DIVISION 600
INCIDENTAL CONSTRUCTION

SECTION 601
STRUCTURAL CONCRETE

601.1-DESCRIPTION:

This work shall consist of furnishing and placing portland cement concrete for structures, and incidental construction, in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions as shown on the Plans or established by the Engineer.

All concrete shall be air-entrained.

Classes of concrete shall be used as indicated below unless noted otherwise on the Plans:

Class A concrete shall be used in railing, cribbing, precast shapes, for filler, and in steel grid floors.

Class K concrete shall be used in all sidewalks, parapets, decks, and median barriers when they are a part of the bridge superstructure.

Class B concrete shall be used in all beams and girders, roadway sidewalks, columns, hammerhead piers, arch rings including ties and spandrel walls, rigid frames, box culverts, heavily reinforced abutments, retaining walls, footings, pedestals and other areas not specifically designated as to class of concrete.

Class C concrete shall be used in massive footings and pedestals, massive pier shafts, gravity walls and, in general, for non-reinforced or lightly reinforced concrete.

Class D concrete shall be used as unformed and non-reinforced concrete for backfilling of any excavated pockets or voids on which footings are to be located.

If the Contractor so elects, the Engineer may permit the use of a higher class concrete than the particular class designated for the work, in which event the higher class concrete shall meet the Specifications applicable without additional compensation.

When called for on the Plans, an admixture of water-reducing retarder shall be added to all concrete so specified. A retarder may be used in other concrete at the Contractor's option.

A water-reducing admixture may be used at the Contractor's option. A water-reducing admixture may not be used in conjunction with a water-reducing retarder.

The work will be accepted in accordance with these Specifications and the applicable requirements of 105, 106, and 109.

601.2-MATERIALS:

Materials shall meet the requirements specified in the following Sections or Subsections of Division 700:

MATERIAL	SECTION OR SUBSECTION
*Portland Cement	701.1, 701.3
Air-Entraining Admixtures	707.1
Water-Reducing, Set-Retarding Admixtures	707.2
**Fine Aggregate	702.1
Coarse Aggregate	703
Boiled Linseed Oil	711.2
Petroleum Spirits (Mineral Spirits)	711.5
Water	715.7
Curing Materials	707.6-707.10
Water Reducer	707.3
Epoxy Resin Protective Coating	707.11
Pozzolanic Additives	707.4

*It is normally intended that the product of only one mill or of any one brand or type of portland cement be used on any one structure.

**Only siliceous sand shall be used as fine aggregate in bridge deck wearing surfaces.

***The use of a pozzolanic additives will not be permitted when a blended hydraulic cement is used. Unless otherwise permitted by the Engineer, only one source of a pozzolanic additive shall be used in any one structure.

Shipping and Storage of Cement: Cement shall be shipped from pretested and approved bins at the mill or distribution terminals. Cement stored by the Contractor for a period longer than 90 days shall be retested before being used in the work. Cement failing to meet any of the specified requirements at any time prior to incorporation into the work will be rejected and shall be removed from the work. Cements of different brands, types, or from different mills shall be stored separately.

Shipping and Storage of Pozzolanic Additives: Pozzolanic additives shall be shipped from only those sources approved by the Division. Bulk pozzolanic additives shall be stored at the job site in weatherproof bins. Pozzolanic additives from different sources or from different lots at the same source shall be stored separately.

CONSTRUCTION METHODS

601.3 - PROPORTIONING:

601.3.1 - Mix Design Requirements:

Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportion of materials, including admixtures, to be used which will result in a workable concrete having the applicable properties enumerated below, including those of Table 601.3.1A. A mix design prepared in accordance with MP 711.03.23, shall be required for each class of concrete to be used in the work. The mix design shall be accompanied by a statement giving the source of materials and certified test data from a Division approved laboratory demonstrating the adequacy of the mix design. The Contractor shall notify the Engineer of any change in the source of materials or the addition of admixtures during the progress of the work, since such change may necessitate a new mix design. The Contractor shall also state the Ā value of the fine aggregate and the Ā value of the combined grading of the coarse aggregate, fine aggregate, and cement used in the mix design.

TABLE 601.3.1A
{ENGLISH}

Class of concrete	Design 28 Day Compressive Strength	Target Cement Factor	Maximum Water Content	Standard Size of Coarse Aggregate	Entrained Air
	Pounds per Square inch	Bags/c.y. *	Gal/bag Of cement **	Number	Percent
A	3500	7¼	5¾	7, 78, or 8	7½
K	4000	7	5	57, 67	7
B	3000	6	5½	57, 67	7
C	2500	5¼	6½	57, 67	6
D	2000	4¼	7	57, 67	5½

{METRIC}

Class of concrete	Design 28 Day Compressive Strength	Target Cement Factor	Maximum Water Content	Standard Size of Coarse Aggregate	Entrained Air
	Mpa	Kg per cu. M. *	L/Kg Of cement **	Number	Percent
A	24	404	0.51	7, 78, or 8	7½
K	28	390	0.44	57, 67	7
B	21	335	0.48	57, 67	7
C	17	295	0.58	57, 67	6
D	14	235	0.62	57, 67	5½

*An equal volume of a pozzolanic additive may be substituted for Portland cement up to the maximum amount in Table 601.3.1B. Only one pozzolanic additive is permitted in a mix design.

TABLE 601.3.1B

MATERIAL	CLASS OF CONCRETE	QUANTITY
Fly Ash	B, C, D	1 Bag (15%)
	A, K	1 ¼ Bags (19%)
Ground Granulated Furnace Slag	A, B, K	3 Bags (45%)
	C, D	2 Bags (30%)
Microsilica	All Classes	1/2 Bag (8%)

** When using a pozzolanic additive, volumes of these materials shall be considered as cement for purposes of establishing maximum water content.

MP 711.03.26 shall be used to control the cement factor in all classes of concrete.

601.3.2 - Field Tolerances and Adjustments:

601.3.2.1 - Consistency:

Concrete shall have the consistency which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain a uniform consistency. The optimum consistency for various types of highway structures shall be as indicated in Table 601.3.2.

TABLE 601.3.2 CONSISTENCY

TYPE	*OPTIMUM CONSISTENCY Inches of Slump (mm of slump)
i. For structures which have exposed, inclined surfaces such as concrete gutters, cast in place concrete slope protection, etc., requiring low slump concrete to allow proper placement and consolidation and the maintenance of the prescribed geometry; those structures which are placed by slip form construction methods where a low slump is required to maintain the prescribed geometry; and mass nonreinforced concrete.	1 inch (25 mm)
ii. For reinforced concrete structures which are sufficiently massive and generally have sufficient clearances to allow the access of workers into the immediate area of concrete placement, such as bridge piers, column and abutment footings; piers, large columns, and other similar type structures into which workers may enter for the purpose of placing and consolidating the concrete.	2 inches (50 mm)
iii. a. For reinforced concrete structures which are not easily accessible for spading and vibrating and offer a fair degree of difficulty in the placement and consolidation of the concrete, such as pier caps and abutments, beams and girders, box culverts, miscellaneous structure footings and other slab type structures, wall or vertical sections 8 inches (200 mm) or greater in width with one line of reinforcement or 12 inches (300 mm) or greater in width with two lines of reinforcement.	3 inches (75 mm)
b. For bridge decks with a mix design having a water content between 3.96 and 5.0 gallon (15 and 19 liters) per bag of cement.	2 ½ inches (62 mm)
c. For bridge decks with a mix design having a maximum water content of 3.95 gallon (15 liters) per bag of cement.	5 inches (125 mm)

TYPE	*OPTIMUM CONSISTENCY Inches of Slump (mm of slump)
iv. For structures which are inaccessible to workers and generally offer a considerable degree of difficulty in the placement and consolidation of the concrete, such as long slender columns and thin-walled 3 ½ sections less than 8 inches (200 mm) thickness.	3 ½ inches (87 mm)
v. For structures which present peculiar conditions under which concreting must be done, such as structural steel encasement; other special structures which contain small openings through which the concrete must pass; tremie concrete which must be placed and consolidated into all spaces without mechanical disturbances; and other special structures which would require high consistency concrete for proper placement and consolidation.	**

* If the consistency exceeds the target value plus one inch (25 mm), the Contractor shall take immediate steps to reduce the slump of succeeding loads by making necessary adjustments in the mixture. The Contractor will be allowed a reasonable time for the trucks already on the road for a central mix or truck mix operation. Failure to comply will be cause for rejection of the concrete. If the consistency exceeds the target value plus 1 ¾ inches (445 mm), the concrete will be rejected.

** The optimum consistency shall be that consistency which will allow a proper placement and consolidation of the concrete into all spaces.

601.3.2.2 - Air Content:

The target value of the entrained air at the point of placement shall be as shown in Table 601.3.1A. If the entrained air does not conform with the target value within plus or minus 2.5 percentage points, the Contractor shall take immediate steps to adjust the air content of succeeding loads by making necessary adjustments in the mixture. The air content shall be measured on loads already batched and enroute, as well as the first load to which any adjustments were made in batching procedures. If the air content exceeds the target value plus 3.0 percentage points the concrete shall be rejected. When the concrete is delivered in a truck mixer and the air content is less than the target value minus 2.5 percentage points the concrete shall be rejected, or the Contractor may use additional air entraining agent in an amount that is intended to achieve the target value specified. The addition is permitted under the following conditions:

i. The air entraining agent is the same as used in the approved mix design and is thoroughly mixed with a minimum of 2 gallons (7.57 liter) of water. The solution will be directed to the front of the mixer.

ii. The mixer is turned a minimum of 30 revolutions, at mixing speed, or the number of revolutions established in tests to comply with uniformity requirements, whichever is more.

iii. Immediately after mixing, the air content and slump shall be measured by a certified inspector or technician.

An air adjustment may be attempted twice per truck. If after the second addition the specified air content is not achieved, the concrete shall be rejected. These procedures do not alter the limits placed on time to discharge, the total revolutions of the mixing drum, or the specified slump.

601.3.2.3 - Yield:

The approved mix design shall be subject to modification under the conditions prescribed.

After the start of the first concreting operation and immediately after the specified consistency and entrained air have been established, three unit weight determinations shall be made from different batches and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be determined from the average unit weight. The design mix shall be adjusted as required to correct the actual yield to correspond to the theoretical.

During the progress of the work, the actual yield may be verified; and, if the yield based on a single unit weight determination should differ from the theoretical more than plus or minus two percent, two additional unit weight determinations shall be made and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be determined from the average unit weight, and the design mix shall again be adjusted as required to correct the actual yield to correspond to the theoretical.

In addition to the mix design adjustments specified above to correct for yield, other adjustments in the design mix proportions shall be made as necessary to maintain a plastic, workable mix with suitable finishing characteristics.

No change in the brands or sources of material shall be made without prior approval of the Engineer. Methods for determining the properties enumerated above shall be in accordance with 601.4.

601.3.2.4 - Total Solids Ã

The combined grading of the coarse aggregate, fine aggregate, and cement used in the structural concrete shall conform to the design mix Ã plus or minus the tolerance specified in the following table for the coarse aggregate size used.

TABLE 601.3.2.4 - Total Solids Ã

COARSE AGGREGATE SIZE NUMBER	DESIGN MIX Ã TOLERANCE
3 OR 4	± 0.35
57 OR 67	± 0.25
7, 78 OR 8	± 0.15

Ā is the value of total solids (coarse aggregate, fine aggregate and cement). The grading of the total solids shall be determined by the Contractor at least once each production day. Should the moving average of any five consecutive grading test results of the total solids have an Ā outside the specified mix design tolerance limits, production shall be discontinued until appropriate corrections are made. Corrections shall be made either in the proportions of the concrete (the mix design), the gradation of the aggregates, or the storage and loading of the aggregate, as the Contractor may elect.

601.4-TESTING:

601.4.1-Sampling and Testing Methods:

Sampling fresh concrete	AASHTO T 141
Sampling aggregate	MP 700.00.06
Sieve analysis of fine and coarse aggregates	AASHTO T 27 and T 11
Slump of portland cement concrete	AASHTO T 119 (Note 1)
Air content of freshly mixed concrete	AASHTO T 152 AASHTO T 196 With MP 711.03.20
Unit weight/Yield of concrete	AASHTO T 121
Making and curing concrete compressive specimens	AASHTO T 23 With MP 601.04.20
Compressive strength of cylindrical concrete specimens	AASHTO T 22
Total moisture content of aggregate by drying	AASHTO T 255
Predicting potential strength of portland cement concrete	MP 711.03.31
Determination of Ā of total solids in concrete	MP 601.03.51
Determination of free moisture in fine aggregate using 20 gram or 26 gram A “Speedy Moisture Tester”	MP 702.00.20

601.4.2

Note 1 - When testing concrete produced by volumetric batching and continuous mixing, the consistency testing shall be delayed for approximately three to five minutes after mixing.

601.4.2-Contractor's Quality Control: Quality control of the structural concrete is the responsibility of the Contractor as designated in MP 601.03.50. The Contractor shall maintain equipment and qualified personnel, including at least one certified portland cement concrete technician who shall direct all field inspection, sampling and testing necessary to determine the magnitude of the various properties of concrete governed by the Specifications and shall maintain these properties within the limits of this Specification. The quality control plan designated in MP 601.03.50 shall be submitted to the Engineer at the preconstruction conference. Work shall not begin until the plan is reviewed for conformance with the contract documents.

601.4.3-Acceptance Testing: Acceptance sampling and testing of portland cement concrete is the responsibility of the Division, except for furnishing of necessary materials.

Quality control sampling and testing performed by the Contractor may be utilized by the Division for acceptance.

Strength as used in this specification, is only one indicator of the durability of the portland cement concrete. Evaluation of structural concrete may include evaluation of the freeze-thaw durability, scaling characteristics, abrasion resistance, density and such other factors the Division deems appropriate.

601.4.4-Compressive Strength Tests for Acceptance: A strength test shall consist of three standard test specimens. The test shall be the average of the three specimens, except that if one specimen shows manifest evidence of improper sampling, molding, or testing, it shall be discarded and the remaining two strengths averaged. Should more than one specimen representing a given test show definite defects due to improper sampling, molding, or testing, the entire test shall be discarded.

Compressive strength tests shall conform to the requirements of Table 601.3.1. Statistical analysis may indicate a percentage of production to be below nominal minimum design strength. Concrete represented by compressive strengths below the nominal minimum design strength of Table 601.3.1 may be removed and replaced by the Contractor. If the Contractor elects to leave the material in place, it will be evaluated as to adequacy for the use intended. All concrete evaluated as unsatisfactory for the use intended shall be removed and replaced or otherwise corrected by and at the expense of the Contractor as required in 105.3. When an evaluation indicates that the work may satisfactorily remain in place, a statistical analysis will be made of the material. If this statistical analysis indicates at least 93 percent of the material may be expected to have compressive strengths equal to or greater than that shown in Table 601.3.1 and 99.87 percent of the material may be expected to have compressive strengths at least one standard deviation above the allowable

design stress ($f_c + \sigma$), the work will be accepted as substantially complying with the specification requirements. If this statistical analysis indicates that less than 93 percent of the material may be expected to have compressive strengths equal to or greater than that shown in Table 601.3.1 or less than 99.87 percent of the material may be expected to have compressive strengths at least one standard deviation above the allowable design stress ($f_c + \sigma$), the Engineer will provide for an appropriate adjustment under the provisions of 601.15.

The Division's statistical analysis will be based on a minimum of 10 cylinder test results. These results may be from the concrete item beingplaced, the same class of concrete on the project or the same class of concrete from the producer.

601.5-EQUIPMENT AND TOOLS:

601.5.1-Field Laboratory: Field laboratory provisions shall conform to the requirements prescribed in 501.5.1.

601.5.2-Batching Plant and Equipment:

601.5.2.1-General: The batching plant shall include bins, weigh hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a separate bin, weight hopper, and scale for cement shall be included. The cement weight hopper shall be properly sealed to preclude dusting during operation and shall be properly vented to prevent a build-up in pressure. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it. When fly ash is used in the concrete a separate bin shall be included.

601.5.2.2-Bins: Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

601.5.2.3-Scales: The scales for weighing aggregates and cement shall conform to the requirements in 109.1.

Scales shall be inspected and sealed as often as may be deemed necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 50 lb. (20 kg) weights for testing scales.

601.5.2.4-Automatic Weighing Devices: Batching plants equipped to proportion aggregates and bulk cement by means of automatic weighing devices of an approved type may be used.

601.5.2.5-Water Measuring Equipment: Water shall be measured by volume or by weight. The device for the measurement of the water shall be readily adjustable and, under all operating conditions, shall havean accuracy

within one percent of the quantity of water required for the batch.

601.5.2.6-Admixture Dispenser: A positive, automatic method shall be used for adding each admixture in solution.

601.5.2.7-Aggregate Sampling: Provisions shall be made to allow a rapid sampling of the aggregates as they pass from the storage bin to the weigh hopper or as they pass from the storage bin into the conveyor feed.

601.5.3-Mixers and Agitators: Site and central mixers, truck mixers, truck agitators, and non-agitator trucks shall conform to the requirements of AASHTO M 157, except as modified.

Volumetric mixers shall conform to the requirements of AASHTO M 241, except as modified.

Central mixers shall be equipped with a device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, providing that each batch is mixed for the specified time period.

All mixers shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down ¾ in. (20 mm) or more. The Contractor shall either have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or provide permanent marks on blades to show points of ¾ in. (20 mm) wear from new conditions. Holes of ¼ in. (6 mm) diameter near each end and at midpoint of each blade are recommended).

601.6-HANDLING, MEASURING, AND BATCHING OF MATERIALS:

Handling, measuring, and batching of materials for ready-mix concrete shall conform to the requirements specified in 501.7. Handling, measuring, and batching of materials for volumetric batching and continuous mixing shall conform to the applicable requirements specified in 501.7 and AASHTO M 241.

601.7-MIXING:

Concrete may be central-mixed, truck-mixed, or shrink-mixed as defined in AASHTO M 157 and will be designated as ready-mixed concrete. The production of ready-mixed concrete shall meet the applicable requirements of AASHTO M 157, paragraphs ten and eleven, except as otherwise specified.

Concrete for incidental construction items may be made be volumetric batching and continuous mixing as designated in ASTM C 685, except as otherwise specified. Concrete produced by this method will not be permitted in bridge, box culvert, pavement, or retaining wall construction.

When a truck mixer or agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within one and one-half hours after the addition of the cement to the aggregates. Each batch of the concrete delivered at the job site shall be accompanied by a batch ticket (Form HL 411A) bearing complete batching information. In adverse weather or under other conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85° F (30° C) or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed one hour. When a truck mixer is used for the complete mixing of the concrete, the mixing operation shall begin within one hour after the cement has been added to the aggregate.

The addition of water after completion of initial mixing will not be permitted, except that when concrete is delivered in truck mixers, additional water may be added to adjust to a specified consistency. In this event, a minimum of 20 additional revolutions of the truck mixer drum at mixing speed shall be required before discharge of any concrete; the maximum allowable time between the addition of the cement to the aggregates and the discharge of the batch shall not be exceeded. Concrete that is not within the specified consistency limits at the time of placement shall not be used.

Shrink-mixed concrete is a ready-mixed concrete which is initially and partially mixed in a central mix plant and lastly mixed to completion in a truck mixer while in transit to or after arrival at the job site. Shrink-mixed concrete will be allowed for use in the work if specified in the Contract.

601.8-FORMS:

601.8.1-General: Forms shall be of wood, metal or other approved material and shall be mortar tight and sufficiently rigid to prevent distortion due to pressure of the concrete and other loads incident to the construction operations including vibration. Wood forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. Stay-in-place forms will not be permitted unless provided for in the Contract.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Suitable jacks, wedges or other approved devices shall be used to maintain the forms at correct elevation and to permit lowering the centers gradually and uniformly without injury to the structure.

A "Telltale" or other approved type of indicator shall be attached to the forms and arranged in such a manner that any settlement or movement in the forms or falsework is indicated. Forms shall be filleted and chamfered as shown on the Plans and shall be given a bevel or draft in the case of all projections to assure easy removal.

All field welding shall be performed by a certified welder. Welding of form ties and supports to the beam will not be permitted. Welding of screed rail supports will not be permitted in the top flange in tension zone.

601.8.2-Form Lumber: Form lumber for all exposed concrete surfaces shall be dressed at least on one side and two edges.

601.8.3-Metal Ties: Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 1 in. (25 mm) from the face without injury to the concrete. Only rods shall be used for internal ties. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color.

601.8.4-Cleanouts: Where the bottom of the form is inaccessible, the lower form area shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

601.8.5-Surface Treatment: Forms shall be treated with oil in such manner as to prevent contamination of reinforcing steel. Oil which will adhere to or discolor the concrete shall not be used.

601.8.6-Metal Forms: The metal used for the forms shall be of such thickness that the forms will remain true to shape. All bolts and rivet heads shall be countersunk. Clamps, pins, and 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 do not line up properly shall not be used. Metal forms shall be kept free of rust, grease, or other foreign matter.

601.8.7-Removal of Forms and Construction of Superimposed Elements: The forms for any portion of the structure shall not be removed until the concrete is strong enough to prevent damage. Methods of form removal likely to cause overstressing of the concrete shall not be used.
The minimum requirements for removal of forms or supports and the construction of superimposed elements shall be as specified in Table 601.8.7.

TABLE 601.8.7
REQUIREMENTS FOR REMOVAL OF FORMS AND CONSTRUCTION OF SUPERIMPOSED ELEMENTS

STRUCTURAL ELEMENT	REMOVAL OF FORMS	PLACING CONCRETE IN SUPERIMPOSED ELEMENTS
	Compressive Strength – psi (Mpa)	Compressive Strength – psi (Mpa)
Bridge Decks	2000 (14.0)	3000 (21)
Columns	2000 (14.0)	2000 (14.0)
Walls & Beams	2000 (14.0)	2000 (14.0)
Footings	500 (3.5)	2000 (14.0)
Components Supported By Falsework	3000 (21)	3000 (21)
Parapets	2000 (14.0) (See 601.11)	----

601.8.8-Slip Forming: Slip forming and related methods of placing concrete may be used. At the Contractor's option, parapet wall joints and median barrier on the bridge may be sawed in lieu of formed open joints and the joints shall be spaced as shown on the Plans and shall be ¼ in.± 1/16 in. (6 mm ± 1.6 mm) wide. Joints shall be sawed full width from the top of the wall to the upper break point in the wall. From the upper break point to the bottom of the wall a 2 inches (50 mm) minimum depth saw cut shall be made along the face and back of the wall. Joints shall be sealed in accordance with Section 501.16.1. The face of the back-up material shall be ½ in. (13 mm) minimum from the concrete surface.

Initial sawing of joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excess raveling, usually 4 to 24 hours. All joints shall be initially sawed before uncontrolled shrinkage cracking takes place, but no later than 24 hours after placement of concrete.

601.8.9 601.8.10

601.9-ADVERSE WEATHER CONDITIONS:

601.9.1-Cold Weather Concreting: The plastic concrete shall have a temperature of at least 50° F (10° C) but not more than 85° F (30° C) at the time of placing. When the plastic concrete has a temperature of less than 55° F (13° C), the provisions for cold weather concreting shall apply. Maintenance of at

least the minimum temperature shall be accomplished by heating the water or the aggregates, or both, as necessary. Heating methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. Heating equipment shall be capable of heating the materials to achieve the specified temperature of the plastic concrete. The temperature of the aggregates or water shall not exceed 150° F (65° C) at the time the cement is added to the mixture. Materials containing frost or lumps of frozen materials shall not be used.

If the Contractor is placing concrete or plans to place concrete during cold weather conditions, the Contractor shall advise the Division of his plans for curing and protecting the concrete. The Division may at any time, require the Contractor to provide additional protection to cause the provisions of this specification to be met.

Stockpiled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire.

Binned aggregates may be heated by steam-coil or water-coil heating. The use of live steam on or through binned aggregate will not be permitted.

The use of calcium chloride to hasten the initial set of structural concrete will not be permitted.

Insulated forms may be used for protecting and curing concrete. There will be no additional cost to the Division for the use of insulated forms.

601.9.2-Hot Weather Concreting: The Contractor will be required to state, at the pre-construction conference, his plan of action when the temperature of plastic concrete reaches 90° F (32° C).

When a free air, shaded thermometer in the vicinity of the concrete production plant reaches 85° F (30° C), thermometer readings of the temperature of the plastic concrete shall be taken at least hourly.

When the temperature of the plastic concrete reaches 85° F (30° C), the elapsed time between the introduction of the mixing water to the cement-aggregates and discharge of the mix shall not exceed 1 hour. At this temperature or above, particular attention shall be paid to the Specification provisions concerning the sprinkling and wetting of surfaces not oil-treated, the maintenance of coarse aggregate stock in saturated surface-dry condition, and the prompt start of concrete curing operations.

When the temperature of the plastic concrete reaches 90° F (32° C), immediate steps shall be taken to cool either mixing water or aggregates, or both, in order to maintain a plastic concrete temperature of 90° F (32° C) or less. Crushed or flaked ice may be used to cool the mixing water. Crushed or flaked ice may also be introduced into the mixing drum when the concrete is batched and mixed in a truck mixer. The ice will be considered as part of the mix water in the mix proportions. The mixing operation shall not be considered complete until all ice in the drum has melted.

In no event shall concrete be placed when its temperature in the plastic state

at the completion of mixing exceeds 90° F (32° C).

Bridge Decks: The Contractor's plan of action for all bridge deck concreting operations shall contain provisions designed to minimize the probability that any bridge deck concrete will be placed when the ambient temperature is greater than 85° F (30° C).

601.10-PLACING CONCRETE:

601.10.1-General: Concrete shall not be placed until forms and reinforcing steel have been inspected and approved. The forms shall be cleaned of all debris immediately prior to placing concrete, and surfaces not oil treated shall be wetted. The method and sequence of placing concrete will be subject to approval by the Engineer. Concrete shall be placed so that no segregation will occur and no displacement of reinforcement will be caused. Concrete shall be placed in the forms as nearly as practical in its final position in order to avoid rehandling, and an approximately horizontal surface of the plastic concrete shall be maintained. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement. Concrete shall not be placed until all laitance which may have formed on concrete previously placed, or any loose deleterious material on reinforcing bars, has been removed.

601.10.2-Chutes and Troughs: Concrete shall not be dropped in the forms a greater distance than 5 feet (1.5 meters) without the use of closed chutes or pipes. When chutes or troughs are used under steep slope conditions, they shall be equipped with baffle boards or shall be used in short lengths to reverse the direction of movement. All chutes, troughs or pipes shall be kept clean and free of hardened concrete by flushing with water after each run. Flushing water shall be discharged outside the forms. Aluminum chutes, troughs or pipes shall not be used.

601.10.3-Vibrating: Concrete shall be compacted by the operation of approved mechanical vibrators within the concrete. When required, vibrating shall be supplemented by hand spading to assure proper compaction, to force all coarse aggregate from the surface, and to bring mortar against the forms to produce a smooth finish. Vibrators shall be manipulated in such a manner that concrete is worked around reinforcement and imbedded features and into angles of the form. Vibration shall be of sufficient duration to accomplish compaction but shall not be prolonged to the point where segregation occurs. Vibration shall not be used to cause concrete to flow from point to point within forms.

601.10.4-Placing Concrete Bridge Decks: Concrete for bridge decks shall be placed and finished with mechanical equipment unless waived by the Engineer. The Contractor shall furnish the Engineer information as to the weight of the proposed machine, the volume of concrete to be placed per hour, and the operating procedure to be followed.

601.10.5

Where beam support screeds are used and the distance between the support and gutter line is in excess of 1 ft. (300 mm), the Contractor shall use devices to control the grade of the gutter line during the deck finishing operations.

601.10.5-Depositing Concrete Under Water: Concrete shall not be placed until all laitance which may have formed on concrete previously placed has been removed. Still water shall be maintained at the point of deposit. While depositing foundation concrete, pumping shall be discontinued if it results in a flow of water inside the forms. All concrete deposited under water shall have the minimum cement content increased at least 10 percent.

Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie, a closed bottom dump bucket, or other approved method and shall not be disturbed after being deposited.

601.11-FINISHING CONCRETE SURFACES:

The surface of the concrete shall be finished immediately after form removal.

The exposed surfaces of bridge parapets, wingwalls and headwalls shall be given a Class 2, Rubbed Finish, or a Class 1 Ordinary Surface Finish supplemented with wood float rubbing. When the Class 1,Ordinary Finish is used, the forms shall be removed as early as practical, not to exceed six hours (in lieu of 601.8.7) after placing, and the finish completed including rubbing with a wood float and water. The rubbing shall produce anonplastered, smooth textured and uniform color surface. Other concrete surfaces except bridge decks shall be given a Class 1, Ordinary Finish.

601.11.1-Class 1, Ordinary Surface Finish: Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces except those which are not to be exposed or are not to be waterproofed. On all surfaces the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the class of concrete being finished. Mortar used in pointing shall be not more than 30 minutes old. The mortar patches shall be cured as specified in 601.12. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

The resulting surfaces shall be true and uniform. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be rubbed as specified for Class 2, Rubbed Finish.

601.11.2-Class 2, Rubbed Finish: After removal of forms, the rubbing shall be started as soon as the condition of the concrete will permit. The concrete shall be thoroughly saturated with water immediately prior to rubbing and shall be kept saturated throughout the rubbing operation.

Sufficient time shall have elapsed before wetting down to allow the mortar used in pointing to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand in the same proportion as the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface obtained. The past produced by this rubbing shall be left in place. 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 all the paste produced by the first rubbing operation has been removed from the face of the concrete except from depressions and defects which have been filled with the paste. The surface of the concrete after rubbing shall have a non-plastered, smooth texture and a uniform color.

After the final rubbing is completed and the surface has dried, the surface shall be rubbed with burlap to remove loose powder.

The resulting surfaces shall be free from all unsound patches, paste, powder, and objectional marks.

601.11.3-Class 6, Float Finish: This finish, for horizontal surfaces, shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating tool of wood, canvas or cork. Before the finish has set, the surface cement film shall be removed with a fine brush in order to have a fine grained, smooth but sanded texture.

601.11.4-Finishing Concrete Bridge Decks: Any addition of water to the surface of the concrete to assist in the finishing operations will not be permitted. When conditions are such that unusually rapid drying is occurring, an atomized mist may be used to prevent the rapid evaporation of water from the concrete surface during the final finishing.

After striking off, consolidating and floating have been completed, both while the concrete is still plastic, the surface shall be checked fortrueness with a straightedge. The Contractor shall furnish an accurate scraping type straightedge with a minimum length of 10 feet (3.048 meter) and swung from a handle at least 3 feet (1 meter) longer than one-half the width of the slab.

The straightedge shall be held in successive positions parallel to the road centerline and in contact with the roadway surface and operated from side to side until the surface is within the permissible tolerance provided. Advance along the roadway shall be in successive stages of not more than one-half of the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck-off, consolidated, and refloated. High areas shall be cut down and refloated. The straightedge testing and reflecting shall continue until the surface is found to be free from observable departures

from the straightedge and the slab has the required grade and contour.

Upon completion of the above operations, the surface shall be smoothed with a lute or smoothing float, four to 6 feet (1.2 to 1.8 meters) in length, after which the surfaces shall be tested with an accurate straightedge. This checking straightedge shall be 10 feet (3.048 meters) long and shall be held in a position parallel to the centerline of the roadway. The advance of this straightedge along the slab shall be in successive stages of not more than one-half of its length. When tested with this straightedge, the finished surface shall be free from observable departures from the straightedge.

Upon completion of the above operations, the surface of the concrete shall be given a groove finish while the concrete is still plastic. The tool used shall produce a groove that is approximately 3/32 in. (2 mm) wide. The depth of this groove shall be⅛ in. (3 mm) to 3/16 in. (5 mm) and spaced approximately ½ in. (13 mm) center to center. The grooves shall be formed in a direction that is transverse to the centerline of the roadway or parallel to the skew. On any one bridge the direction of the grooves shall be consistent. Adjacent strokes to establish the texture shall abut one another without appreciable overlap. Texturing shall be performed when the concrete surface is of such plasticity as to prevent excessive raveling (concrete too dry) or to prevent mortar from flowing back into the grooves (concrete too wet). All texturing shall be accomplished with a single pass of the tool. To facilitate drainage, the 12 inches (300 mm) immediately adjacent to the curbline shall be leftuntextured.

When finishing has been completed and the concrete has hardened sufficiently, the surface shall be given a further test fortrueness with a rolling straightedge. Areas showing high spots of more than ⅛ in. (3 mm) shall be marked by the Engineer and, only when directed by the Engineer, such areas shall be ground with an approved grinding tool, utilizingcarborundum stones or industrial diamond wheels; grinding shall be done to an elevation where the area or spot will not show a surface deviation in excess of ⅛ in. (3 mm) when tested with the 10 ft. (3.048 meter) rolling straightedge, except that the maximum depth of grinding shall not exceed ¼ in. (6 mm). The ground areas shall be treated as directed by the Engineer. Where the initial deviation from the straightedge is ½ in. (13 mm) or more, the Contractor will be required to remove and replace the complete pour in which the areas not meeting the required tolerance are located.

After grinding, all areas either high or low, not meeting the requirements of ⅛ in. (3 mm) tolerance will be measured and disposition of these areas will be as set forth in 601.15.2.

601.11.5

601.12-CURING AND PROTECTING CONCRETE:

601.12.1-Curing Under Normal Conditions: All concrete shall be protected by one or more of the curing materials, meeting the requirements of 601.2, as soon as possible after placement to prevent loss of moisture from the surface. Burlap and water curing shall be used on all bridge decks.

Concrete surfaces shall be kept completely and continuously moist. Curing shall be continued for a period of at least 7 days. This curing period may be

reduced if the contractor presents evidence that the in place concrete has attained 70% of the specified strength for the class of concrete under cure. Under no circumstances, shall the period of cure be less than 3 days. The reduced curing period option is not applicable to Class K concrete placed in bridge decks. Surfaces may have coverings temporally removed for finishing, but the covering shall be restored as soon as possible.

Membrane forming curing compounds may be used providing they do not conflict with other requirements of these Specifications. If membrane forming curing compound is used, all surfaces shall be given the required finish prior to application of the curing compound with the concrete protected by some other method before finishing.

Curing compound shall be applied at a minimum rate of one gallon of liquid coating per 300 sq. ft. (13.6 liters of liquid coating per 100 m^2) of concrete surface for each application. The curing compound shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of the concrete finish. If the surface is dry, the concrete shall be saturated with water and the curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

During the curing period, any coating marred or otherwise disturbed shall be given an additional coating. Should the surface coating be subjected continuously to injury, another method of cure shall be immediately substituted. If the use of an impervious compound results in a streaky or blotched appearance, the method shall be stopped and water curing applied until the cause of the defective appearance is corrected.

601.12.2-Curing Under Cold Weather Conditions: When the air temperature is expected to fall below 30° F (-1° C), the Contractor shall provide suitable measures to maintain the concrete surface temperature between 50° F (10° C) and 90° F (32° C).

Calendar days on which the surface temperature of the concrete falls below 50° F (10° C) shall not be considered days of curing. In no event shall the temperature of the concrete be allowed to fall below 35° F (2° C) before the specified curing is completed. The Contractor shall be responsible for the quality and strengths of the concrete placed or cured, or both, during the cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

When protection is removed from the structure after the specified curing is complete, the temperature of the concrete shall not be permitted to fall at a greater rate than 20° F (11° C) per 24 hour period.

601.12.3-Protection of Finished Surfaces: All exposed finished surfaces of concrete shall be protected to prevent rust stains, paint splotches, scars or

other blemishes tending to disfigure or discolor the finished surface. Where reinforcing steel bars or other steel inserts are left exposed for extended periods or over the winter, they shall be given a coat of neat cement paste to prevent rust staining.

Any stains or other blemishes shall be corrected by the Contractor.

601.13-PROTECTIVE SURFACE TREATMENT:

601.13.1-Linseed Oil: After the concrete is at least 14 days old, a protective surface treatment as specified shall be applied to the entire top surface of bridge decks, approach slabs when they are included in the Contract, concrete bridge medians, top and curb face of bridge sidewalks, and inside faces of parapets.

The surface shall be dry for at least 48 hours before treatment and shall be free from oil, grime, and loose dirt or particles. Immediately before application, the entire surface shall be air blown to remove any loose dust.

The surface treatment mixture shall consist of 50 percent boiled linseed oil and 50 percent petroleum spirits (mineral spirits), by volume.

The mixture shall be sprayed, and the nozzle shall be kept within 18 inches (450 mm) of the surface. Hand tank type pressure sprayers will be permitted. The temperature of the concrete and air shall be 50° F (10° C) or higher at the time of application.

The first coat shall be applied at the rate of 0.025 gal. per sq. yd. (40.0 sq. yd. per gal.) (0.11 liters per square meter (8.8 m^2 per liter)) and the second coat at the rate of 0.015 gal. per sq. yd. (67.0 sq. yd. per gal.) (0.068 liters per square meter (14.7 m^2 per liter)).

The second coat shall not be applied until the concrete has regained its dry appearance.

The Contractor is cautioned to guard against fire of all sorts, including cigarettes, as this material is flammable.

Metal hand rails shall be protected from spray by shielding or masking.

The Contractor shall prohibit all pedestrian or vehicular traffic on the structure during the drying period of the protective coating.

The Contractor shall not apply a protective coating when it is anticipated that there will be precipitation within five hours of the time of application. Any coating damaged by rain or moisture shall be corrected by an additional application.

601.13.2-Epoxy Resin Protective Coating: The top surface of abutment bridge seats, including drainage areas, and the adjacent bottom 6 inches (150 mm) of the backwall and the top surface of pier caps which are located beneath expansion devices shall receive an epoxy resin protective coating. The area immediately beneath the bearing masonry plates may be omitted at the Contractor's option.

Concrete surfaces to be coated shall be sound, dry and free of alllaitance and curing materials. The coating shall not be applied until the concrete has attained the age recommended by the manufacturer.

When required by the Engineer in the field, concrete surfaces shall be cleaned of all oil, grease and other potential bond inhibiting matter by acid etching with a 10 percent to 15 percent muriatic acid solution. The acid solution shall be spread and allowed to react until bubbling has subsided, approximately three to five minutes. The surface shall then be thoroughly flushed with clear water and allowed to dry. Where, in the opinion of the Engineer, acid etching is insufficient to clean the concrete, then sandblasting or an approved method of mechanical abrading shall be required.

The exact indicated amounts of the base polymer and the reacting system, as recommended by the manufacturer, shall be measured into mixing container and mixed thoroughly with a low-speed paddle-type mixer. After mixing, the material shall stand for an induction period of one hour before application.

Following the one hour induction period, the mixed protective coating may be applied by brush, roller or spray. When applied by roller, a first quality, long nap roller is recommended for rough surfaces, and a short nap roller for smooth surfaces. If applied by spray, an externally atomized spray gun is recommended. If thinning is necessary for spray application, thinner shall be of the type and amount recommended by the coating manufacturer.

Two coats of mixed material shall be applied in thin, uniform coats of approximately 2 to 3 mil (50 µm to 75 µm) dry film thickness each (4-5 mils wet thickness (100-125 µm wet thickness)). The second coat shall be applied approximately 24 hours after the application of the first coat. One gallon of the system will cover approximately 275 sq. ft. of smooth concrete, first coat; a second coat will cover approximately 400 sq. feet. One liter of the system will cover approximately 6.75 m^2 of smooth concrete, first coat; a second coat will cover approximately 10 m^2.

In all cases application shall be made at temperatures recommended by the manufacturer.

601.14-METHOD OF MEASUREMENT:

The quantity of work done for Class A, Class K, Class B, Class C and Class D concrete will be measured in cubic yards (meters), complete in place and accepted, as determined by the dimensions on the Plans or contract documents, and will be the number of cubic yards (meters) established in the Proposal, subject to adjustment as provided for in 104.2 and 109.2.

No deductions will be made for the volume occupied by pipe less than 8 inches (200 mm) in diameter, nor for reinforcing steel, anchors, conduits, weep holes or piling, or other small inserts.

The cost of copper, copper-nickel alloy or other type of flashing, expansion joint filler, preformed joint filler, concrete bearing pads, drain pipes for weep drains through abutments, wings and walls or bridge floors, unless otherwise specified, shall be included in the unit prices bid for the several classes of concrete.

601.15-BASIS OF PAYMENT:

601.15.1-General: The quantities, determined as provided above, will be paid for at the contract unit prices bid or at the adjusted percent of contract price as specified for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, field laboratory, supplies and incidentals necessary to complete the work.

No additional payment will be allowed for concreting under adverse weather conditions nor when the use of a higher class concrete than that specified is permitted.

601.15.2-Price Adjustments: The Contractor will be assessed an equitable deduction of fifteen dollars per sq. ft. (one-hundred-sixty dollars per square meter) for areas of bridge decks not meeting the specified ⅛ in. (3 mm) tolerance and not specified to be removed nor directed to be ground, and for any areas that have been ground but do not meet the specified tolerance. Deviations will be tested with a 10 foot (3.048 meter) rolling straightedge.

Concrete found not in compliance with the requirements of 601.4.4 for compressive strength will be paid for at a reduced contract price in accordance with the following formula:

$$\text{Percent Reduction} = \frac{f'_c - X}{f'_c - (f_c + s)}$$

Where:

f'_c = Design Strength, psi (MPa)
X = Observed strength, psi (MPa)

s = Standard Deviation
f_c = Design Stress

The percent reduction shall be applied to the sublot with the low strength.

601.16-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
601001-*	CLASS A CONCRETE	CUBIC YARD (METER)
601002-*	CLASS B CONCRETE	CUBIC YARD (METER)
601003-*	CLASS K CONCRETE	CUBIC YARD (METER)
601005-*	CLASS C CONCRETE	CUBIC YARD (METER)
601006-*	CLASS D CONCRETE	CUBIC YARD (METER)

*Sequence number

SECTION 602
REINFORCING STEEL

602.1-DESCRIPTION:

This work shall consist of furnishing and placing epoxy coated or uncoated reinforcing steel in accordance with these Specifications and in reasonably close conformity with the Plans.

602.2-MATERIALS:

Reinforcing steel bars and fabric reinforcement shall meet the requirements of 709.1 and 709.4 respectively, except rail-steel shall not be used in bridge decks or parapets.

Epoxy coated reinforcing steel bars shall meet the requirements of 709.1.2, except rail-steel shall not be used in bridge decks and parapets.

CONSTRUCTION METHODS

602.3-ORDER LISTS:

All order lists and bending diagrams shall be furnished by the Contractor. If requested by the Engineer, order lists and bending diagrams shall be submitted for approval. Approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams.

602.4-PROTECTION OF MATERIALS:

Steel reinforcement shall be stored above the well drained surface of the ground upon platforms, skids, or other supports and shall be protected from mechanical injury. Reinforcement shall be free from injurious defects such as cracks and laminations. Any loose scale, loose rust, dirt, paint, grease, oil or other foreign materials present on the reinforcement shall be removed by wire brushing, sand blasting or other approved methods before the placement of concrete.

Reinforcing steel which will be exposed over the winter shall be protected, within one week after the placing of the initial concrete, with a brush coat of neat cement, mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before the placing of the adjacent pour.