

SECTION 900

STRUCTURES

SECTION 901

CEMENT CONCRETE MASONRY

DESCRIPTION

901.20 General.

Cement concrete masonry with or without reinforcement as required for bridges, culverts, walls, steps, drop inlets and other work shall be constructed to the designs and dimensions indicated on the plans or as directed and to close conformity with the lines and grades established by the Engineer.

Where necessary, at the direction of the Engineer, the dimensions or design may be adjusted to fit foundation, slope or construction conditions as encountered.

MATERIALS

901.40 Materials.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Cement Concrete	M4.02.00
Latex Modified Mortar and Concrete Overlayments	M4.07.0
Reinforcing Steel	M8.01.0
Epoxy Coated Reinforcing Bars	M8.01.7
Stay-in-Place Bridge Deck Form	M8.21.0
Preformed Expansion Joint Filler	M9.14.0
Preformed Bituminous Fiber Joint Filler	M3.05.3
Preformed Compression Joint Seals (Bridges)	M9.14.1
Polyurethane Joint Sealer (Flow Type)	M9.14.3
Polyurethane Joint Sealer (Non-Sag Type)	M9.14.4
Plastic Water Stops	M9.07.0
Shear Connectors	M8.04.1
Curing Materials	
Impervious Liquid Membrane	M9.06.5
Waterproof Paper	M9.06.0
Burlap	M9.06.3
White Polyethylene for Curing	M9.06.1B
Polyethylene Coated Burlap	M9.06.4
Concrete Penetrant/Sealer	M9.15.0

For any project using 100 cubic meters or more of cement concrete, the Contractor shall supply to the project for the use of the Engineer the following equipment as an incidental item, if not already provided for in a previous section.

1. Concrete cylinder molds with plastic covers, 150 millimeters in diameter by 300 millimeters high, meeting the requirements of AASHTO M 205.
2. One complete slump test set meeting the requirements of AASHTO T 119 consisting of one each of the following:
 - a. slump cone (AASHTO T 119)
 - b. tamping rod (AASHTO T 119)
 - c. sheet metal pan (600 millimeters x 600 millimeters x 75 millimeters)
 - d. cement mold brush

- e. large scoop
- f. mixing trowel
3. One air meter meeting the requirements of AASHTO T 152, Type B.
4. One concrete curing box-Curamold (LA-1300-1).
5. Two 15 liter heavy duty buckets.

CONSTRUCTION METHODS

901.60 Forms.

Approved centers and forms shall be provided by the Contractor. Piles shall be used for falsework if required by the Engineer. No extra compensation for falsework or falsework piling shall be allowed, such work being considered part of the form work. Falsework shall be set to give the structural camber indicated on the plans or as specified, plus allowance for shrinkage, shortening under load or settlement. Forms, falsework and centering shall be designed for a liquid head, equal to the maximum height of the liquid concrete in the forms for various placing conditions assuming the load of the liquid concrete to be 2400 kilograms per cubic meter, and in addition thereto a live load allowance of 2.4 kiloPascals on horizontal surfaces.

When not otherwise specified on the plans, or in the special provisions, forms for all exposed portions of bridges and structures shall be lined with approved material, or form sheathing which shall consist of five-ply water-proof plywood, approved metal sheathing or other approved material in order to give the concrete a smooth even finish and uniform appearance.

This requirement shall not apply to the underside of the deck of a bridge over a waterway, the underside of a bridge over a railroad, or any part of a structure that will be at least 600 millimeters below the surface of adjacent ground in the completed project. Any material that will provide tight forms will be acceptable for such locations.

Full sheets of plywood or other approved material shall be used wherever possible and shall be placed in a regular pattern. The use of small pieces and leftovers will not be permitted except as they may be needed to complete the design. Forms in good condition may be reused, but forms for any one exposed face shall be all new or all used material and a mixture of old and new forms will not be permitted. Forms for cylindrical pier columns shall be smooth and reasonably free of joints.

The sheathing shall be jointed tightly to prevent leakage from the mix and it shall be of sufficient strength to hold the concrete without bulging between supports. Forms shall be properly braced and tied so as to maintain proper dimensions. Bolts, rods, or other satisfactory form ties shall be used for internal ties. Wire ties will not be permitted except when directed or where concrete is not exposed to view. The Engineer may require the Contractor to employ screw jacks or hard wood wedges in connection with the centering of falsework in order to take up any distortion or settlement in the form work either before or during the placing of the concrete.

Approved inserts shall be used in connection with all ties in the region of exposed surfaces on the concrete. They shall be so designed as to permit their removal from the concrete without injury to the concrete, and the metal remaining in the concrete shall be not closer than 40 millimeters to the surface. The inserts shall be truly round, not more than 40 millimeters in outside diameter and shall be treated with nonstaining mineral oil or other satisfactory material adequate for preventing any adherence to surrounding concrete. Special tools and methods shall be used to remove the inserts from the concrete in a manner to prevent damage to the concrete. When forming the concrete surface in front of coated reinforcing mats, all ties and any parts thereof that are to be left in place shall be either epoxy coated or galvanized within a minimum of 75 millimeters of that concrete surface.

Form ties of a design with a weakened section 40 millimeters back from the concrete face may be used at places of minor pressure when permitted by the Engineer, but such ties shall be provided with special inserts so as to assure the breaking off of the ties at the proper depth inside the face of the concrete. When such ties fail to break off at the designed depth, the tie metal shall be drilled out before the tie hole is patched.

The use of wooden struts within forms, or of metal ties without approved inserts, as required, will not be permitted.

The centers shall be true to the lines, satisfactorily supported and firmly secured. They shall remain in place as long as directed and shall be replaced with new ones if they lose their proper dimensions and shape.

Forms for the roadway deck slabs shall be so construed that under full dead load, the thickness of the slabs shall be the required thickness shown on the plans and the surface of the pavement will accurately conform to the profile grades, cross sections and alignment shown on the plans. Allowance shall be made for the camber of the floor members as erected

and for the additional dead load deflections of the floor members.

Slab haunches shall be provided over steel girders, floor beams or stringers. The depth of haunches shall be variable as required to maintain the uniform thickness of slab between the steel supports.

All exposed edges and corners of concrete not otherwise specified on the plans shall be formed with a wooden triangular 45° chamfer strip 20 millimeters on the square sides. These triangular chamfer strips shall be machine surfaced on all sides and shall be of uniform dimensions throughout the project. Any chamfered or beveled corners of concrete specified on the plans of larger size shall be formed and finished as required for other parts of the adjacent forms.

Where rustications are called for on the plans, as for abutments and wingwalls, the form liners for rustications shall be surfaced on all sides true to line, plans and dimensions in accordance with the detail on the plans. The form liners shall be fastened to the forms in such a manner that the form liners will remain in the concrete when the forms are removed. These moldings shall not be removed until the concrete has hardened sufficiently so that the edges of the concrete adjacent to the moldings shall not be damaged.

Bridge bearing anchor bolts in piers shall be set accurately by template prior to placing concrete. Anchor bolts in abutments may be set by template or by drilling and grouting. Grout shall be a non-shrinking type.

The shape, strength, rigidity, water-tightness and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged lumber must be resized before being used. Forms which are unsatisfactory in any respect shall not be used and shall be removed immediately from the work.

The inside of forms shall be coated with non-staining mineral oil or other approved material to prevent adherence of the concrete to the forms, immediately before placing the concrete. When oil is used, it shall be applied before the reinforcing steel is placed. Any material which will adhere to, discolor or affect the concrete in any manner shall not be used. Forms for bridge decks shall not be oiled but shall be dampened with water ahead of concrete placement.

In the construction of copings, railings and other intricate sections, extreme care shall be taken in the construction to insure true lines.

Prior to placing concrete in the forms all foreign matter and any extraneous materials shall be removed.

Forms shall be inspected immediately preceding and during the placing of the concrete. All dimensions shall be checked carefully and any errors, bulges, warping or other defects shall be remedied before any concrete is placed.

Temporary openings shall be provided for inspection at the base of the column and wall forms and near the bottom of all deep members.

The foregoing specifications for forms as regards design, mortar-tightness, chamfers or moldings, bracing, alignment, treatment by coating with oil or other approved material, removing and reuse, shall apply to metal forms when such forms are approved for use. The metal forms used shall be of such strength that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. 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 matter that will tend to discolor the concrete. Metal forms shall be provided with an adjustable metal section or occasional sections where wooden forms may be inserted to compensate for slight inaccuracies in measurement.

Removable or stay-in-place forms for bridge decks may be used as alternates except in hazardous locations where stay-in-place forms shall be used. Hazardous locations are defined as high volume roadways and all railroads under the bridge.

Removable forms shall be used for forming end diaphragms, bays with longitudinal construction joints, and overhanging portions of decks.

Material to prevent concrete from adhering to the forms shall not be used when stay-in-place forms are used.

Design of Permanent Steel Bridge Deck Forms.

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

1. The steel forms shall be designed on the basis of dead load of form, reinforcement and plastic concrete plus 2.4 kiloPascals for construction loads. The unit working stress in the steel sheets shall not be more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 250 megaPascals.

2. Deflection under the load of the forms, the plastic concrete and reinforcement shall not exceed 1/180 of the form span or 13 millimeters whichever is less. In no case shall this design loading be less than 6 kiloPascals total.

The permissible form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits.

3. The design span of the form sheets shall be the clear span of the form plus 50 millimeters measured parallel to the form flutes.
4. Physical design properties shall be computed in accordance with requirements of the American Iron and Steel Institute Specification for the Design of Cold Formed Steel Structural Members, latest published edition.
5. All reinforcement shall have minimum concrete cover of 25 millimeters.
6. The plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete deck shall be maintained.
7. Permanent steel bridge deck form shall not be considered as lateral bracing for compression flanges of supporting structural members.
8. Permanent steel bridge deck form shall not be used in panels where longitudinal deck construction joints are located between stringers.
9. Welding shall not be permitted to flanges in tension or to structural steel bridge elements fabricated from non-weldable grades of steel.
10. Fabricator's shop and erection drawings shall be submitted to the Engineer for approval. These plans shall indicate the grade of steel deck form sheets and a clear indication of locations where the forms are supported by steel beam flanges subject to tensile stresses.

All forms shall be installed in accordance with approved fabrication and erection plans.

Form sheets shall not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 25 millimeters at each end. Form supports shall be placed in direct contact with the flange of stringer or floor beam. All attachments shall be made by permissible welds, bolts, or clips of other approved means. However, welding of form supports to flanges of steels not considered weldable and to portions of flange subject to tensile stresses shall not be permitted. Welding and welds shall be in accordance with the provisions of AWS D2.0 pertaining to fillet welds except that 3 millimeter fillet welds will be permitted.

Any permanently exposed form metal where the galvanized coating has been damaged shall be thoroughly cleaned, wire brushed and painted with two coats of zinc oxide-zinc dust primer, Federal Specification TT-P-64 Id, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds need not be touched up.

The Contractor's method of construction should be carefully observed during all phases of the construction of the bridge deck slab. These phases include installation of the metal forms; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete placement and vibration; and finishing of the bridge deck. Should the Engineer determine that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, the Contractor shall remove at least one section of the forms at a location and time selected by the Engineer for each span in the contract. This should be done as soon after placing the concrete as practicable 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.

After the deck concrete has been in place for a minimum period of 2 days, the concrete shall be tested for soundness and bonding of the forms by sounding with a hammer as directed by the Engineer. If areas of doubtful soundness are disclosed by this procedure, the Contractor will be required to remove the forms from such areas for visual inspection after the pour has attained adequate strength. This removal of the permanent steel bridge deck forms shall be at no cost to the project. 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 do not justify rejection of the work, the concrete shall be repaired as the Engineer may direct and shall be given an Ordinary Surface Finish, in accordance with the contract specifications. If the concrete where the form is removed is unsatisfactory, additional forms, as necessary, shall be removed to inspect and repair the slab, and the Contractor's methods of construction shall be modified as required to obtain satisfactory concrete in the slab. All unsatisfactory concrete shall be removed or repaired as directed by the Engineer.

The amount of sounding and form removal may be moderated, at the Engineer's discretion, after a substantial amount of slab has been constructed and inspected, if the Contractor's methods of construction and the results of the inspections as outlined above indicate that sound concrete is being obtained through the slabs.

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

901.61 Reinforcement.

The Contractor shall submit for approval detailed plans and schedules of the reinforcing bars so that the reinforcement may be properly placed and its mass readily computed. If it is impractical to obtain or use bars of the full length required, the bars shall be lapped for the length shown on the plans. If no lap length is provided, the lap length shall be calculated for the type of bar used according to the latest AASHTO Standard Specifications for Highway Bridges for a Class C splice.

Coated bars shall be either epoxy coated or galvanized, as specified on the plans. Where coated bars are called for without designation, they may be either epoxy coated bars or galvanized bars, however mixing epoxy coated and galvanized bars will not be permitted. Where coated bars are used in combination with uncoated bars in a reinforcing mat or cage and the coated bars will touch or be tied to uncoated bars with wire ties, only epoxy coated bars may be used.

All support devices and ties for galvanized bars used in deck reinforcing shall be coated so that there is no electrical continuity either between reinforcing mats or between the reinforcing and the stay-in-place forms or steel beams.

All support devices and ties for epoxy coated bars used in deck reinforcing shall be either epoxy coated or coated with a plastic material compatible with the epoxy reinforcing bar coating.

The steel shall be bent in the shop true to templates and shall be placed accurately as shown on the plans with the following tolerance:

1. Cover (clearance from face of concrete to bar) ± 5 millimeters.
2. Horizontal spacing of bars ± 50 millimeters (however the required number of bars must be placed). The minimum spacing cannot be decreased. The reinforcement shall be placed so as to insure its remaining in the correct position during the placing and hardening of the concrete. No splicing shall be at points of maximum stress and the clear distances between spliced bars shall not be less than 1-1/2 times the nominal diameter of the bars, 1-1/2 times the maximum size of the coarse aggregate, nor less than 40 millimeters.

The required distance between reinforcing steel and the forms shall be maintained by means of stays, blocks, ties, hangers or other approved supports. The spacing of reinforcing supports shall not exceed 1.2 meters.

Steel reinforcing mats shall be firmly secured against displacement by tying every other intersection point with a maximum of 300 millimeters between tied joints. In addition, steel reinforcing mats (top and bottom) shall be securely connected together so that uniform vertical spacing can be maintained throughout. This connection may be accomplished by tying with coated tie wires or other means as approved by the Engineer. Connections shall be placed no farther apart than 1.2 meters on center. Support devices may be utilized for this purpose. Connection devices shall neither deflect the steel reinforcing nor interfere with the smooth flow of concrete.

Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Blocks for spacing reinforcing bars shall also be precast mortar blocks of approved designs and short enough to permit their ends to be adequately covered with concrete. The precast mortar blocks shall be made from the same materials and of the same proportions of sand and cement as that of the concrete in which they are to be used. They shall be cast and properly cured before use and shall have a wire of copper or other non-rusting metal or other approved device cast into each block suitably placed so that the block can be securely fastened to the reinforcement. Layers of bars, except for those placed in bridge decks, shall be separated by such blocks, which may be reinforced, and which shall have slots to receive the bars and hold them in place, or by other approved means. Any parts of metal supports that are left in place within

75 millimeters of an exposed surface of the concrete shall be made of either non-rusting metal, epoxy coated or galvanized. Galvanizing of such parts shall be in accordance with Subsection 960.64. The use of pebbles, pieces of broken stone, metal pipe or wooden blocks will not be permitted.

Reinforcement in any member or section shall be in place and approved by the Engineer before the placing of concrete begins. In no case shall reinforcing steel be driven or forced into the concrete after it has taken its initial set; and any reinforced concrete placed in violation of this provision will be rejected by the Engineer, and then shall be removed and replaced by the Contractor entirely at his/her own expense.

When wire mesh is used as reinforcement, it shall be furnished and placed in accordance with the plans. If the wire mesh is shipped in rolls, it shall be straightened into flat sheets before being used.

Dowels, where required, shall be furnished and placed as indicated on the plans and as directed.

Reinforcement that extends continuously within the concrete of the substructure and the concrete of the superstructure, or any other reinforcement that might stain the exposed surface of the bridge shall be given a light coat of

neat cement grout on the surfaces of the reinforcement that will be exposed for more than three weeks before being encased in concrete. Subsequent coats of grout may be required.

901.62 Anchors.

Bent plate edging, steel curbing, expansion dams at back of parapet and fixed dam assemblies shall be anchored to the concrete by use of headed anchors. Headed anchors shall conform to the requirements of stud shear connectors.

901.63 Partition Tile.

The tile under the sidewalk above the bridge deck slab shall be light weight hollow partition tile. The blocks shall be closely butted. The end blocks shall be left open at the lower end of the sidewalk.

901.64 Shear Connectors.

All shear connections shall be the stud reinforcement type and the following requirements shall apply:

A. Stud shear connectors shall be end welded to steel beams or girders with automatically time stud welding equipment connected to a suitable power source.

B. If two or more stud welding guns are to be operated from the same power source, they shall be interlocked so that only one gun can operate at a time and so that the power source has fully recovered from making one weld before another weld is started. The power source shall be adequate to meet the requirements of the size of stud being welded.

C. At the time of welding, the studs shall be free from any rust, rust pits, scale, oil or other deleterious matter which would adversely affect the welding operation.

D. Welding shall not be done when the base metal temperature is below -18 °C, or when the surface is wet or exposed to rain or snow.

E. While in operation the welding gun shall be held in position without movement until the welded metal has solidified.

F. When necessary to obtain satisfactory welds, the areas on the beam or girder to which the studs are to be welded shall be wire-brushed, peened, prick-punched, or ground free of scale or rust.

G. Longitudinal and lateral spacings of studs with respect to each other and to edges of beam or girder flanges shall not vary more than 10 millimeters from the dimension shown on the plans except that a variation of 25 millimeters will be permitted where required to avoid obstruction with other attachments on the beam or where a new stud is being welded to replace a defective one. The minimum distance from the edge of a stud to the edge of a beam shall be 25 millimeters, but preferably not less than 40 millimeters.

H. The first two studs welded on each beam or girder, after being allowed to cool, shall be bent 45° by striking the stud with a hammer. If failure occurs in the weld of either stud, the procedure shall be corrected and two successive studs successfully welded and tested before any more studs are welded to the beam or girder. The Engineer shall be promptly informed of any changes in the welding procedure at any time during construction.

I. When the temperature of the base metal is below 0 °C, one stud in each 100 studs welded shall be bent 45° in addition to the first two bent as specified in H above.

J. Studs on which a full 360° weld is not obtained may, at the option of the Contractor, be repaired by adding a 5 millimeter fillet weld in place of the lack of weld, using the shielded metal-arc process with low-hydrogen welding electrodes.

K. If the reduction in the height of the studs as they are welded becomes less than normal, welding shall be stopped immediately and not resumed until the cause has been corrected.

L. Before welding a new stud where a defective one has been removed, the area shall be ground smooth and flush, or in the case of a pullout of metal, the pocket shall be filled with weld metal using the shielded metal-arc process with low-hydrogen welding electrodes and then ground flush. In compression areas of flanges, a new stud may be welded adjacent to the defective area in lieu of repair and replacement on existing weld area. (See G above.)

M. Inspection Requirements.

1. If visual inspection reveals any stud which does not show a full 360° weld, any stud which has been repaired by welding, or any stud in which the reduction in height due to welding is less than normal, such stud shall be struck with a hammer and bent 15° off the vertical. For studs showing less than a 360° weld, the direction of bending shall be opposite to the lack of weld. Studs that crack either in the weld or the shank shall be replaced.

2. The Engineer, at his/her option, may select additional studs to be subjected to the bend test specified above.

3. The studs tested that show no signs of failure may be left in the bent position.
4. If during the progress of the work, inspection and testing indicate in the judgment of the Engineer that the shear connectors being obtained are not satisfactory, the Contractor will be required at his/her expense to make such changes in welding procedure, welding equipment and type of shear connector as necessary to secure satisfactory results.

901.65 Handling and Placing Concrete.

The Contractor shall notify the Engineer at least 24 hours in advance of his/her intention to place concrete.

All concrete shall be placed during daylight, and the placing of concrete shall not be started unless it can be completed and finished during daylight hours, except that when an adequate and approved lighting system is provided beforehand, the Engineer may waive this requirement.

No concrete shall be placed in a bridge or other structure where piles are required until all piles in the structure have been driven, unless otherwise directed by the Engineer. However, the placing of concrete in the steel shells for cast-in-place concrete piles and steel pipe piles shall be done as specified in Subsection 940.69.

No concrete shall be placed until the depth, character and water conditions of the foundations, the adequacy of falsework and forms, the absence of debris in the forms, the condition of the construction joints, and the condition and spacing of the reinforcing steel have been inspected and approved by the Engineer.

The placing of concrete shall be so regulated that the pressures caused by the wet concrete shall not cause distortion or movement of the forms.

The operation of handling and placing the concrete shall be conducted so as to form an artificial stone of maximum density and impermeability and of uniform texture which shall show smooth surfaces when the forms are removed.

Concrete shall be deposited in such manner that the total deflection or settlement of supporting members and the final finishing of the surface shall have occurred before initial set of the concrete takes place. An approved admixture shall be used as necessary to retard setting.

Calcium Chloride or any other admixture containing chloride salts shall not be used in concrete placed on permanent steel deck forms.

A. Transportation.

The concrete shall be transported from the mixer and placed in the forms by a method which will permit handling concrete of the slump required without segregation. Buggies and wheelbarrows used for this purpose shall be equipped with pneumatic tires. Chutes may be used but the use of long chutes will be permitted only on authority from the Engineer. If such conveyors are allowed and the quality of the concrete as it reaches the forms or the methods of placing or working it therein are not satisfactory, the Engineer may order their use discontinued and the substitution of a satisfactory method of placing. Chutes shall be metal or metal lined, inclined so as to have a slope of between 1:2 (1 vertical to 2 horizontal) and 1:3 (1 vertical to 3 horizontal); and shall extend as nearly as possible to the point of placing concrete. Long chutes shall be provided with reverse flow or remixing hoppers in order to correct for segregation. All chutes shall be kept clean and free from coatings of hardened concrete.

Transportation of concrete by pumping will be permitted provided that the required slump or air content can be maintained at the discharge end of the hose and there is no adverse effect to the mix design. The equipment shall be suitable in kind and adequate in capability for the work. The operation shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline shall be ejected in such a manner that there will be no separation of the ingredients.

Pumping through aluminum piping will not be permitted.

At the conclusion of placement, the entire equipment shall be thoroughly cleaned.

B. Depositing.

The concrete shall be placed in the form in the approved manner to prevent stone pockets, voids or segregation and to reduce handling and flowing in the forms to a minimum. The concrete shall not be dropped more than 1 meter or dragged more than 3 meters in the forms. Points of deposit shall be spaced not more than 6 meters apart nor more than 3 meters from the ends of the forms. Concrete shall be properly distributed in the forms by hand shoveling. The forms shall be filled at a rate of 300 millimeters to 1 meter in depth per hour unless an alternate form design is submitted and approved by the Engineer. Care shall be taken to avoid splashing the forms and reinforcing above the level of the concrete as placed. Beams and slabs shall be placed in one continuous operation.

C. Consolidation.

Each layer shall be thoroughly consolidated by rodding and vibration. The face of the forms shall be carefully spaded, if possible, to bring a dense mortar to the face, and produce a good finish.

All concrete for masonry structures, unless otherwise directed, shall be compacted by means of approved mechanical vibrators operated within the mass of the concrete. The Contractor shall provide approved methods of vibration to fully consolidate the mix. Vibrators shall be of internal type of standard make and approved capacity, and shall be capable of transmitting vibrations of the concrete at frequencies of not less than 4500 impulses per minute.

Vibration of forms or reinforcing shall not be permitted except where internal vibration is not practicable and then only with the approval of the Engineer.

The vibrator shall be applied directly to the mass at the point and time of deposit and moved throughout the mass continuously from point to point in the mix using care to avoid over vibration, causing segregations, over finished surface and excess water gain. Vibrators shall not be used close to the forms.

When concrete is placed in lifts, vibrators shall be inserted into at least half the depth of the underlying lift so as to thoroughly consolidate the two lifts into an integral mass without streaks or hardened lift lines. Vibrators shall not be used to move concrete in the forms.

A sufficient number of vibrators shall be provided to obtain proper compaction in accordance with the rate of deposit.

Extreme care shall be taken to prevent penetrating or disturbing previously placed concrete which has become partially set.

D. Placing Concrete Under Water.

Concrete may be deposited in water only when provided by the plans or in the Special Provisions or by approval in writing by the Engineer; and only under the direct supervision of the Engineer.

The concrete shall be of the designation required except that an additional 10 percent of cement shall be added to all concrete deposited under water except that mass concrete shall be placed with the cement content required by Special Provisions.

The method and equipment to be used shall be approved by the Engineer before work is begun.

Concrete deposited under water shall be carefully placed in a compound mass in its final position and shall not be disturbed after being deposited. Special care must be taken to maintain still water at the point of deposit. No concrete shall be placed in running water and all form work designed to retain concrete under water shall be watertight. The consistency of the concrete shall be carefully regulated and special care shall be taken to prevent segregation of the materials. The concrete shall be distributed uniformly over the entire area between forms in order to maintain a level surface.

The work shall be carried out in a continuous operation with sufficient rapidity to prevent the formation of layers or inclined seams. Concrete shall not be placed in water having a temperature below 2 °C. Pumping of water will not be permitted while the concrete is being deposited nor before it is sufficiently hardened.

One of the following methods may be used:

1. Bottom Dump Bucket.

The bucket shall be open top type and have a capacity of not less than 1 cubic meter, and shall also be of a type that cannot be dumped until it rests on the surface on which the concrete is to be deposited. The bottom doors, when tripped, shall open freely downward and outward. The bucket shall be filled to strike-off capacity and shall be slowly lowered to avoid back wash. It shall then be raised very slowly as the concrete is discharged, only to the height necessary to permit emptying of the bucket, after which the bucket shall be slowly withdrawn to well above the surface of the water, in order to maintain, as nearly as possible, still water at the point of discharge and to avoid agitating the mixture. The bottom dump bucket shall not be used in a pile footing or where deposited through reinforcing steel.

2. Tremie.

The tremie shall be watertight, consisting of a tube constructed in sections with flange couplings fitted with gaskets, and the inside diameter shall be sufficiently large to permit a free flow of concrete. The spacing of tremie tubes shall not exceed 6 meters on centers or 3 meters from the forms. Tremie tubes shall not be moved horizontally or the seal purposely broken once placing of concrete is started.

The radius of influence of a tremie shall not be assumed to exceed 3 meters. The means of supporting the tremie shall be as such as to permit it to be rapidly lowered when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of the work so as to prevent water from entering the tube and shall be kept entirely sealed at all times and the tremie tube kept full to the bottom of the hopper during the depositing of the concrete. When a batch is dumped into the hopper the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow shall then be stopped by lowering the tremie. Special care shall be taken

to maintain as nearly as practicable a uniform flow and to avoid dropping the concrete through the water. The flow shall be continuous until the work is completed. If the charge is lost during depositing, the tremie shall be withdrawn and refilled.

Dewatering may start when the concrete seal has reached a compressive strength of 8.5 megaPascals.

All laitance and scale shall be removed so that sound, durable concrete is exposed to the area on which the construction is to be based and shall be leveled off with epoxy bonded concrete or mortar.

E. Concrete Exposed to Sea Water.

Concrete structures so located as to be subject to the action of sea water shall be constructed in a manner to provide a maximum resistance to its disintegrating action.

The concrete shall be of the class required with an additional 10 percent of cement and shall be mixed for a period of time 50 percent more than the time specified in Subsection M4.02.10. The water content shall be carefully controlled and so regulated as to produce concrete of maximum impermeability. In placing concrete, care shall be taken to avoid the formation of pockets and the concrete shall be thoroughly compacted to the satisfaction of the Engineer. The original surface of the concrete shall be left undisturbed. In order to secure a thick and dense surface film, the surfaces of the forms shall be heavily coated with shellac or an approved form oil. The range of possible disintegration of the concrete from an elevation below that of low tide to an elevation above that of extreme high tide shall be determined by the Engineer, and, except with his/her special permission, no construction joints shall be located within this range. In the determination of this range, due consideration shall be given to wave action, ice formation and other conditions affecting the extreme limits of possible deterioration and disintegration.

Concrete in sea water within the range as above determined shall, except when especially provided for by the plans or in the Special Provisions, be deposited in the dry and no sea water shall be allowed to come in direct contact with the concrete until it has been permitted to harden for at least 10 days and preferably for a longer period.

901.66 Joints.

A. Construction Joints.

Concrete in structures shall be placed in such a manner that all construction joints shall be exactly horizontal or vertical, as the case may be, and that they shall be straight and as inconspicuous as possible.

When construction joints are definitely shown on the plans, all concrete between consecutive joints shall be placed in a continuous operation.

In order to allow for shrinkage, concrete shall not be placed against the second side of the construction joints for at least 12 hours after that on the first side has been placed.

Approval of the Engineer in writing must be secured before the placing of any construction joints not shown on the plans, except in case of emergency as specified in paragraph D hereinafter.

The plans on which a day's work is to terminate shall be predetermined before depositing of concrete begins. They shall in general be perpendicular to the lines of principal stress and in regions of small shears. Horizontal joints will not be permitted in concrete girders, beams, abutments, or retaining walls, unless otherwise indicated on the plans. Slabs acting with concrete beams or girders shall be placed continuously as a unit, unless otherwise indicated on the plans.

Unless otherwise indicated on the plans, interlocking or keying at construction joints shall be provided by use of keyways or dowels in a manner approved by the Engineer.

Horizontal joints in piers or abutments shall generally be avoided and when used shall not be located within 1 meter of normal water level.

In piers or abutments or walls requiring a construction joint it shall generally be a keyed vertical joint extending the full height above the footing. In piers, abutments or retaining walls the second portion placed at a vertical joint shall be placed not earlier than 24 hours after the first portion is placed, except with special permission of the Engineer.

Construction joints not shown on the plans and above ordinary low water level in abutments and retaining walls that retain earth fills shall have approved waterstops and shall be furnished at the Contractor's expense.

Joints in cantilevered members, unless shown on the plans, shall be avoided.

When making a horizontal construction joint, care shall be taken to have the concrete below the joint as dry as possible and any excess water or creamy material shall be removed before the concrete sets. Within 12 hours after the concrete below the joint has been placed, the top surface shall be thoroughly cleaned by the use of wire brushes and all laitance and loose material removed so as to expose clean, solid concrete. Care must be taken not to loosen any of the course aggregate in the concrete. If for any reason this laitance is not removed before the concrete has hardened in place, it shall be removed using such tools and methods as may be necessary to secure the results specified above. Immediately

before placing concrete above the joint, the surface of the concrete below the joint which has been cleaned as specified above shall be thoroughly wetted and coated with mortar of the same proportions used in the concrete. This mortar shall be thoroughly brushed into all openings and crevices with a stiff broom and new concrete shall be placed before this mortar has taken initial set. On all exposed surfaces, the line of the proposed joint shall be made truly straight by tacking a temporary horizontal straight edge on the inside of the form with its lower edge on the line of the joint and then placing the concrete sufficiently higher than this edge to allow for settlement. Immediately before placing the new concrete, the forms shall be drawn tightly against the concrete already in place.

In construction joints, approved waterstops of plastic material shall be placed not less than 75 millimeters from the face of concrete and shall extend a minimum of 65 millimeters into the concrete unless otherwise shown on plans.

Prior to the use of plastic waterstops, the manufacturer's installation instructions shall be furnished to the Engineer.

B. Expansion Joints.

Expansion joints constructed in bridges, walls and other structures shall be of the thickness shown and as located on the plans. The joint filler shall be cut to the same shape as the area to be covered except that it will be 5 millimeters smaller along all surfaces that will be exposed in the finished work unless shown otherwise on the plans. The filler shall be fixed firmly against the surface of the concrete already in place in such a manner that it will not be displaced when the concrete is deposited against it. When necessary to use more than one piece to cover any surface, the abutting pieces shall be placed in close contact and the joint between the separate pieces shall be covered with a layer of two-ply roofing felt, one side of which shall be covered with hot asphalt to insure proper adhesion. The 5 millimeter spaces along the edges at exposed faces shall be filled with wooden strips of the same thickness as the joint material. These wooden strips shall be saturated with oil and have sufficient draft to make them readily removable after the concrete is placed.

Whatever material is used, the exposed edge of the filler shall be the finished edge as it comes from the fabricator in order to avoid exposure of material roughened by cutting. Each piece of filler shall be fastened to the concrete on one side of the joint with a single line of No. 10 gauge insulation nails 75 millimeters long and 300 millimeters on centers.

Immediately after forms are removed, the expansion joint shall be carefully inspected and any concrete or mortar that has sealed across the joint shall be cut neatly and removed. The outer edge of the joint shall be straight, parallel and satisfactory in appearance.

In expansion joints, approved waterstops of plastic material shall be placed not less than 75 millimeters from the face of the concrete and shall extend a minimum of 115 millimeters into the concrete, measured from the center line of the joint, unless shown otherwise on the plans.

Prior to the use of plastic waterstops, the manufacturer's installation instructions shall be furnished to the Engineer.

All surfaces to which sealants are to be applied shall be thoroughly cleaned to remove all loose concrete, dirt, oil, grease, paint, lacquer, rust, scales, bituminous or other foreign materials. Projections of concrete into joint space shall be removed. Steel surfaces shall be sandblasted or mechanically brushed to obtain a bright, clean, metal surface. Loose particles or dirt shall be removed and the joint shall be dried before application of primer and/or sealer. A bond breaker shall be used so that the joint sealer shall not be placed in direct contact with bituminous material or bituminous filler.

A primer shall be used, when so designated in the manufacturer's instructions. The sealant shall be mixed and applied in accordance with the manufacturer's instructions. Application shall be made only when air temperature is 10 °C or over. The sealant shall be installed in a neat and workmanlike manner to the depth specified on the plans. The sealant surface shall be either flush with, or be not more than 3 millimeters above adjacent joint surfaces.

Any material that does not adhere or bond to the applied surface, or fails to set up properly, will be removed and replaced at the expense of the Contractor. Any material improperly mixed or which sets up before placement will likewise be rejected and be replaced at the expense of the Contractor.

C. Bonding to Concrete Already Set.

In bonding new concrete to concrete already set, the surface of the concrete shall be thoroughly cleaned, roughened, wetted with clean water, and then flushed with a mortar composed of equal parts of the cement and sand specified for the new concrete, before new concrete is placed adjacent thereto. New concrete shall be placed before mortar has taken initial set. In lieu of the mortar, an epoxy adhesive suitable for bonding fresh concrete to hardened concrete may be used. The epoxy adhesive shall be applied in accordance with the manufacturer's recommendations.

D. Emergency.

When the work of placing concrete is unexpectedly interrupted by breakdowns, storms or other causes and the

concrete as placed would produce an improper construction joint, the Contractor shall form a construction joint to the satisfaction of the Engineer. When such a joint occurs at a section on which there is a shearing stress, the Contractor shall provide an adequate mechanical bond across the joint by forming a key, inserting reinforcing steel or by some other satisfactory means, which will prevent a plane of weakness.

901.67 Weep Holes and Drains.

Weep holes shall be provided through all structures as indicated on the plans and as directed. Ends of weep holes that are to be covered by filling material shall be protected by 6.35 millimeter mesh galvanized wire screen 23 gauge and not less than one cubic meter of screened gravel or crushed stone conforming to Subsection M2.01.1.

Drains shall be provided for bridge superstructures as indicated on the plans.

901.68 Protection, Curing and Finishing.

A. Protection.

Suitable precautions shall be taken to thoroughly protect the concrete from any damage by weather conditions or otherwise during and after placing.

1. Hot and Dry Weather.

During hot dry weather, and as directed, all new concrete shall be kept shaded from the sun, shielded from the wind and kept wet with water, or protected by other approved methods to retain the moisture in the concrete throughout the curing period.

2. Rainy Weather.

During rainy weather all new concrete shall be properly covered, as may be necessary to prevent damage. Sufficient approved material for covering shall be available at the site of the work for immediate use as may be needed.

3. Cold Weather.

During cold weather all new concrete shall be fully protected, by methods approved by the Engineer, until properly set and hardened to prevent damage. See Subsection 901.72.

B. Curing.

All concrete shall be kept fully saturated and protected against any drying action by methods of curing specified herein or as otherwise approved by the Engineer for not less than 5 days after placing standard cement concrete or for not less than 2 days after placing high early strength cement concrete.

All surfaces of concrete which are to receive a rubbed surface finish or on which bitumen is to be placed, and concrete at construction joints and exposed bridge deck concrete shall be cured in accordance with requirements below for water curing. All other concrete may be cured in accordance with requirements below for water curing or waterproof membrane curing.

1. Water Curing.

Curing of concrete shall begin by fog spraying immediately after the initial set. Fog spraying shall continue until the burlap cover has been placed. The amount of fog spray shall be strictly controlled, so that accumulations of standing or flowing water on the surface of concrete shall not occur.

Should atmospheric conditions render the use of fog spray impractical, the Contractor shall use plastic covers of suitable weight and securely weighed down, but not directly in contact with the deck concrete. The covers shall be used only until the initial set has taken place. The burlap covers shall be placed immediately thereafter. On the windward side of the panel being cured, the Contractor shall erect canvas barriers of suitable height when necessary to protect the curing concrete from the direct force of the wind.

The area of concrete to be cured shall be covered by wet burlap blankets when concrete has set sufficiently, but in no case later than 5 hours after placing of concrete. Fog spray or covers shall be used continuously during this period.

The materials for the coverings shall conform to the pertinent requirements for the same provided under Subsection M9.06.03. The coverings shall be kept thoroughly wet by sprinkling with a fine spray of water until they may be removed. Wooden forms without liners, if left in place longer than 2 days after the placing of the concrete, shall be thoroughly wet down at least once each day for the remainder of the required curing period. Formed surfaces shall, after the removal of forms, be cured in like manner for the remainder of the required period, the entire surface of the concrete being thoroughly drenched with water and covered immediately after the forms are removed. Portions of the covering material may be removed temporarily when and as necessitated by any required finishing or waterproofing operation.

2. Impervious Liquid Membrane Curing.

Immediately after the free water has disappeared on surfaces not protected by forms and immediately after the

removal of forms, if such are removed before the end of the required curing period, the concrete shall be sealed by spraying as a fine mist a uniform application of the membrane curing material in a manner as to provide a continuous uniform, water impermeable film without marring or otherwise damaging the concrete. The impervious liquid membrane material used shall conform to the requirements for the same provided under Subsection M9.06.5 except that only AASHTO M 148, Type I shall be permitted.

The membrane curing shall be applied in one or more separate coats at the rate of at least 3.0 liters per 10 square meters. If, in the Engineer's judgment, discontinuities or pinholes exist or if rain falls on the newly coated surface before the film has dried sufficiently to resist damage, an additional coat of the material shall be applied immediately to those affected areas at the specified rate. If a slight delay in application shall occur, which permits the concrete surface to dry, the surface of the concrete shall be thoroughly moistened with water, immediately prior to the application of the membrane curing material. Application of membrane curing may be delayed for 12 hours if the concrete surface is protected and kept moist by the use of wetted burlap.

The membrane compound shall be thoroughly agitated immediately before application. The liquid shall be applied under pressure by means of an approved pressure spray which shall be held not more than 600 millimeters away from the concrete and the spray protected from any wind by suitable means as may be necessary, so as to apply the material directly onto the concrete surface.

The sprayed surface film shall be protected from abrasion or damage for the duration of the required curing period. The placing of materials or unnecessary walking on the surface will not be allowed until the film is at least 2 days old; and then only if no damage is caused to the surface film during the required curing time.

3. Curing by Other Methods.

a. Waterproof Paper. Subject to approval by the Engineer, waterproofed paper may be used for curing particular surfaces of concrete and, if allowed, shall be furnished and used entirely in accordance with the provisions for such under Subsection 476.74, except that the length of time for the curing period shall be as specified herein.

b. Other methods of curing may be used only when approved in writing by the Engineer prior to any use in the work.

C. Finishing.

The external surface of all concrete shall be thoroughly vibrated and spaded during the operation of depositing the concrete by means of tools of an approved type. The vibrating and spading shall be such as to force all coarse aggregate away from the surface and slowly work the mortar against the forms to produce a smooth finish free from water and air pockets or honeycomb.

Unless otherwise shown on the plans or provided in the Special Provisions, the final finish required on particular concrete shall be as follows:

1. Formed Surfaces not Exposed to View.

Immediately after forms have been removed and form ties cut back from the face of the concrete, all voids and cavities shall be filled with a stiff mortar of the same composition and air-entrainment as the mortar in the original concrete mix. The mortar for filling shall have been mixed and let set for 30 minutes and then remixed before placing in the work. In case the operation of filling is delayed, the surface of the concrete shall be thoroughly cleaned and washed with water, if necessary, before the mortar is applied.

2. Formed Surfaces Exposed to View.

Within 48 hours after the forms have been removed and form ties cut back from the face of the concrete, all fins, projections and irregularities shall be carefully removed and all voids and cavities shall be carefully and completely filled with a stiff mortar of the same composition and air-entrainment as the mortar in the original concrete mix. The same brand and color of cement, and the same kind and color of aggregate as was used in the original concrete mix shall be used in this mortar. The mortar for filling shall have been mixed and let set for 30 minutes and then remixed before placing in the work. The surface film of all such pointed surfaces shall be carefully removed before setting of the mortar occurs.

If the Engineer determines these surfaces as prepared do not present a uniformly smooth, clean surface of even texture and appearance, the surface shall be treated and rubbed to obtain a satisfactory finish. The Engineer shall be the sole judge of the amount of rubbing which will be required.

If rubbing is required, the rubbing will start with 48 hours of notification that rubbing is required, the surface should be wetted with clean water and rubbed with a No. 16 carborundum brick or other abrasive of equal quality until even and smooth and of uniform appearance, without applying any cement or other coating. If additional finishing is necessary it shall be obtained by a thorough rubbing with a No. 10 carborundum brick or other abrasive of equal quality. Subject to approval by the Engineer, rubbing may be performed by use of satisfactory power equipment and tools, providing that the operational procedures shall be the same as those outlined above for hand rubbing.

Rubbing will be kept to a minimum found necessary to produce smooth, even surfaces of uniform appearance. Rubbing will not be required to fill very small surface air bubble holes, to remove a uniform wood grain pattern left by forms, not to remove inconspicuous lines or marking between form panels. Rubbing will not be required for the underside of bridge decks.

Patches required for form ties, if carefully and properly done, may not necessitate rubbing. If however, this work is done in such a manner that these patches are conspicuous, the entire exposed face on which they occur shall be rubbed.

After the final rubbing is completed, and the mortar has set up, the surface shall be thoroughly drenched and kept wet with clean water for a period of 5 days, unless otherwise directed.

No rubbing will be permitted when the air temperature is below 5 °C.

3. The use of mortar, cement water mixture or neat cement for topping or treatment of any concrete surface will not be permitted.

4. Bearing Areas for Superstructure Metal.

The surfaces of concrete on bridge seats, piers and pedestals, which are to support shoes or bearing plates of the superstructure, unless otherwise shown on the plans, shall be finished 5 millimeters higher than the required elevations, over areas extending 75 millimeters outside of the shoes or bearing plates. After the concrete has been cured and thoroughly hardened, these areas shall be dressed down by tooling, rubbing, grinding, or otherwise, as may be approved, so as to provide true level surfaces at the required elevations. Satisfactory drainage shall be provided where necessary to prevent water accumulation at bearing areas.

5. Sidewalks and Median Strips on Bridges.

After being placed, the horizontal concrete surfaces shall be properly screeded and finished to true grade and surface. The finish shall be with an approved float, followed by light brushing with a fine brush but without the addition of any water to remove the cement film, leaving a fine grained, smooth but sanded texture. The surfaces shall then be cured as specified herein.

6. Bridge Approach Slabs and Bridge Decks.

(a) *Bridge Approach Slabs.* After concrete is placed, the top surface shall be struck off to the proper crown and longitudinal profile with an approved template. Satisfactory supports, furnished by the Contractor, shall be set and maintained in place for proper operation of the template so that the surface shall be furnished to the required elevations. These supports shall be carefully removed from the concrete before any set of the concrete occurs, and the spaces left by such removal shall be immediately filled and finished to the level of the adjacent surfaces. The surface shall be checked, by means of an approved straight-edge (not less than 3 meters in length), furnished by the Contractor, as the Engineer may direct. Any irregularities, measuring more than 5 millimeters vertically, shall be corrected and the whole surface shall be made smooth and even. No load of any kind shall be placed on the concrete after setting of the concrete has begun, and any work on the concrete then required shall be performed from approved bridges furnished by the Contractor, which will not rest on the new concrete in any manner.

Where membrane waterproofing is to be used the surface of the concrete shall be screeded to the true cross section and left without any projections that might puncture the membrane or depressions that could retain liquid.

(b) *Bridge Decks.* The placing and finishing of these surfaces shall be performed as specified herein.

(1) The Contractor shall submit for approval by the Engineer a detailed schedule showing the time schedule and the sequence he/she intends to use in placing of deck concrete. Also at least 15 days before the erection of screed rails, the Contractor shall submit his/her screed erection plans and details for review and approval by the Engineer. These plans shall also include details of finishing operation equipment and equipment for placement of the concrete.

No concrete shall be placed in any part of the work until steel reinforcement, shear connectors, anchors, drainage piping, conduit lines, etc. have been inspected and approved by the Engineer. The Contractor shall schedule his/her work in such a manner that all forms and reinforcement and other appurtenances shall be set by him/her, and checked by the Engineer on the day preceding the day of pour. The daily placement for the deck slab shall begin early in the morning.

(2) *Setting Screed Rails and Checking of Reinforcement Bars.*

(a) The screed rails and their support shall be of steel and be accurately set so that the finished surface shall conform to the profiles shown on the plans. The supports shall be adjustable, of substantial construction, and shall be placed and adjusted to properly provide for the deflection of forms, supporting beams, falsework, floor beam stringers and weight of finishing machine which may occur during placement of concrete. The supports shall be placed in order to fit the concrete placing procedures and furnish continuity in the required contours for the finished surface. All screed support devices which are to be left embedded in the concrete shall be either epoxy coated or galvanized in accordance with Subsection 960.64.

(b) Prior to the placing of the concrete all reinforcing bars shall be rigidly tied to their supports after being

accurately positioned with proper clearances from the final surfaces of the concrete. The required concrete cover over the top bars shall be checked by riding the screed over the bars and measuring the distance from bottom of screed to top of bars every 3 meters longitudinally and all bars transversely. Discrepancies which are in excess of 5 millimeters shall be rectified by repositioning the top bars to secure the required cover.

(3) Placing of Concrete.

Concrete shall be placed in a uniform manner across the entire width being cast. Dumping of mix in concentrated accumulations shall be avoided. Concrete shall be uniformly placed in front of the screed so that moving of the concrete is kept to a minimum.

Concrete shall not be placed when the ambient temperature is below 5 °C, except as stipulated in Section 901.72, or above 30 °C. At no time shall the internal temperature of the concrete being placed be higher than 21 °C.

(4) Finishing of Concrete.

(a) Only mechanized methods of finishing the freshly placed concrete shall be allowed except at locations inaccessible for mechanical screed and only when approved by the Engineer. Machine finishing of deck slab will not be required in areas outside of curb line, which will support the second lift of concrete for sidewalks, safety curbs, medians or barriers.

(b) Finishing Machines shall be mechanically operated, of rigid construction, riding on rails placed parallel to the bridge centerline and securely fastened to the supporting steel. They shall be of an approved type and shall be operated such that, when concrete is properly consolidated and finished, the surface of the concrete will be at the elevation indicated on the plans, or ordered by the Engineer. The finishing machine shall be set on the screed rails and be aligned parallel to abutments and piers and shall not be so light that it tends to ride the concrete rather than the rails. Only two passes of screed will be allowed over a given area of deck, and the lap of consecutive passes shall be limited to a minimum.

(c) After the concrete has been struck off it shall be further smoothed by means of a longitudinal float of suitable design approved by the Engineer. The float shall be worked from a bridge with a dragging motion while held in position parallel to the road centerline, and passed gradually from one side of the deck to the other. Where membrane waterproofing is to be used, the surface of the concrete shall be checked to ensure that it is without any projections that might puncture the membrane or depressions that could retain liquid.

(d) Where the surface of the concrete is to be used as the riding surface for traffic, once all the irregularities have been removed, a wet burlap bag consisting of a double thickness of approved burlap without seams and about 1 meter in drag width and long enough to span the entire width of surface being finished shall be pulled along the surface in a longitudinal sweeping manner by workers operating from outside the edges of the pavement, or such a burlap drag may be attached to the finishing machine. Where narrow areas adjacent to edges of surface have not been reached in the aforementioned operation, they shall be satisfactorily finished with approved burlap as directed by the Engineer.

The pavement wearing surface shall then be given a final finish by pulling a light broom (about 750 millimeters wide and having two thin rows of flat bristles) gently and squarely across the surface from one edge to the other so as to remove any laitance and other surface blemishes and so as to produce uniform corrugations, not more than 3 millimeters in depth. Walking on the fresh surface of the concrete shall not be permitted.

(e) Where the deck slab will support a sidewalk, safety curb, median or barrier, the surface of the concrete will be finished as follows. A 25 millimeter wide strip immediately adjacent to the curb and coping lines will be given a smooth tooled finish. The remainder of the concrete surface will be raked to a maximum 6 millimeter amplitude parallel with the curb line.

(f) As specified herein and as may be found further necessary, in the judgment of the Engineer, any required work of finishing shall be done from adequate bridges furnished by the Contractor and they shall not be in contact with the surface of the concrete in any manner.

(g) While the concrete is still plastic the surface of the pavement shall be tested with a 3 meters straight-edge attached to a handle of sufficient length to permit testing of the full width of the slab. The straight-edge shall be laid parallel to the centerline of the pavement and any irregularity of 3 millimeters or greater shall be corrected immediately.

(h) Within 24 hours after completion and hardening the surface shall again be checked by the Contractor in the presence of the Engineer, with the straight-edge held parallel to the centerline, and variations exceeding 3 millimeters shall be plainly marked and shall be corrected at the Contractor's expense in a manner satisfactory to the Engineer.

(i) Hand Finishing. When hand finishing is used the surface of the concrete shall be struck off by means of a wooden or steel template of approved section. The template shall be constructed to produce the desired surface contour and have sufficient strength to retain its strength under all working conditions. For its proper use, the template should be

at least 600 millimeters longer than the width of the surface to be struck off. In general, vibrating templates shall be used for this operation. Subject to prior approval by the Engineer, non-vibrating templates may be used; the approval for such use to depend on the extent of the work and design requirements.

Satisfactory supports, furnished by the Contractor, shall be set and maintained in place for proper operation of the template so that the surface of the concrete shall be finished to the required elevations for the finished surface. The supports shall be carefully removed from the concrete as soon as possible during the finishing operations, and the spaces left by such removal shall be immediately filled and finished to the level of the adjacent surface.

After the concrete has been deposited, spread and consolidated as required herein, it shall be struck off immediately with the template above the grade so that there will be sufficient concrete to fill low and porous spots. The template shall be operated by moving forward with a combined longitudinal and transverse motion and so manipulated that it bears fully on the control supports. A slight excess of material shall be kept in front of the cutting edge. The concrete shall be worked so as to embed coarse aggregate and to remove porous spots but not so as to force excess mortar or water to the surface. Low spots shall be filled and the material worked into place. The resulting surface shall be only slightly above the required grade and shall be uniform in appearance, density and composition.

The concrete shall then be brought to the required grade and density, and all surplus material removed, by striking off the concrete with the template in the operational manner required above except that the template shall be held firmly on the supports and operated in a slow, even speed. Finishing with the template and removing of any projections or depressions shall be continued until the required surface is obtained.

As soon as possible after finishing as specified, the surface of the concrete shall be finished in accordance with the operations and requirements prescribed herein after completion of the machine finishing under the subsection "Machine Finishing."

Satisfactory supports, furnished by the Contractor, shall be set and maintained in place for proper operation of the machines so that the surface of the concrete shall be finished to the required elevations.

Unless otherwise shown on the plans, the roadway concrete shall be placed and finished the entire width of the roadway area. When shown on the plans, longitudinal keyed and reinforced construction joints shall be constructed at such locations and in accordance with the details required by the plans or as approved by the Engineer.

901.69 Removal of Forms and Loading on Structures.

The word forms as used herein shall include all supports of the actual forms enclosing the concrete.

The forms for any portion of the structure shall not be removed until the concrete is strong enough, as determined by the Engineer, to avoid possible injury from such removal. Forms shall not be removed or disturbed without the prior approval of the Engineer. Form (supports) shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

When test cylinders are taken from the concrete in the members of a structure, the forms shall be left in place until the concrete has attained the strength designated in the following table, and, regardless of strength attained, for the minimum period indicated. In the absence of cylinder tests, the forms shall remain in place for the period specified under minimum loading period. However, in order to facilitate any particular finishing operations, side forms carrying no load may be removed 24 hours to 72 hours (depending on weather conditions and class of concrete) after the placing of the concrete has been completed, subject to the approval of the Engineer and with the complete curing process to be continued as required.

No superimposed load of any kind or for any purpose will be allowed on a structure before the expiration of the period of time prescribed in the table, whether or not the forms have been removed, except as follows:

(A) A superimposed live load not exceeding 2400 kilograms, operated at a speed not to exceed 8 kilometers per hour, may be allowed on bridge deck concrete 5 days after standard cement concrete is placed and 3 days after high early strength cement concrete is placed provided the concrete has reached a compressive strength of 23 megaPascals.

(B) A superimposed dead load mass not exceeding 39 kilograms per square meter may be allowed under the same time and strength requirements as for a live load, provided the load is placed near the ends of the beam spans. Where possible, the load shall be spread over two or more beams.

FOR STANDARD CEMENT CONCRETE

Minimum Strength of Concrete in	Minimum Days for Forms	Minimum Days Before Design
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Length of Span	MegaPascals	in Place	Loading
Up to 3 meters	23	8	10
Over 3 meters - Up to 6 meters	23	10	14
Over 6 meters - Up to 9 meters	23	12	18
Over 9 meters	23	14	22

FOR HIGH EARLY STRENGTH CEMENT CONCRETE

Length of Span	Minimum Strength of Concrete in MegaPascals	Minimum Days for Forms in Place	Minimum Days Before Design Loading
Up to 3 meters	23	5	5
Over 3 meters - Up to 6 meters	23	5	5
Over 6 meters - Up to 9 meters	23	8	8
Over 9 meters	23	10	10

In case a particular increase in strength of concrete in a particular period of time is required by the Contract, or is directed or approved by the Engineer, and is between the strength attained by the use of standard cement concrete and the strength attained by the use of high early strength cement concrete, the time periods as required in the tables above shall be adjusted proportionally to fit the particular time in which the stated strength is attained by such procedure. The strength shall be attained by an extra amount of Standard Cement or by the use of particular elements of approved admixtures.

The time requirements provided in both the above tables date from the complete placing of concrete in the member, and are the minimum requirements for the most favorable weather conditions. Longer periods, as directed by the Engineer, will be required to compensate adequately for adverse weather conditions.

For a concrete deck supported on steel stringer beams or floor beams, the span will be considered as the distance between center of beams. For composite concrete and steel beams the span governing the "Minimum Days for Forms in Place" shall be the distance between center of beams, and the span governing the "Minimum Days Before Design Loading" shall be the distance between the center lines of main bearings. For concrete slabs, T-beams, and girders the distance shall be between center lines of main bearings; and for arches and rigid frames, the distance between springing lines.

If a placing sequence is not stated on the plans or in the Special Provisions of a contract which includes the construction of a continuous span structure, the forms for the entire continuous group shall remain in place until every span of the group has been supported for the minimum required period of time.

No backfill or any other operation that could in any way cause stress in the concrete shall begin prior to the period of time required before loading of the structure.

Any defective work discovered after the forms have been removed shall be immediately removed and replaced. If the surface of the concrete is bulged, uneven or show excessive voids or form joint marks which cannot be repaired satisfactorily, the entire section shall be removed and replaced. All repairs and renewals due to defective work shall be done at the expense of the Contractor.

901.70 Protection of Pipes and Conduits.

The Contractor shall care for and protect from injury all pipes, wires and conduits encountered in the work by furnishing and maintaining suitable supports, including steel bars, where directed on the bridge during construction.

The Contractor shall provide suitable openings in the abutments, walls, piers, and superstructures as shown on the plans and as may be directed. If required, the opening shall be filled with brick masonry in a satisfactory manner.

901.71 Date, Seal, Bench Marks and Ornaments.**A. Date.**

The Contractor shall place a date on bridges as shown on the plans or as directed. The date shall be cast or cut in masonry as directed. Detail drawings of the date will be furnished by the Department.

B. Seal.

If indicated on the plans, the Contractor shall place a bronze replica of the State Seal on Bridges, as directed by the Engineer. The seal will be furnished by the Department.

C. Ornaments.

Concrete ornaments shall be furnished and placed by the Contractor on bridges when indicated on the plans. The ornamental castings may be either cast in place or precast.

901.72 Concrete Construction During Cold Weather.

Any concrete placed during cold weather shall be placed at the Contractor's risk and any damage or unsatisfactory concrete shall be removed and replaced at the Contractor's expense. Concrete mixed or placed when the air temperature is below 5° C will be considered cold weather concrete and will require special treatment. In general the special treatment is indicated below.

No concrete shall be placed when the atmospheric temperature in the shade and away from artificial heat is below 2° C or when the temperature may be expected to drop below -1° C within 24 hours, except upon permission in writing by the Engineer, which shall not be granted until satisfactory provisions have been made to protect the work.

If the air temperature in the shade and away from artificial heat may be expected to reach 5° C or lower at any time during the day or night of the 24 hours following the placing of the concrete, protective cover, heating or protective cover and heating will be required on all exposed surfaces. When the air in the shade and away from artificial heat is 5° C or lower temperature, the mixing water and/or aggregates may be heated (prior to cement being added) by approved methods so that the temperature of the aggregates and water mixture is not less than 20° C nor more than 60° C. The temperature of the concrete shall not be less than 15° C nor more than 30° C at the time of placing it in the forms. The heating shall be done in a manner to preclude the occurrence of overheated areas which might result in damage to the materials. Any material containing frost or lumps of hardened material shall not be used.

Where it may be expected that considerable heat will be generated by the hydration of the concrete, and in some cases where heat is not rapidly dissipated, suitable coverings shall be used to protect concrete. Heavy footings in which the concrete is placed at a temperature of 20° C and protected by the surrounding earth, except on top, shall be protected down to an air temperature of about -10° C by a tarpaulin placed over the top with an air space between the concrete and the tarpaulin. Mass concrete, when concrete as such is so specified on the plans or so defined by the Engineer, may be protected down to an air temperature of about,

-7° C by enclosure with tight wooden forms at least 16 millimeters in thickness and the concrete is placed at a temperature of 20° C except at corners and edges. Double sheating, insulation board or tarpaulins with a dead air space between the covering and the forms shall be placed to equally protect such edges and corners. Enclosures and added artificial heat will be required for such concrete placed at lower air temperatures.

The Contractor shall have readily available for installing on the work adequate material for the proper enclosure or covering of the concrete together with adequate equipment for satisfactory heating as may be necessary.

As much as possible of any enclosure for protection shall be in place before depositing of any concrete and the remainder shall be installed as rapidly as possible in order to reduce heat losses to a minimum.

The temperature of the concrete inside the enclosure shall be held above a minimum temperature of 10° C and the air surrounding the fresh concrete shall be kept a temperature within a 10° C to 25° C range. The temperature of the concrete shall be maintained above 20° C for the first three days or above 10° C for the first five days after the concrete is completed in place, except periods of time may be reduced when satisfactory strength is attained sooner, as with the use of high early strength cement concrete, then a minimum of 20° C for two days or 10° C for four days will be required. In any case the periods of time provided above are minimum requirements and extensions of these periods of time will be required provided that such may be necessary to develop satisfactory strength in the concrete.

After the concrete has been cured for the required length of time, the temperature within the housing shall be gradually reduced no faster than 0.5° C per hour until it equals the surrounding air temperatures.

Heating within the enclosure shall be attained by such means of artificial heat as will maintain the temperatures specified continuously and with a reasonable degree of uniformity in all parts of the enclosures. All exposed surfaces of concrete within the enclosure shall be kept sufficiently moist to prevent any rapid drying of the surface concrete with possible resulting damage to the concrete in place. Heating appliances shall not be placed in such a manner as to endanger the enclosure, forms or supports, or expose any area of concrete to rapid drying out or other injury due to excessive temperatures.

Should the Contractor wish to secure permission to use other methods than those provided above for protective retaining of heat within the concrete or direct protective heating of the concrete by adequate facilities for same, such

request shall be made in writing by him/her to the Engineer and shall include verifiable evidence of satisfactory results obtained by use of such methods. Other methods than those provided herein shall not be used unless approved in writing by the Engineer, and then only under the full responsibility of the Contractor.

901.73 Concrete Penetrant/Sealer.

Concrete penetrant/sealer shall be applied to bridge copings, beam seats, parapets, end posts, median barriers and other cement concrete surfaces as designated and shown on the plans and in accordance with these and the manufacturer's specifications. This work shall consist of furnishing all necessary labor, materials and equipment to treat concrete surfaces, including surface preparation and application.

The concrete penetrant/sealer shall conform to M9.15.0. Clear concrete penetrant/sealers after complete application, shall not stain, discolor or darken the concrete to any appreciable degree. Application of the penetrant/sealer shall not alter the surface texture and shall be compatible with the use of surface finish coatings and/or caulking. The surface shall dry to a tack free condition. Application of the penetrant/sealer shall be in accordance with the manufacturer's recommendations, including condition and preparation of surfaces to be treated.

The preparation process shall not cause any undue damage to the concrete surface, remove or alter the existing surface finish, or expose the coarse aggregate of the concrete.

Concrete surfaces prepared for treatment shall be approved by the Engineer.

The concrete penetrant/sealer shall be used as supplied by the manufacturer and not diluted or altered in any way. The penetrant/sealer shall be applied onto the concrete surfaces at the manufacturer's recommended rate of coverage. Manufacturer's safety precautions shall be strictly adhered to.

The Contractor shall exercise all reasonable precaution to prevent the penetrant/sealer from coming in contact with any joint sealers, so as to prevent any possible loss of bond of the joint sealer.

901.74 Dowel Bar Splicer/Reinforcing Bar Splicer.

Dowel Bar Splicer/Reinforcing Bar Splicer, a mechanical device to join steel reinforcing bars, shall meet the following requirements:

1. All mechanical splicers shall develop, as required, at least 125% of the specified yield strength of steel reinforcing in tension and compression. Reinforcing Bar Splicers which have been tested and approved and are on the approved products list are acceptable for use on Massachusetts Highway Department bridge projects. A copy of the approved product list may be obtained from the Department's Research and Materials Section.

2. Equivalent Joining devices may be used but they must be submitted to the MHD Research and Material Laboratory for testing and approval. The contract time shall not be extended to allow for the above testing and approval process.

3. Special consideration shall be given to the minimum concrete cover requirements over stirrups, ties and spirals at the reinforcing bar splicer locations. All portions of the reinforcing bar Splicer shall meet the cover requirements as specified in construction drawings.

4. During testing, ultimate testing failure must occur in the reinforcing bar being joined, rather than the joining device. The mechanical connection device must not introduce notch effects that would cause the bar to rupture at the mechanical connection device before the required yielding can occur in the adjoining bar stock. Assembly features shall provide for reasonably error free work under construction conditions.

5. Reinforcing Bar Splicers shall be tested with epoxy coated reinforcing steel, and the final assembly shall be in conformance with the specifications for epoxy coating. The Engineer will be the sole judge for the above criteria.

COMPENSATION

901.80 Method of Measurement.

Cement concrete masonry will be measured by the cubic meter and the quantity shall be determined in accordance with dimensions shown on the plans and such alteration of the plans as are specifically ordered by the Engineer in writing. No deduction shall be made in bridges for rustications, chamfered corners of dimensions less than 100 millimeters on the square sides, or for the volume of pipes less than 500 millimeters in diameter, drainage inlets, or for anchor bolts or reinforcing bars. The volume occupied by pipe culverts in headwalls shall be deducted.

Reinforcement for cement concrete masonry structures shall be measured by the kilogram. The mass of bars shall be the product of the length as shown on the approved plans and schedules and the standard mass per meter of length as adopted by the Concrete Reinforcing Steel Institute. Wire, metal clips, metal chairs or other fastening and supporting devices used for keeping the reinforcement continuous and in correct position will not be considered reinforcement and the Contractor will receive no additional compensation for their use.

The mass of wire mesh (incorporated in the structure) shall be the computed mass in accordance with the plans based on the standard mass accepted by the trade for the unit area of the particular mesh.

901.81 Basis of Payment.

Cement concrete masonry will be paid for at the contract unit price per cubic meter under the particular item of Cement Concrete Masonry of the Class required, as shown on the plans or as directed, complete in place and accepted.

The Contractor shall have no claims for special allowances for extra cement or apparent shrinkage due to inaccurate proportioning or control, bulging of forms, spilling, waste or for any other project conditions within his/her control.

Payment for additional cement required to be used in proportioning by volume and in placing of concrete under water shall be included in the contract unit price paid for the particular designation of cement concrete masonry specified or directed.

When high early strength cement concrete masonry is used (where originally standard cement concrete was specified) by order of the Engineer after the Contract has been executed, the Contractor will be paid in addition to the contract unit price for such standard cement concrete masonry the sum of \$5.00 per cubic meter for all high early strength cement concrete masonry as is so directed to be used. When the contract has specified that high early strength cement concrete shall be used, or if the Contractor is permitted to choose such concrete as an option, then no additional payment will be made for such concrete.

Latex Modified Mortar and Concrete Overlayments will be paid for at the contract unit price per square meter, complete in place and accepted including surface preparation.

Steel reinforcement including wire mesh will be paid for at the contract unit price per kilogram under the item for Steel Reinforcement for Structures, complete in place. No payment will be made for any fastening devices or supports that may be used for keeping the reinforcement in correct position.

Galvanized steel curb bars and steel dowels will be paid for at the contract unit price per kilogram under the item for Steel Reinforcement for Structures.

The work specified under Subsections 901.70, 901.71, 901.72, and 901.73 shall be done without extra compensation except when openings for pipes, wires and conduits are required to be blocked up, the brick masonry will be paid for at the contract unit price per cubic meter of the kind of masonry in which the opening occurs.

Holes for dowels shall be drilled by the Contractor without extra compensation.

901.82 Payment Items.

901.	30 MPa - 40 mm - 335 kg Cement Concrete Masonry	Cubic Meter
902.	25 MPa - 40 mm - 310 kg Cement Concrete Masonry	Cubic Meter
903.	20 MPa - 40 mm - 280 kg Cement Concrete Masonry	Cubic Meter
904.	30 MPa - 20 mm - 390 kg Cement Concrete Masonry	Cubic Meter
904.1	35 MPa - 20 mm - 420 kg Cement Concrete Masonry	Cubic Meter
905.	30 MPa - 10 mm - 425 kg Cement Concrete Masonry	Cubic Meter
906.	35 MPa - 40 mm - 400 kg Cement Concrete Masonry	Cubic Meter
907.	Latex Modified Mortar and Concrete Overlayment	Square Meter
910.	Steel Reinforcement for Structures	Kilogram
910.1	Steel Reinforcement for Structures - Epoxy Coated	Kilogram
911.	Shear Connectors	Lump Sum
999.901	Allowance for High Early Strength Concrete	Cubic Meter

SECTION 930

PRESTRESSED CONCRETE BEAMS