab ties, a bar chair will be required along the longitudinal centerline of each beam. The upper layer of reinforcing steel shall be supported over the supports for the lower layer of steel with rows of approved continuous steel bar supports consisting of a minimum of 3 longitudinal wires. The upper layer of reinforcing steel shall be securely tied to the structural steel, stud shear developers, or other structural components at not greater than 5 feet intervals along each beam or girder. Tie-downs shall consist of two loops of 16 gauge tie wire. Coated bars shall be tied with coated tie wire that will not damage or cut the coating.

Epoxy coated reinforcement placed in the deck shall be covered to prevent exposure to the sun's ultraviolet rays when the concrete for the deck has not been cast within two months from the time of placing the epoxy coated reinforcement.

5. **Splicing.** Bars shall not be spliced except as provided for on the plans.
6. **Lapping.** Sheets of mesh or bar mat reinforcement shall overlap each other a minimum of 24 inches to maintain a uniform strength and shall be securely fastened in at least two locations at the overlaps.
7. **Cutting Epoxy-Coated Reinforcement.** Bars permitted to be cut shall be either sawed or sheared. Cut or sheared ends of bars shall be repaired.

8. **Repair of Epoxy Coating.** The Contractor shall be responsible for repair of the coating due to bending, sawing, shearing, or damage during shipping, unloading, storage, installation, and handling at the construction site.

Patch all sawed or sheared ends and any defects in the coating that are discernable to the unaided eye with a patching/repair material selected from the Qualified Products List according to AASHTO M 284. Clean areas to be patched by removing all surface contaminants and damaged coating. Roughen the area to be patched before applying the patching material. Where rust is present, remove the rust by blast cleaning or power tool cleaning immediately before applying the patching material.

Promptly treat the bar according to the resin manufacturer's recommendations and before detrimental oxidation occurs. Overlap the patching material onto the original coating for 2 inches or as recommended by the manufacturer. Provide a minimum 8 mils dry film thickness on the patched areas. Field repairs will not be allowed on bars that have severely damaged coatings. Replace bars with severely damaged coatings. A severely damaged coating is defined as a coating with a total damaged area in any 12 inches length of bar that exceeds 5 percent of that surface area of that portion of the bar. Coat mechanical splices after splice installation according to AASHTO M 284 for patching damaged epoxy coatings.

- F. **Placing Galvanized Metal Pipe Sleeves.** Galvanized metal pipe sleeves shall be placed in the bridge to carry facilities of utility companies across the bridge. The pipe sleeves will be furnished at the bridge site by the utility company at no cost to the Contractor. The Contractor shall notify the utility company at least one week prior to needing the sleeves.

No additional payment will be allowed for inconveniences or delays caused by the operations of the utility company.

- G. **Placing Conduit.** Conduit shall be accurately placed in the position shown and firmly held during the placing of the concrete. The conduit shall be carefully aligned, and all joints fitted tightly. The sleeve expansion joints in the superstructure shall be carefully assembled and protected to permit movement after the concrete encasement is placed. The concrete encasement shall not be placed until the alignment of, and connection to, the conduits have been approved. The Contractor shall swab the conduit for its entire length immediately after casting the encasement to remove any mortar which may have entered the conduit.

When the plans or proposal provide for a utility company to install conduit or ducts in the structure, the Contractor shall notify the utility company at least one week in advance of the time that the utility company will be required to install their conduit or ducts. No additional payment will be allowed the Contractor for additional work of forming for conduit or ducts.

- H. **Placing Concrete.**

1. **General.** Forms, bracing, reinforcing steel, and preparations for casting concrete shall be approved prior to starting concrete placing operations. At the time concrete is placed, the forms, piling, and reinforcing steel shall be clean, and all sawdust, chips and other debris shall have been removed from the interior of the forms. Struts, stays, and

braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their location, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. The concrete shall be promptly placed with minimum handling to avoid segregation of the materials and the displacement of the reinforcement. Except for concrete sub-footings, each pour shall be completed in a continuous operation with no interruption in excess of 45 minutes between placing contiguous portions of concrete. Each layer shall be placed and consolidated before the preceding layer has taken initial set. For concrete subfootings, the placing of a full-depth portion of the subfooting for a substructure unit at one time and completion at a later time will be allowed.

No additional concrete shall be placed on substructure concrete until the substructure concrete has been properly cured for at least three days or the substructure concrete has attained at least 70 percent of its minimum 28-day flexural or compressive strength according to subsection 701.03.G and Table 701-1. Mechanical attachment to substructure concrete shall not be used to support forms until the substructure concrete has attained at least 70 percent of its minimum 28-day flexural or compressive strength according to subsection 701.03.G and Table 701-1. The Engineer will lower the required concrete strength provided the Contractor submits acceptable engineering calculations by a Professional Engineer licensed in the State of Michigan showing that the imposed loads will not exceed 70 percent of the concrete strength at the time the load is applied. The Contractor shall verify the existing concrete strength by testing at least two beams or cylinders cured in the same environment as the concrete items they represent. The testing shall be done on the project site and shall be witnessed by the Engineer.

The top of concrete subfootings shall be cast within ½ inch of plan elevation.

Concrete placement shall be so regulated that the pressures caused by wet concrete shall not exceed those used in the design of the forms.

The concrete shall be deposited in the forms in layers of suitable thickness and to as near final position as possible. The layers shall be not more than 12 inches in thickness in pier caps and wall sections, unless otherwise approved by the Engineer. The requirement for wall sections may be modified depending on the spacing of steel reinforcement.

For concrete placed by pumping, any water-cement slurry used to lubricate the inside of the discharge pipe at the beginning of a pour shall be disposed of outside the forms.

All concrete for substructure units other than subfootings and tremie seals shall be placed in the dry and vibrated.

Subfooting and tremie concrete shall be placed full depth of the section being constructed. Place footing concrete and column concrete in layers not to exceed 36 inches.

Concrete shall not be allowed to freefall more than 5 feet, except superstructure concrete shall not be allowed to freefall more than 6 inches to the top of reinforcing steel. When concrete is dropped more than 5 feet, the concrete shall be deposited through approved pipes or tubes which are at least 6 inches in diameter and which are arranged to avoid segregation of the concrete. When the reinforcing bars are spaced so close that a 6 inch tube cannot be used, the bar ties shall be loosened and the bars spread enough to permit the use of the tube or chute. Before the bars are covered with concrete, they shall be placed back in the correct position and tied.

Mechanical, high-frequency internal vibrators shall be used to consolidate the concrete during and immediately after depositing. Where epoxy coated or other coated reinforcement is used, the vibrator head shall be rubber coated to prevent damage to the coating. The consolidation of concrete by hand methods will be permitted only where the use of vibratory equipment is not feasible. The vibrators shall be of a type approved by the Engineer and shall be capable of visibly affecting an approved mixture for a distance of at least 18 inches from the vibrator. Sufficient vibrators shall be used to properly compact the incoming concrete within 15 minutes after placing.

Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation.

Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. The application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibrators shall not be held against the forms or reinforcing steel, nor shall they be used for flowing the concrete or spreading it into place. Care shall be used not to disturb partially hardened concrete.

After the initial set of the concrete, the forms and the projecting reinforcement shall not be disturbed.

All forms and reinforcing steel above concrete being placed, and all placing equipment shall be kept clean and free from coatings of hardened concrete. Water used for flushing the placing equipment shall be discharged clear of the concrete and forms.

If concreting operations are permitted to extend into the night, the work shall be lighted so that all operations are plainly visible for inspection. Sidewalk, curb, or barrier pours shall not be cast until deck concrete has attained at least 75 percent of its minimum 28-day flexural or compressive strength according to subsection 701.03.G and Table 701-1.

Heavy equipment, such as mixers and slip-form machines, will not be permitted on the deck until the deck concrete has reached an age of at least seven days and then not until the concrete has attained at least 100 percent of its minimum 28-day flexural or compressive strength according to subsection 701.03.G and Table 701-1.

2. **Hot Weather Limitations.** Concrete mixtures used in bridge decks may be cast when the combination of air temperature, temperature of the concrete, relative humidity and wind velocity at the site are such that the rate of evaporation is not more than 0.20 psf per hour, determined from Table 706-1. No structural concrete shall be cast when the temperature of the concrete is above 90 °F.

The Contractor shall supply approved equipment for determining the relative humidity and wind velocity at the site.

3. **Placing Concrete Under Water.** Concrete may be deposited under water when provided on the plans. Concrete deposited in water shall be Grade T as specified in Table 701-1. It shall be carefully placed in a compact mass, in its final position, by means of a tremie or by pumping and shall not be disturbed after being deposited. Bottom dump buckets will not be permitted. Still water shall be maintained at the point of deposit, and the forms under water shall be tight.

The tremie tube shall be supported to permit free movement of the discharge end over the entire surface of the work and to permit rapid raising or lowering to adjust the flow of concrete. The concrete shall be placed full depth in one continuous operation, completing the work to grade progressively from one end of the cofferdam to the other. The tremie tube shall be kept in the freshly deposited concrete at all times, being withdrawn only at the completion of each pour, or as required by piling or cofferdam bracing. After withdrawing the tremie tube, it shall be recharged with concrete above water and lowered to the new position at a point where the discharge end can be set into the freshly deposited concrete. During placing operations, the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by raising the discharge end of the tube slightly, but not out of the concrete. The tremie tube shall be equipped such that the bottom end will be closed when the pipe is not enclosed in concrete.

Cofferdams shall not be dewatered until the tremie concrete has been placed and has attained at least 50 percent of its minimum 28-day compressive strength as determined in subsection 701.03.G and Table 701-1, or until it is determined by breaking test beams, cured in water on top of the tremie concrete, that the modulus of rupture is at least 325 psi. The above requirement shall in no way be construed as relieving the Contractor of the responsibility for failure in any part of the cofferdam.

To insure a clean surface of top of tremie concrete, all laitance or other unsatisfactory material shall be removed by means which will not result in structural damage. A tolerance of +6 inches or -0 inch will be allowed at the elevation of the top of tremie seals. All concrete in excess of this tolerance shall be removed.

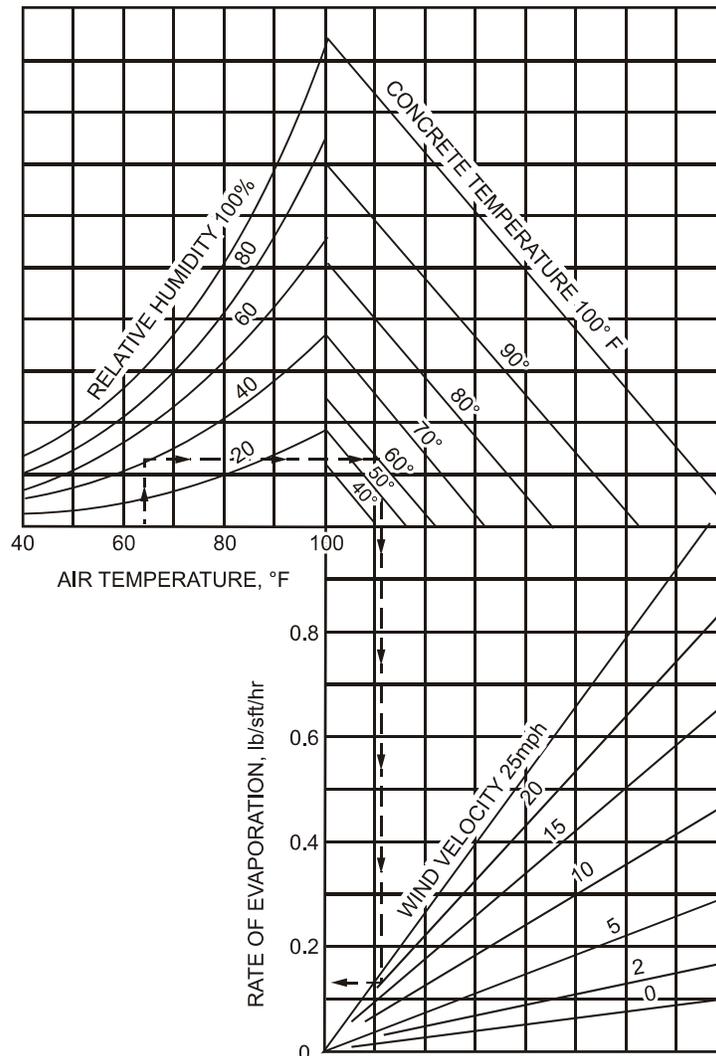


Table 706-1 Surface Evaporation from Concrete

To estimate rate of evaporation:

1. Enter with air temperature, measured at a level about 4-6 feet above the evaporating surface, on its windward side and shielded from the sun, then move up to relative humidity.
2. Move right to line corresponding to the concrete temperature.
3. Move down to line approximating wind velocity, measured at a level about 18 inches above the evaporating surface.
4. Read evaporation rate on scale to left of this point.

- I. **Nighttime Casting of Superstructure Concrete.** The following restrictions apply for all designated deck slab pours.

1. **Construction Methods.** Cast concrete deck slab pours at night with work starting between one hour after sunset and midnight or as designated by the Engineer. The time of sunset shall be that time published by the National Weather Service for the date of the proposed night casting or will be determined by the Engineer if the National Weather Service sunset time is not available. The Contractor shall coordinate nighttime deck pours with other contract work assigned to the Engineer to allow scheduling of the required inspection.

The deck pouring sequence and curing requirements shall be strictly observed as shown on the plans and outlined in these specifications. If approved by the Engineer, pours shown to be done simultaneously may be done consecutively that night using adequate retarder in the first pour to prevent initial set until the second pour is completed.

2. **Lighting Requirements.** The work area shall be lighted to an average intensity of 10 foot candles minimum. Sufficient light sources shall be provided to achieve this illumination requirement. The deck lighting scheme shall be submitted to the Engineer for approval. Lighting alignment shall not interfere with or impede traffic on open roadways.

- J. **Cold Weather Precautions.** The concrete shall be protected to prevent damage from cold weather. Frozen concrete or concrete damaged by cold weather will be rejected and shall be removed and replaced at the Contractor's expense.

The requirements for the protection of concrete specified under Ordinary Protection will be required when official US Weather Bureau forecasts indicate that the air temperature will remain below 50 °F, but not below 40 °F.

The requirements for the protection of concrete specified under Low Temperature Protection will be required when official US Weather Bureau forecasts indicate that the air temperatures will be below 40 °F.

All curing requirements specified in subsection 706.03.N.1 shall apply, except that only one application of interim curing compound is required.

1. **Ordinary Protection.** Ordinary protection of concrete consists of protection by means of tarpaulins, straw covering, or other approved means. At times when the prevailing temperature will produce concrete of less than 45 °F, the temperature of the concrete shall be raised as specified in subsection 701.03.C.1.

Keyways, anchor bolt wells or other depressions on exposed horizontal surfaces shall be sealed against the admission of water. Footings may be protected by being completely and continuously submerged under water inside the cofferdam area, when permitted by the Engineer. Submersion shall not take place until two hours after

concrete has been placed. After submersion, sufficient water shall be maintained to cover the concrete, and to keep any ice from coming in direct contact with the concrete.

2. **Low Temperature Protection.** Protection of concrete from low temperatures shall be accomplished by the use of insulated forms or by heating and housing. The requirements concerning the temperature of the concrete at the time of placing in the forms shall be as specified in subsection 701.03.D. The concrete temperature shall be maintained at a minimum temperature of 40 °F.
- a. **Insulated Forms-Substructure Concrete.** Blanket insulation shall be applied tightly against the forms and fastened securely. The corners at edges and ends shall be well insulated. When depositing concrete against previously cast concrete, the blanket insulation shall be extended at least 14 inches and securely held in place against the previously cast concrete. Any tears or holes in the blanket shall be patched or covered.

Polystyrene insulation shall be cut in widths to fit snugly between studs of wood forms and shall be fastened securely. In the case of steel forms the insulation boards shall fit tightly between the ribs and shall be held in place by adhesive or approved fasteners.

The insulating blankets or polystyrene insulation shall have either the minimum thickness or the minimum R value shown in Table 706-2.

**Table 706-2 Insulation Requirements**

Insulation Requirements, Minimum				
Thickness of Pour, inches	For Unlined Steel Forms		For Wood-Lined Steel or Wood Forms	
	inches	R Value	inches	R Value
12 or less	2	7.0	2	5.25
12 to 24	2	7.0	1-1/2	5.25
More than 24	1 -1/2	5.25	1	4.0

Forms shall be free of ice, snow and frost at the time of casting concrete. No substructure concrete shall be placed when the atmospheric temperature is below 35 °F, unless the interior of the forms, metal surfaces, and the surface of the concrete adjacent to the new pour are preheated to that temperature or higher. Heating by direct flame will be permitted with gas fired burners only. No substructure concrete shall be cast using insulated forms when the atmospheric temperature is below 15 °F; except that subfootings, footings, and cast-in-place concrete piles may be cast when the atmospheric temperature is above 0 °F. Exposed portions of cast-in-place concrete piles shall be carefully wrapped in insulating blankets or protected with straw.

The top of all pours shall be covered with insulating blankets, except for inaccessible areas around protruding reinforcing bars, which may be covered with

hay or straw; the tops of such pours, including the insulation, shall then be covered with tarpaulins or other approved material.

The insulated forms shall remain in place until the concrete has attained at least 50 percent of its minimum 28-day flexural or compressive strength according to subsection 701.03.G and Table 701-1. Loosening of forms for the purpose of lowering temperatures will not be permitted except at the direction of the Engineer. The blankets or straw may be removed from the tops of footings, on or after the third day after casting, only as necessary to permit forming of subsequent portions of the unit. The approval of the Engineer shall be obtained before loosening forms or removing the top covering. The form shall not be removed before the end of five full days after the final placement of concrete in an individual unit. However, when the outside air temperature is 0 °F or below, or when the weather forecast for the next 24 hours is for 0 °F or below, the forms shall not be removed until the eighth day after casting unless otherwise directed by the Engineer, and then only when the outside temperature is between 0 °F and 32 °F provided the temperature difference between the air and the concrete surface is not more than 30 °F. If possible, forms shall be removed about the middle of the day to take advantage of the generally higher afternoon temperatures and radiant heat of the sun.

- b. **Insulated Forms-Superstructure Concrete.** No superstructure concrete shall be placed when the atmospheric temperature is below 40 °F, unless the interior of the forms, metal surfaces and the surface of the concrete adjacent to the new pour are preheated to that temperature or higher. Heating by direct flame will be permitted with gas fired burners only. Placing of superstructure concrete shall not be started when the atmospheric temperature is below 35 °F.

The bottom of deck forms need not be insulated. The top of the freshly cast concrete shall be protected as soon as possible with insulating blankets or polystyrene insulation in order to maintain a minimum concrete temperature of 40 °F. Joints between insulation material shall be tightly joined. See Table 706-2 for insulation requirements.

Tarpaulins or other suitable material shall be hung from the top of the curb fascia so that the entire section being protected is enclosed. Any time the temperature falls below 15 °F during the curing period, heated air shall be circulated under the enclosed portion of superstructure being protected. It shall be maintained for the remainder of the protection period specified for concrete protected by heating and housing.

When the US Weather Bureau forecast indicates that the temperature will go below 20 °F during the curing period, the Contractor shall have sufficient material and heating equipment available on the job site to comply with the previous requirements.

- c. **Heating and Housing.** Before placing concrete in the forms satisfactory housing shall be provided for the section of concrete to be placed so that the temperatures specified can be maintained within the enclosure.

Enclosures shall be arranged to permit removal of forms and finishing of concrete surfaces without interruption of heating.

The heating system shall be arranged to provide uniform heating by forced air or radiation within the enclosure. The heating system shall be vented to prevent direct contact of carbon dioxide exhaust gases with the placing and curing of the concrete. Before placing any concrete, the reinforcing steel and form surfaces shall be preheated, to a temperature between 40 °F and 75 °F.

During and after the period of placing concrete, the heating system shall be operated to maintain the temperature of the air within the enclosure between 40 °F and 75 °F. Temperatures shall be maintained within the enclosure until the concrete has attained at least 50 percent of its minimum 28-day flexural or compressive strength according to subsection 701.03.G and Table 701-1.

At the close of the heating period, the temperature shall be decreased to the approximate temperature of the outside air at a rate not to exceed 15 °F per 12-hour period, after which the housing may be removed. The surface of the concrete shall be permitted to dry during the cooling period.

In the event of heating system failure, emergency salamanders shall be available within an hour. These salamanders shall be capable of maintaining a minimum temperature of 40 °F. The salamanders shall be located and operated, and provision for moisture shall be made, as required by the Engineer.

- K. **Construction and Expansion Joints.** Joints in concrete structures shall be constructed only where provided on the plans. The contact surface of concrete already in place shall be thoroughly cleaned of laitence and other objectionable material and shall be thoroughly wetted before placing new concrete. The face edges of all joints shall be carefully finished true to line and elevation. The surface of joints which provide for expansion in the plane of the joint shall be finished to within  $\frac{1}{8}$  inch tolerance with respect to a true plane. Keys shall be formed within reasonable tolerances, using suitable material.
1. **Sealer.** Poured joint sealers shall be of the type shown on the plans or specified in the proposal. Where hot-poured or cold-applied joint sealer is specified, the material handling requirements shall be as specified in subsection 602.03.S.
  2. **Fiber Joint Filler.** Premolded expansion joint material shall be accurately shaped to fit the adjacent concrete. It shall be securely held in place to prevent formation of fins of concrete under or between sections of the material.
  3. **Joint Seals.** For joints in concrete the seals shall be installed as shown on the plans.
    - a. **Sawing Construction Joints.** The joint groove at each transverse construction joint shall be sawed to the dimensions shown on the plans. The joint groove shall be symmetrical about the construction joint.

- b. **Sawing Expansion Joints** The expansion joint groove shall be sawed to the dimensions shown on the plans, and shall be symmetrical about the centerline of the filler.

If the saw cut does not make contact with the filler used to form the lower part of the joint, the depth of the saw cut shall be increased until it extends below the top of the filler.

Vertical sections of the joint in the curb or sidewalk may be sawed or formed.

- c. **Cleaning After Sawing.** All deleterious material that may damage adjacent concrete by blocking the sawed joint or preclude later satisfactory operation or cleaning of the joint shall be removed immediately after the sawing operation is completed.
- d. **Patching Transverse Joints.** The patching of transverse joints shall be done as specified in subsection 602.03.P.
- e. **Installing Seals.** The top of the installed seal shall be  $\frac{1}{4}$  inch below the surface of the deck.

#### 4. **Expansion Joint Devices.**

The Contractor shall inform the Engineer which expansion joint devices are selected for each location. The Engineer will furnish the standard shop drawings of the joint device. These drawings will be general and will not include dimensions peculiar to the specific installation. These dimensions will be the responsibility of the Contractor and will not be reviewed by the Department.

The devices shall be installed as shown on the plans and the standard shop drawings. The joint seal shall be installed in one continuous piece for the length of the joint as shown on the plans and according to manufacturer's recommendations.

All welding shall be according to subsection 707.03.D.8.

All epoxy shall be certified and dated.

- L. **Placing Anchor Bolts and Position Dowels in Concrete.** Anchor bolts and position dowels shall be accurately set in concrete either by use of a template during casting of the concrete or, when permitted on the plans, by drilling holes in the hardened concrete according to subsections 712.03.J and K.

The surface around anchor bolts or position dowels shall be finished according to subsection 706.03.M.2.

- M. **Finishing Plastic Concrete.** Care shall be taken to avoid over-vibration or over-finishing of the completed surface. Water may be applied to the surface of the concrete as an aid to finishing only by means of an approved fog sprayer and then only when approved by the

Engineer. After finishing, sidewalks and curbs shall be textured in a transverse direction with a broom to produce uniform, thin, narrow grooves not over  $\frac{1}{8}$  inch in depth. The final deck surface shall be textured according to subsection 706.03.M.3.

1. **Machine Finishing.** A self-propelled transverse finishing machine will be required for striking off and finishing the concrete surfaces which will be subject to highway traffic. In order to accommodate the type of finishing machine being used, the Engineer may authorize elimination of longitudinal construction joints called for on the plans.

Just prior to beginning the placement of concrete, the finishing machine shall be operated over the full length or width of the bridge segment to be paved. This test run shall be made with the screed adjusted to its finishing position. While operating the finishing machine in this test, the screed shall be checked for deflection and proper adjustment. The depth of the reinforcement below the screed, the controlling dimensions of deck reinforcement and forms shall be measured and recorded. All necessary corrections shall be made before any concrete is placed.

When finishing concrete surfaces, the screed shall complete sufficient passes with ample material along the entire leading edge to ensure filling low spots. The final pass of the screed shall leave the surface at the proper grade and free from water and latence. Care shall be taken to remove all objectionable material from the gutters, where final hand finishing will be permitted.

As soon as practical the work bridge shall be placed behind the finishing machine.

While the concrete is still plastic, the Contractor shall test the slab surface for trueness by means of a 10-foot straightedge or other suitable methods approved by the Engineer. The Contractor is to finish the surface in order to meet the required specification and cross section. Truss type vibrating screeds will be allowed when conditions (safety, configuration) warrant and when authorized by the Engineer.

The supports for the rails, when located in the concrete, shall be the type which can be removed without disturbing the concrete, or partially removed so that no part remains less than 3 inches below the finished concrete surface. Such supports shall be removed and the resulting holes filled with concrete and finished flush with the deck concrete before the deck concrete has hardened.

2. **Hand Floated Surface Finish.** On areas not required to be finished by machine, such as bridge seats, sidewalks, areas of bridge decks under sidewalks, and other similar surfaces, a floated surface finish will be required. Such finishing shall be accomplished by striking off the concrete surface with a screed accurately set to the required cross section. Vibrating or oscillating screeds may be used when conditions permit, at the option of the Contractor. The screed shall move on suitable guides set to the required elevation for the finished surface with proper allowance for camber, if required. After striking off, the surface shall be finished with a wooden or magnesium float.

The concrete surface under elastomeric bearings shall be given a broom finish.

3. **Texturing.** The final deck surface shall be grooved as soon as the deck concrete has set sufficiently to maintain a texture. The grooves shall be constructed perpendicular to the centerline or shall be skewed, not to exceed the maximum angle of skew of the bridge. The grooves shall be formed in the plastic concrete while the concrete is in such condition that the grooves will be formed cleanly without either slumping of the edges or tearing of the surface. The grooving shall end at a distance of 12 inches to 16 inches from the edge of the curb or barrier. The deck shall not be grooved within 3 inches to 6 inches of the expansion or contraction joints or at the end of the slab. The desired surface texture consists of grooves spaced on  $\frac{1}{2}$  inch centers,  $\frac{1}{8}$  inch wide, and  $\frac{1}{8}$  inch deep. Some randomness in spacing is allowed, provided that the spacing between grooves remains within the range of  $\frac{1}{4}$  inch to 1 inch.

Deck surfaces not grooved to the specified requirements may be required to be removed and replaced. Concrete decks permitted to remain in place but having grooves which are too shallow shall be regrooved after the concrete has attained its designed strength. The grooving shall be done with blades mounted on a machine built expressly for grooving pavements. Grooving blades shall be  $0.095 \pm 0.003$  inch wide and spaced randomly from  $\frac{3}{4}$  inch to  $1\frac{1}{4}$  inch on centers. The grooves shall be in the same orientation as the initial grooving oriented at right angles to the centerline of the pavement and cut uniformly to a depth of  $\frac{1}{8}$  inch.

The residue from the grooving operations shall be removed and disposed of as approved by the Engineer to avoid dust and to prevent debris from entering drainage systems.

4. **Surface Tolerances.** As soon as practicable, the surfaces shall be checked and, if not within the specified tolerances, shall be ground with a carborundum brick or by other approved methods to meet the specified surface requirements. If grinding to obtain specified evenness results in an elevation below acceptable limits, corrective measures shall be taken as directed by the Engineer.

Bridge seats shall be finished without unevenness of more than  $\frac{1}{16}$  inch under any bearing or masonry plate, nor deviation from established elevation of more than  $\frac{1}{8}$  inch.

Concrete subfootings shall be cast to within  $\frac{1}{2}$  inch of plan elevation and footings, wingwalls, parapets, slope walls, headers and similar surfaces shall be finished to within  $\frac{1}{4}$  inch of plan elevation.

For final deck surfaces, the decks shall be cast to a surface tolerance of  $\frac{1}{8}$  inch in 10 feet. Prior to acceptance, they will be straightedged with a 10-foot straightedge by the Engineer. All high spots or ridges exceeding  $\frac{1}{8}$  inch, or other defects, will be plainly marked and shall be removed or reduced by rubbing with a carborundum brick and water, or by grinding, and then regrooved to meet the grooving requirements.

- N. **Curing.** For air temperatures below 40 °F, structural concrete shall be cured according to subsection 706.03.J. When the air temperature is 40 °F or higher, structural concrete shall be cured as follows.

## 1. Top Surfaces Exposed in the Completed Structure.

- a. **Other than Bridge Decks.** Immediately upon completion of concrete finishing operations, the curing compound shall be applied by spraying uniformly on the concrete surface. Unless otherwise specified, the Contractor may use either transparent or white membrane curing compound. If using white membrane curing compound, the application rate shall not be less than 1 gallon of compound per 150 square feet. If using transparent membrane curing compound, the application rate shall be applied in two coats at a rate of not less than one gallon of compound per 300 square feet of surface for each coat. The second coat shall be applied as soon as the first coat becomes sufficiently dry to avoid runoff but in any case, within two hours after application of the first coat. The curing compound shall not be diluted.
- b. **Bridge Decks.** Curing shall consist of a two-phase continuous 7-day wet cure procedure. Prior to commencement of concreting operations, the Contractor shall demonstrate that all curing materials and equipment are on-site and in proper operating condition.

The first phase of the curing procedure shall consist of a spray application of curing compound meeting the requirements specified in section 903. Curing compound shall be applied in a single application beginning immediately after the sheen of bleed water has left the textured concrete surface. The curing compound application rate shall not be less than 1 gallon per 150 square feet of surface. Application of curing compound shall progress so as not to leave more than 10 feet of textured concrete surface exposed without curing compound at any time.

The second phase of curing procedure shall consist of covering the concrete surface with clean, contaminate-free wet burlap as soon as the curing compound has dried sufficiently to prevent adhesion, and the concrete surface will support it without deformation, but not more than two hours after the concrete was cast. A minimum of 12 hours prior to commencement of concreting operations, the burlap shall be continuously soaked in clean water. Prior to its use, the burlap sheeting shall be draped or suspended vertically for sufficient time to remove any excess water from its surface which may dilute or damage the fresh concrete, however, the burlap shall not be permitted to dry. The in-place burlap shall also not be permitted to dry. Burlap or other similar products with impervious surfaces are not permitted.

A network of soaker hoses shall be installed over the wet burlap as soon as the concrete surface will support it without deformation. Soaker hoses shall be perforated throughout their lengths, within the limits of curing, and shall be capable of discharging sufficient curing water to uniformly and continuously cover the entire bridge deck surface without having to be periodically relocated. Perforations shall be sized so as to prevent excessive localized discharge of water which may damage the concrete surface. Non-perforated hose shall be used outside the limits of the bridge deck curing. The Contractor shall demonstrate to the Engineer that the soaker hose system provides uniform and thorough coverage of the entire deck surface. A continuous layer of 4 mils polyethylene film (transparent or white color) shall then be securely placed over the entire deck surface and the soaker hose

system. All seams shall overlap 10 inches minimum. The water supply, meeting the requirements of section 911, shall then be activated and maintained to ensure complete and uninterrupted wet curing of the entire deck surface for the remainder of the first seven days following concrete placement. The Contractor shall control the water runoff so as not to cause traffic hazard or soil erosion problems. The curing water runoff shall not be discharged into surface waters.

The continue wet cure shall be maintained until the concrete has reached an age of at least 7 days, and until the concrete has attained its minimum 7-day compressive strength according to section 701 and Table 701-1. Strength results achieved prior to seven days shall not be considered basis for removal of the continuous wet cure prior to the completion of the 7-day continuous wet curing period.

2. **Top Surfaces to Which Succeeding Portions of the Structure Will Be Bonded.** Top surfaces on which succeeding portions of the structure (medians, shoulders, sidewalks, parapets, membrane waterproofing, and latex or other overlayments) will be placed, shall be kept free of curing compound. These surfaces shall be cured by being kept continuously wet for a minimum of seven days and until the concrete has attained its minimum 7-day flexural strength according to subsection 701.03.G and Table 701-1. The curing may be discontinued when casting the succeeding portion of structure. The wet curing shall be started as soon as the concrete has hardened sufficiently to prevent marring or water damage.
3. **All Surfaces Other than Top Surfaces.** All surfaces other than top surfaces shall be cured by being kept continuously wet a minimum of 5 days and until the concrete has attained at least 70 percent of its minimum 28-day flexural strength according to subsection 701.03.G and Table 701-1. Alternately, the concrete may be cured by leaving forms or other waterproof devices in place during the curing period or by the application of transparent membrane curing compound for structures, except as follows. Membrane curing compound shall not be used on surfaces which are required to be cured by the application of water, to which other concrete is to be bonded, or to surfaces to which joint waterproofing or protective coatings are to be applied. Surfaces of steel dowels, anchors, waterstop, and similar devices shall be free of curing compound at the time of encasement.

The transparent membrane curing compound for structures shall be applied in two coats at the rate of not less than one gallon of compound per 300 square feet of surface for each coat. The first coat shall be applied immediately after removal of the forms. The second coat shall be applied not less than thirty minutes nor more than two hours after the application of the first coat.

The curing compound shall be applied by brush, roller or spraying equipment capable of producing a continuous, uniform film, without the compound running or sagging. The spray equipment shall be approved by the Engineer before it is used on the work.

Should the method of applying the compound not produce a uniform film, the use of curing compound shall be discontinued and the curing shall be done by keeping the concrete surface continuously wet for the specified curing period.

- O. **Removal of Falsework and Temporary Supports.** Falsework and temporary supports supporting concrete structures, other than railings, shall remain in place for a minimum of five days and until the concrete has attained at least 70 percent of its minimum 28-day compressive strength according to subsection 701.03.G and Table 701-1. Falsework for railings may be removed after 15 hours unless otherwise directed by the Engineer.

All materials used in connection with falsework shall be removed to the bed of the stream, except that such construction as is located outside of low water limits shall be removed to not less than 6 inches below the finished ground surface.

- P. **Removing Forms.** Vertical forms, including bulkheads at construction joints, shall not be removed for a period of 15 hours after the pour is completed. The removal of forms under slab spans, beams, girders and brackets shall be governed by the requirements for the removal of falsework supporting concrete structures according to subsection 706.03.O. Where forms are braced against portions of the finished work, which are subject to movement due to temperature changes, the restraining falsework shall be removed or adjusted to prevent damage to the new work from such movement.

- Q. **Placing Beams on Substructure Units.** Do not place beams until the substructure concrete has obtained at least 70 percent of its minimum 28-day flexural or compressive strength according to subsection 701.03.G and Table 701-1.

R. **Finishing Hardened Concrete.**

1. **General.** All fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or waterproofed. On all surfaces, honeycomb areas, broken corners or edges, cavities produced by form ties, other defects, and all holes more than  $\frac{3}{4}$  inch in diameter and  $\frac{3}{8}$  inch in depth shall be thoroughly cleaned, and after having been kept saturated with water shall be carefully pointed and trued with Type II mortar. The mortar shall be composed of cement and fine aggregate mixed in the proportions used in the grade of concrete being finished. Mortar used in pointing shall be a workable mix which has been prepared sufficiently in advance of use to permit it to attain its initial set. Consistency may be restored by reworking but not by retempering. The cement shall be a mixture composed of  $\frac{2}{3}$  of the same brand used in the concrete and  $\frac{1}{3}$  white cement. The fine aggregate shall be from the same source as that used in the concrete. The mortar patches shall be cured according to subsection 706.03.N.
2. **Rubbed Surface Finish.** When a rubbed surface finish is called for on the plans, the rubbing shall be started as soon as possible after the forms have been removed. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for a minimum period of one hour. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing of rod holes and defects to set so it will not be damaged with water during the saturation period. Surfaces to be

finished shall be rubbed with a medium-coarse carborundum stone. The surface shall not be painted or plastered with either neat cement or mortar. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time.

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

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

- S. **Penetrating Water Repellent Treatment.** Penetrating water repellent shall be selected from the Qualified Products List. The Contractor shall supply the Engineer with the product data sheets before the material is applied. The product data sheets shall indicate the manufacturer's recommended surface preparation, application procedure and temperature range.

Unless adjacent steel surfaces are to be coated after the concrete is cleaned, they shall be protected to prevent damage. Should damage occur, it shall be repaired at the Contractor's expense. Damage to the coating system shall be repaired as specified on the plans or in the proposal.

1. **Application.** The penetrating water repellent material shall be applied at the application rate specified in the Qualified Products List. The material shall be applied according to the manufacturer's recommendations. The penetrating water repellent material shall be used as supplied by the manufacturer and not diluted or altered in any manner.
2. **Limitations.** The concrete shall not be treated until it has cured a minimum of seven days. During the final 48 hours of the curing period, the concrete shall be allowed to air dry. The concrete surface shall be dry at the time the penetrating water repellent material is applied.

The penetrating water repellent material shall be applied when the concrete or air temperature is within the range recommended by the manufacturer, but in no case less than 40 °F.

The material shall not be sprayed when wind, rain, or other conditions prevent proper application.

- T. **Electrical Grounding System.** All work shall be done by licensed electricians experienced in grounding system installations. Bonding jumpers shall be welded across the steel structure at the expansion joints and across the steel fence posts at the expansion joints. The grounding cable shall be installed down the piers or abutments from the bonding jumpers, fence posts, or steel fence to the grounding rod. All connections shall be made

with exothermic welds. The proper mold and associated equipment shall be used for each connection.

Bonding jumpers and grounding cables shall be installed to allow for at least 2 inches of expansion between connections.

A ground shall be installed at each side of the bridge preferably at opposite ends, as described in these specifications or as shown on the plans.

Ground resistance shall be measured by the fall of potential method and shall not exceed 25 ohms. If 25 ohms cannot be attained with a single 8-foot grounding rod, then additional 8-foot grounding rods shall be driven (either added to the top of the first ground or driven as a second ground) and connected to the first ground until 25 ohms of resistance is attained.

- U. **Name Plates.** The Contractor shall furnish, fabricate, imprint, and install structure name plates according to the details specified on the plans or in the proposal.

Name plates with the required data imprinted legibly in the surface shall be submitted to the Engineer for approval prior to installation.

- V. **Wall Drain.** Attachment shall be by methods recommended by the manufacturer of the strips. The geotextile layer shall be peeled from the core at the lower edge and wrapped around the foundation underdrain. Additional sections of geotextile shall be furnished if necessary to completely encapsulate the pipe-strip junction. Laps of geotextile shall be shingled to preclude the entrance of backfill material.

The top composite strip shall be held snug against the wall by mechanical means or by a heavy bead of caulking, as approved, until the backfill is placed.

Damage to the composite strip shall be repaired, or the strip replaced. The composite strip shall be protected from prolonged exposure to sunlight according to the manufacturer's instructions and is to be delivered from the manufacturer to the job site and stored in ultraviolet resistant wrapping.

**706.04 Measurement and Payment.**

<b>Contract Item (Pay Item)</b>	<b>Pay Unit</b>
False Decking . . . . .	Square Foot
Reinf, Steel . . . . .	Pound
Reinf, Steel, Epoxy Coated . . . . .	Pound
Reinf, Steel, Culvert and Headwall . . . . .	Pound
Conc, Grade — . . . . .	Cubic Yard
Substructure Conc . . . . .	Cubic Yard
Superstructure Conc . . . . .	Cubic Yard
Superstructure Conc, Night Casting . . . . .	Cubic Yard
Water Repellent Treatment, Penetrating . . . . .	Square Yard
Expansion Joint Device . . . . .	Foot

Pipe Sleeve, __ inch	Each
Pipe Sleeve, __ inch, Placed	Each
Conduit, __ inch	Foot
Conduit, __ inch, Placed	Foot
Superstructure Conc, Form, Finish, and Cure	Lump Sum
Superstructure Conc, Form, Finish, and Cure, Night Casting	Lump Sum
Bridge Ltg, Furn and Rem	Lump Sum
Bridge Ltg, Oper and Maintain	Cubic Yard
Support, Temp	Each
Conc, Low Temperature Protection	Cubic Yard
Elec Grounding System	Each
Wall Drain	Square Foot
Conc Quality Assurance, Structure	Cubic Yards

- A. **Plan Quantities.** Unless otherwise stated, pay quantities determined for the pay items listed based on plan quantities computed from the lines and dimensions shown on the plans. The volume of concrete is calculated with no subtraction of the steel reinforcement volume.

The weight of bars or bar mats, plain or coated, is computed from the theoretical weight of bars according to Table 706-3, based on the total computed weight for the sizes and lengths of bars, mesh, or bar mats. No allowance is made for the weight of the coating on coated bars.

**Table 706-3 Weights for Reinforcing Bars**

Bar Size Designation	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
Weight, Pounds per Foot	0.376	0.668	1.043	1.502	2.044	2.670	3.400	4.303	5.313	7.65	13.60
Diameter, Round Sections, Inches Nominal	0.375	0.500	0.625	0.750	0.875	1.000	1.128	1.270	1.410	1.693	2.257

B. **Structure Concrete.**

**Substructure Conc** and **Superstructure Conc** are used for bridge structures. **Conc, Grade \_\_** is used for the concrete quantities required for box and slab culverts, headwalls, retaining walls, tremie seals, and other similar structures. Payment for **Substructure Conc** and **Conc, Grade \_\_** includes forming, finishing and curing.

Where concrete is cast against steel sheet piling, the volume is computed on the basis of an outline to the mid-point of the depth of the sheet piling section.

Where concrete footings are cast on or against the surface of excavated rock, an allowance will be made in concrete volume for actual overbreakage of rock within 6 inches outside and 6 inches below the neat outline of the footing.

- C. **False Decking** will be measured for the total area protected. **False Decking** will include costs for furnishing, installing, maintaining, moving, and removing materials or barges used.

Concrete placed by the pumping method will be measured and paid for the same as if the concrete was placed by any other method. There will be no adjustment in the contract unit price of the concrete item because of any adjustments in the proportioning of the aggregates or the increase in the amount of cement to facilitate the use of pumping equipment or for the water-cement slurry pumped through the discharge pipe at the beginning of a pour.

- D. **Water Repellent Treatment, Penetrating** includes preparation of the surface of the concrete and furnishing and placing the water repellent material.
- E. **Expansion Joint Device** quantities are determined by the length of joint device placed within the limits of **Expansion Joint Device** shown on the plans or authorized, including allowance for vertical heights. The furnishing and placing of attaching hardware for the device is included in this item.
- F. **Superstructure Conc, Form, Finish and Cure** will be measured as a unit for each structure.

Permanent metal deck forms includes designing, fabricating, furnishing, and erecting permanent metal deck forms, and furnishing and installing Styrofoam when required. This work will not be paid for separately, but is included in the form, finish, cure pay items.

- G. **Bridge Lighting.**

1. **Bridge Ltg, Furn, and Rem** includes furnishing, placing, and removing material for nighttime lighting.
2. **Bridge Ltg, Oper and Maintain** includes payment for operating and maintaining the lighting system.

- H. **Support, Temp** includes furnishing, placing and removing supports.

- I. **Low Temperature Protection.** If the contract does not include a separate item for **Conc, Low Temperature Protection**, and such work is ordered by the Department and can be attributed to delays caused by the Department, or made necessary by an expedited progress schedule ordered by the Department, a unit price for **Conc, Low Temperature Protection** shall be agreed upon before the work of protection is started.

**Conc, Low Temperature Protection** will be made for the quantity of concrete actually protected, provided that this quantity shall not be increased by failure of the Contractor to

do as much work as indicated by the progress schedule contained in the proposal, nor by reason of the Contractor performing more work than indicated by the progress schedule.

- J. Furnishing and placing the interim curing material on top surfaces of bridge decks which are exposed in the completed structure will not be paid for separately but will be considered as having been included in the unit price bid for the applicable structural concrete pay item.
- K. Measurement and payment of **Bridge Deck Overlay Conc** will be measured and paid for by volume of surfacing mixture used for the overlayment. The overlayment quantity will be determined from the theoretical yield of the design mix and documented by the ticket printout of the cement used and yield tests performed. Deductions will be made for material wasted or rejected will not be measured for payment.
- L. **Electrical Grounding System** includes furnishing and installing the complete system to ground the bridge on two sides.
- M. **Wall Drain** includes furnishing and attaching the geocomposite and the additional geotextile required to wrap the foundation underdrain. **Foundation Underdrain** will be measured and paid for according to subsection 404.04.
- N. The work of furnishing, fabricating, imprinting, and installing name plates in structures will not be paid for separately.
- O. Special treatment for unstable foundations will be paid for at the contract or authorized unit price for the item of work involved.
- P. **Conc Quality Assurance, Structure.** Structure concrete covered by the Department's Concrete Quality Assurance (QA) program will be accepted and paid for according to sections 106, 605 and the following. Pay adjustment for each critical and non-critical concrete QA contract item is calculated using the procedure described in subsections 106 and 605.
  - 1. Payment for **Conc Quality Assurance, Structure** includes all work to test fresh concrete for temperature, air content and slump; mold and cure concrete cylinders; and transport fully cured concrete cylinders to the designated laboratory for acceptance testing.
  - 2. Failure by the Contractor to mold and cure concrete cylinders in accordance with the ASTM C31 will result in non-payment of **Conc Quality Assurance, Structure** for the entire lot represented by the improperly molded or cured cylinders. In addition, the Contractor may be required to core the lot at his expense to verify compressive strength. Payment for the lot will then be based on core strength test results.
  - 3. Total quantity of **Conc Quality Assurance, Structure** will be measured and paid for based on plan quantities for all applicable structure concrete items included in this contract (critical and non-critical) converted to cubic yards. These items include, but may not be limited to, superstructure concrete including nightcasting, substructure

concrete, and concrete Grade T mixes. No payment will be made for overruns unless verified and approved in writing by the Engineer.

4. Concrete quality initiative will be paid according to section 605. Concrete Grade T items will be considered non-critical concrete QA items.
5. Separate payment will not be made for the work required to provide an acceptable concrete mix design, Contractor coring, molding and testing work progress specimens, or for providing and maintaining an effective concrete quality control program. These costs shall be considered included in the applicable unit price for the concrete item.