

**SECTION 600
MISCELLANEOUS CONSTRUCTION**

**SECTION 601
STRUCTURAL CONCRETE**

DESCRIPTION

601.01 This work consists of furnishing and placing portland cement concrete in accordance with these specifications and in conformity with the lines, grades and dimensions as shown on the plans or established.

This work includes preparing concrete surfaces designated in the Contract and applying an approved colored Structural Concrete Coating to them.

601.02 Classification. The classes of concrete shown in Table 601-1 shall be used when specified in the Contract.

Table 601-1 CONCRETE TABLE

Concrete Class	Required Field Compressive Strength	Cement Content: Minimum or Range	Air Content: Percent Range (Total)	Water Cement Ratio: Maximum or Range
B	3000 psi at 28 days	565 lbs./cu. yd.	5 – 8	N/A
BZ	4000 psi at 28 days	610 lbs./cu. yd.	N/A	N/A
D	4500 psi at 28 days	615 to 660 lbs./cu. yd.	5 – 8	0.44
DT	4500 psi at 28 days	700 lbs./cu. yd.	5 – 8	0.44
E	4200 psi at 28 days	660 lbs./cu. yd.	4 – 8	0.44
H	4500 psi at 56 days	580 to 640 lbs./cu. yd.	5 – 8	0.38 - 0.42
HT	4500 psi at 56 days	580 to 640 lbs./cu. yd.	5 – 8	0.38 - 0.42
P	4200 psi at 28 days	660 lbs./cu. yd.	4 – 8	0.44
S35	5000 psi at 28 days	615 to 720 lbs./cu. yd.	5 – 8	0.42
S40	5800 psi at 28 days	615 to 760 lbs./cu. yd.	5 – 8	0.40
S50	7250 psi at 28 days	615 to 800 lbs./cu. yd.	5 – 8	0.38

Class B concrete is an air entrained concrete for general use. Class D or H concrete may be substituted for Class B concrete. Additional requirements for Class B concrete are: Class B concrete shall have a nominal coarse aggregate size of 37.5 mm

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(1½ inches) or smaller. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

Class BZ concrete is concrete for drilled piers. Additional requirements for class BZ concrete are: Entrained air is not required unless specified in the Contract. High range water reducers may be added at the job site to obtain desired slump and retardation. Slump shall be a minimum of 5 inches and a maximum of 8 inches). Class BZ caisson concrete shall be made with 19.0 mm (¾ inch) nominal sized coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

Class D concrete is a dense medium strength structural concrete. Class H may be substituted for Class D concrete. Additional requirements for Class D concrete are: An approved water reducing admixture shall be incorporated in the mix. Class D concrete shall be made with 19.0 mm (¾ inch) nominal sized coarse aggregate. When placed in a bridge deck, Class D concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

Class DT concrete may be used for deck resurfacing and repairs. Class HT may be substituted for Class DT concrete. Additional requirements for Class DT concrete are: An approved water reducing admixture shall be incorporated in the mix. Class DT concrete shall contain a minimum of 50 percent AASHTO M 43 size No. 7 or No. 8 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

Class E concrete may be used for fast track pavements needing early strength in order to open a pavement to service soon after placement. Additional requirements for Class E concrete are: Type III cement may be used. Class E concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 357 or No. 467 coarse aggregate. If all transverse joints are doweled, then Class E concrete shall contain a minimum of 55 percent AASHTO M 43 sizes No. 57, No. 67, No. 357, or No. 467 coarse aggregate. In addition to the compressive strength requirements in Table 601-1 and unless stated otherwise on the plans, Class E concrete shall achieve a field compressive strength of 2500 psi within 12 hours. Laboratory trial mix for Class E concrete must produce an average 28 day flexural strength of at least 650 psi. Approved fly ash may be substituted for portland cement up to a maximum of 30 percent Class F by weight.

Class H concrete is used for bare concrete bridge decks that will not receive a waterproofing membrane. Additional requirements for Class H concrete are: An approved water reducing admixture shall be incorporated in the mix. Class H concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Class H concrete shall contain cementitious materials in the following ranges: 450 to 500 pounds per cubic yard Type II portland cement, 90 to 125 pounds

per cubic yard flyash and 20 to 30 pounds per cubic yard silica fume. The total content of Type II portland cement, flyash and silica fume shall be 580 to 640 pounds per cubic yard. Laboratory trial mix for Class H concrete must not exceed permeability of 2000 coulombs at 56 days (ASTM C 1202). Laboratory trial mix for Class H concrete must not exhibit a crack at or before 14 days in the cracking tendency test (AASHTO PP 34).

Class HT concrete is used as the top layer for bare concrete bridge decks that will not receive a waterproofing membrane. Additional requirements for Class HT concrete are: An approved water reducing admixture shall be incorporated in the mix. Class HT concrete shall contain a minimum of 50 percent AASHTO M 43 size No. 7 or No. 8 coarse aggregate. Class HT concrete shall contain cementitious materials in the following ranges: 450 to 500 pounds per cubic yard Type II portland cement, 90 to 125 pounds per cubic yard flyash and 20 to 30 pounds per cubic yard silica fume. The total content of Type II portland cement, flyash and silica fume shall be 580 to 640 pounds per cubic yard. Laboratory trial mix for Class HT concrete must not exceed permeability of 2000 coulombs at 56 days (ASTM C 1202). Laboratory trial mix for Class HT concrete must not exhibit a crack at or before 14 days in the cracking tendency test (AASHTO PP 34).

Class P concrete is used in pavements. Additional requirements for Class P concrete are: Class P concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 357 or No. 467 coarse aggregate. If all transverse joints are doweled, then Class P concrete shall contain a minimum of 55 percent AASHTO M 43 sizes No. 57, No. 67, No. 357, or No. 467 coarse aggregate. Laboratory trial mix for Class P concrete must produce an average 28 day flexural strength of at least 650 psi. Class P concrete shall contain 70 percent to 80 percent portland cement and 20 percent to 30 percent Class F fly ash in the total weight of cement plus fly ash. Unless acceptance is based on flexural strength, the total weight of cement plus Class F fly ash shall not be less than 660 pounds per cubic yard. If acceptance is based on flexural strength, the total weight of cement plus Class F fly ash shall not be less than 520 pounds per cubic yard.

Class S35 concrete is a dense high strength structural concrete. Additional requirements for Class S35 concrete are: An approved water reducing admixture shall be incorporated in the mix. Class S35 concrete shall be made with 19 mm ($\frac{3}{4}$ inch) nominal sized coarse aggregate, i.e., 100 percent passing the 25.0 mm (1 inch) sieve and 90 percent to 100 percent passing the 19 mm ($\frac{3}{4}$ inch) sieve. When placed in a bridge deck, Class S35 concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

Class S40 concrete is a dense high strength structural concrete. Additional requirements for Class S40 concrete are: An approved water reducing admixture shall be incorporated in the mix. Class S40 concrete shall be made with 19 mm

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(3/4 inch) nominal sized coarse aggregate. When placed in a bridge deck, Class S40 concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight.

Class S50 concrete is a dense high strength structural concrete. Additional requirements for Class S50 concrete are: An approved water reducing admixture shall be incorporated in the mix. Class S50 concrete shall be made with 19 mm (3/4 inch) nominal sized coarse aggregate. When placed in a bridge deck, Class S50 concrete shall contain a minimum of 55 percent AASHTO M 43 size No. 67 coarse aggregate. Approved fly ash may be substituted for portland cement up to a maximum of 20 percent Class C or 30 percent Class F by weight. Laboratory trial mix for Class S50 concrete must not exhibit a crack at or before 14 days in the cracking tendency test (AASHTO PP 34).

MATERIALS

601.03 Materials shall meet the requirements specified in the following subsections:

Fine Aggregate	703.01
Coarse Aggregate	703.02
Portland Cement	701.01
Fly Ash	701.02
Water	712.01
Air Entraining Admixture	711.02
Chemical Admixtures	711.03
Curing Materials	711.01
Preformed Joint Material	705.01
Reinforcing Steel	709.01
Bearing Materials	705.06
Epoxy	712.10
Structural Concrete Coating	708.08

Type I or II cement shall be used unless high early strength concrete or sulfate resisting concrete is called for on the plans or as otherwise permitted.

Prestressing steel shall meet the requirements of subsection 714.01 except as noted on the plans.

Silica fume admixture shall conform to the requirements of subsection 701.03.

Calcium chloride shall not be used in any concrete unless otherwise specified.

601.04 (unused)

CONSTRUCTION REQUIREMENTS

601.05 Proportioning. The Contractor shall submit a Concrete Mix Design Report consisting of design mix proportions, laboratory trial mix and aggregate data for each class of concrete being placed on the project. Concrete shall not be placed on the project before the Concrete Mix Design Report has been reviewed and approved by the Engineer. The Concrete Mix Design cannot be approved when the laboratory trial mix and aggregate data are the results from tests performed more than a year in the past. The design mix proportions shall show the weights and sources of all ingredients including cement, fly ash, aggregates, water, additives and the water cement ratio (w/c). When determining the w/c, cement (c) shall be the sum of the weight of the cement, the weight of the fly ash and the weight of silica fume.

The laboratory trial mix data shall include results of the following:

- (1) AASHTO T 119 Slump of Hydraulic Cement Concrete.
- (2) AASHTO T 121 Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete. Air content from AASHTO T 152 Air Content of Freshly Mixed Concrete by the Pressure Method may be used in lieu of the air content by the gravimetric method in AASHTO T 121.
- (3) AASHTO T 22 Compressive Strength of Cylindrical Concrete Specimens shall be performed with at least two specimens at 7 days and three specimens at 28 days. Three additional specimens tested at 56 days shall be required for Class H and HT concrete.
- (4) Class H and HT concrete shall include a measurement of permeability by ASTM C 1202 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. The concrete test specimens shall be two 2 inch thick disks sawed from the centers of two molded 4 inch diameter cylinders cured no more than 56 days in accordance with ASTM C 192 Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
- (5) Class H, HT and S50 concrete shall include a measurement of cracking by AASHTO PP 34 Standard Practice for Estimating the Cracking Tendency of Concrete. The ring shall be cured in an indoor room with the temperature maintained 65°F to 75°F and relative humidity not exceeding 40 percent.
- (6) Class E and P concrete shall include AASHTO T 97 Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) performed with two specimens at seven days and four specimens at 28 days.
- (7) Class E concrete shall include a report of maturity relationships in accordance with ASTM C 1074 with the following additions or modifications. The Contractor shall provide a multi-channel maturity meter and all necessary wire and connectors. The Contractor shall be responsible for the placement and maintenance of the maturity meter and wire. Placement shall be as directed by the Engineer.
 - (i) The cylinders used to establish the compressive strength vs. maturity relationship shall be cast and cured in the field in conditions similar to the project.

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- (ii) These cylinders shall be tested in pairs at times which yield compressive strengths three sets of which are at or below 2500 psi and one of which is above 2500 psi.
- (iii) Testing to determine datum temperature or activation energy will not be required.
- (iv) A test slab shall be cast at the same time and location as the cylinders. The test slab shall have a length and width of 6 feet x 6 feet and a thickness equal to the pavement design thickness. The maturity of the test slab, when used in the compressive strength vs. maturity relationship from the cylinders, shall indicate that a compressive strength of 2500 psi is achieved in the required time. Slab maturity will be determined with two probes located in the slab approximately 1 and 2 feet from the edge. The test slab shall be covered with a blanket similar to the one to be used on the pavement.

Except for class BZ concrete, the maximum slump of the delivered concrete shall be the slump of the approved concrete mix design plus 1½ inch. Except for class H and HT concrete, the laboratory trial mix must produce an average 28 day compressive strength at least 115 percent of the required 28 day field compressive strength. The laboratory trial mix for Class H or HT concrete must produce an average 56 day compressive strength at least 115 percent of the required 56 day field compressive strength.

The laboratory trial mix shall have a relative yield of 0.99 to 1.02. When Portland Cement Concrete Pavement is paid with a volumetric pay quantity, the relative yield of the concrete produced on the project shall be 0.99 to 1.02. If the relative yield of the produced concrete does not conform to this range for two consecutive yield determinations, concrete production shall cease and the Contractor shall present a plan to correct the relative yield to the Engineer.

Aggregate data shall include the results of the following:

- (1) AASHTO T 11 Materials Finer Than 75 um (No. 200) Sieve in Mineral Aggregates by Washing.
- (2) AASHTO T 19 Unit Weight and Voids in Aggregate.
- (3) AASHTO T 21 Organic Impurities in Fine Aggregate for Concrete.
- (4) AASHTO T 27 Sieve Analysis of Fine and Coarse Aggregates.
- (5) AASHTO T 84 Specific Gravity and Absorption of Fine Aggregate.
- (6) AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregate.
- (7) AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
- (8) AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
- (9) AASHTO T 176 Plastic Fines in Graded Aggregates and Soils by use of the Sand Equivalent Test
- (10) ASTM C 535 Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- (11) ASTM C 1260 Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

Any aggregate with an expansion of 0.10 percent or more at 16 days after casting as determined by ASTM C 1260 shall not be used unless mitigative measures are included in the mix design and subsequent results of CPL 4202 with the design mix proportions show an expansion not exceeding 0.10 percent at 16 days after casting. The Concrete Mix Design Report shall state what mitigative measures were included in the concrete mix design and include results for ASTM C 1260 and CPL 4202.

The Concrete Mix Design Report shall include Certified Test Reports showing that the cement, flyash and silica fume admixture meet the specification requirements and supporting this statement with actual test results. The certification for silica fume shall state the solids content if the silica fume admixture is furnished as slurry.

Where the Contractor's use of fly ash results in any delay, necessary change in admixture quantities or source, or unsatisfactory work, the cost of such delays, changes or corrective actions shall be borne by the Contractor.

The Contractor shall submit a new Concrete Mix Design Report meeting the above requirements when a change occurs in the source, type, or proportions of cement, fly ash, or aggregate. Unless otherwise permitted by the Engineer, the product of only one type of portland cement from one mill of any one brand shall be used in a concrete mix design.

Review and approval of the Concrete Mix Design by the Engineer does not constitute acceptance of the concrete. Acceptance will be based solely on the test results of concrete placed on the project.

601.06 Batching. Measuring and batching of materials shall be done at a batching plant in accordance with AASHTO M 157.

The Contractor shall furnish a batch ticket (delivery ticket) with each load for all classes of concrete. Concrete delivered without a batch ticket containing complete information as specified shall be rejected. The Contractor shall collect and complete the batch ticket at the placement site and deliver all batch tickets to the Engineer on a daily basis. The Engineer shall have access to the batch tickets at any time during the placement. The following information shall be provided on each batch ticket:

- (1) Supplier's name and date
- (2) Truck number
- (3) Project number and location
- (4) Concrete class designation and item number
- (5) Cubic yards batched
- (6) Time batched
- (7) CDOT mix design number
- (8) Type, brand, and amount of each admixture
- (9) Type, brand, and amount of cement and fly ash
- (10) Weights of fine and coarse aggregates

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- (11) Moisture of fine and coarse aggregate
- (12) Gallons of batch water (including ice)

The Contractor shall add the following information to the batch ticket at the placement site:

- (13) Gallons of water added by truck operator plus quantity of concrete in the truck each time water is added
- (14) Number of revolutions of drum at mixing speed (for truck mixed concrete)
- (15) Discharge time
- (16) Location of batch in placement
- (17) Water cement ratio (required for deck concrete only)

The drum on each truck mixer shall be reversed prior to charging to eliminate any wash water remaining in the mixer.

- (a) *Portland Cement and Fly Ash.* Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed.

All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be sealed and vented to preclude dusting during operation. The discharge chute shall be so arranged that cement will not lodge in it or leak from it.

Separate storage and handling equipment shall be provided for the fly ash. The fly ash may be weighed in the cement hopper and discharged with the cement.

- (b) *Water.* Unless water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the calibration unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank. In lieu of the volume method specified above, the Contractor will be permitted to use a water metering device that is accurate within the prescribed limits.
- (c) *Aggregates.* Aggregates from different sources and of different gradings shall not be stockpiled together.

Aggregate shall be handled from stockpiles or other sources to the batching plant in such manner as to secure a uniform grading of the material. Aggregates that have become segregated, or mixed with earth or foreign material, shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. In case the

aggregates contain high or non-uniform moisture content, storage or stockpile period in excess of 12 hours may be required.

- (d) *Bins and Scales.* The batching plant may include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a bin, hopper, and scale for cement shall be included. A single weighing hopper with an accumulative scale will be permitted, provided a separate scale is used for weighing cement.

Scales shall meet the requirements of subsection 109.01.

601.07 Mixing. Concrete may be mixed in stationary mixers, in a central-mix plant, in truck mixers, or in self-contained mobile mixers. Mixing time shall be measured from the time all materials, except water, are in the drum.

Silica fume, when specified, shall be added to the mix during initial batching.

- (a) *Mixing General.* The concrete shall be deposited in place within 90 minutes after batching when concrete is delivered in truck mixers or agitating trucks, and within 60 minutes when delivered in non agitating trucks.

The 90 minute time limit for mixer or agitating trucks may be extended to 120 minutes if:

- (1) No water is added after 90 minutes.
- (2) The concrete temperature prior to placement is less than 90 °F

The 90 minute time limit for mixer or agitating trucks may be extended to 180 minutes if:

- (1) No water is added after 90 minutes.
- (2) The concrete temperature prior to placement is less than 90 °F.
- (3) The approved concrete mix contains a water reducing and retarding admixture which conforms to AASHTO M 194, Type D.

- (b) *Stationary Mixing.* When mixed in a central mixing plant, the mixing time shall be between 50 and 90 seconds. Four seconds shall be added to the specified mixing time if timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

The volume of concrete mixed per batch may exceed the mixer's nominal capacity, as shown on the manufacturer's standard rating plate on the mixer, up to 10 per cent provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided spillage of concrete does not occur.

The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be

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uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

The timing device on stationary mixers 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 Contractor will be permitted to operate while it is being repaired, provided the Contractor furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

(c) *Truck Mixing.* Truck mixed concrete shall conform with one of the following:

1. Concrete mixed entirely in a truck mixer equipped with a mechanical counter shall be partially mixed at the plant or in transit for not less than 20 revolutions of the drum at mixing speed. The revolutions of the drum at charging speed shall not be counted as mixing revolutions. The concrete shall be mixed between 50 and 100 revolutions of the mixer drum at mixing speed at the delivery site before discharge of the concrete.
2. Concrete partially mixed in a stationary central mixing plant with mixing brought to completion in a truck mixer (known as shrink mixing) shall be mixed for a minimum of 30 seconds in the stationary mixer. Mixing shall be completed in the truck mixer for at least 20 but not more than 100 revolutions of the mixer drum at mixing speed at the delivery site before discharge of the concrete.
3. Concrete mixed entirely in a stationary mixer and delivered to the job in a truck mixer shall be remixed for a minimum of 20 revolutions of the mixing drum at mixing speed at the job site prior to discharge.

When water is added at the delivery site to control the consistency of the concrete as specified in subsection 601.02, the concrete shall be mixed for at least 20 revolutions of the mixer drum at mixing speed for each addition of water before discharge. These revolutions are in addition to the minimum revolutions required for mixing at the delivery site. The added water shall not cause the water/cement ratio to exceed the requirements in subsection 601.02. Water from all sources shall be documented by the ready mix producer on the delivery slip for each load of concrete.

The Contractor shall provide a Concrete Truck Mixer Certification. This certification shall show the various pick-up and throw-over configurations and wear marks so that the wear on the blades can be checked. Blades shall be replaced when any part or section is worn 1 inch or more below the original height of the manufacturer's design. A copy of the manufacturer's design, showing the dimensions and arrangement of blades, shall be available to the Engineer at all times.

The Contractor shall furnish a water-measuring device in good working condition, mounted on each transit mix truck, for measuring the water added to the mix after the truck has left the charging plant. Each measuring device shall be equipped with an easy-to-read gauge. Water shall be measured to the accuracy prescribed in AASHTO M 157.

- (d) *Self Contained Mobile Mixer.* Proportioning and mixing equipment shall be of the self-contained, mobile, continuous mixing type subject to the following:

The mixer shall be self-propelled and be capable of carrying sufficient unmixed dry, bulk cement, fine aggregate, coarse aggregate, admixtures and water to produce on the site not less than 6 cubic yards of concrete. The mixer shall have one bin for each size aggregate.

The mixer shall be capable of positive measurement of cement being introduced into the mix. A recording meter visible at all times and equipped with a ticket printout shall indicate the quantity of total concrete mix.

The mixer shall provide positive control of the flow of water into the mixing chamber. Water flow shall be indicated by flow meter and be readily adjustable to provide for minor variations in the aggregate moisture.

The mixer shall be capable of being calibrated to automatically proportion and blend all components of indicated composition on a continuous or intermittent basis as required by the finishing operation, and shall discharge mixed material through a conventional chute directly in front of the finishing machine.

The Contractor shall perform calibration tests according to the equipment manufacturer's recommendations at the beginning of each project, and when there is a change in the mix design proportions or source of materials. The Engineer may require a calibration test or yield check whenever a change in the characteristics of the mixture is observed. The tolerances in proportioning the various ingredients shall be according to subsection 6.8 of AASHTO M 241.

601.08 Air Content Adjustment. When a batch of concrete delivered to the project does not conform to the minimum specified air content, an airentaining admixture conforming to subsection 711.02 may be added, one time only for the batch, at the Contractor's option prior to consideration for rejection or price adjustment. After the admixture is added the concrete shall be re-mixed for a minimum of 20 revolutions of the mixer drum at mixing speed. The concrete will then be re-tested and if found acceptable may be placed in accordance with the specifications. A maximum of three batches per day may be adjusted by adding air entraining admixture at the delivery site.

601.09 Forms.

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- (a) *Design.* Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the concrete operations, including vibration.

The rate of depositing concrete in forms shall be controlled to prevent deflections of the form panels in excess of the deflections permitted by these specifications.

Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wales. Undulations exceeding $\frac{3}{32}$ inch between the center to center distance of studs, joists, form stiffeners, form fasteners or wales will be considered to be excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer.

Forms for drainage inlets may be constructed of any suitable material that will produce a structure with the inside dimensions and at least the wall thicknesses shown on the plans. Undulations of finished interior wall surfaces shall not exceed 0.5 inch.

Where called for in the Contract, the Contractor shall design and construct a permanent bridge deck forming system. Based on what is indicated, the Contractor will be permitted one of the following sets of options:

- (1) If the plans indicate that permanent deck forms are optional, the Contractor shall have the option of constructing a cast-in-place bridge deck using conventional forms, a full depth cast-in-place bridge deck using permanent steel bridge deck forms, or a partial depth cast-in-place bridge deck using precast panel deck forms as a portion thereof.
- (2) If the plans indicate that permanent deck forms are required, the Contractor shall have the option of constructing a full depth cast-in-place bridge deck using permanent steel bridge deck forms, or a partial depth cast-in-place bridge deck using precast panel deck forms as a portion thereof.
- (3) If the plans indicate that precast panel deck forms are required, the Contractor shall construct a partial depth cast-in-place bridge deck using precast panel deck forms as a portion thereof.

- (b) *Construction.* Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted. Deck slab

forms between girders shall be constructed with no allowance for settlement relative to the girders.

The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolor the concrete.

Concrete shall not be deposited in the forms until all work connected with constructing the forms has been completed; all materials required to be embedded in the concrete have been placed, unless otherwise specified on the plans or approved; and the Engineer has inspected said forms and material. Such work shall include the removal of all dirt, chips, sawdust, water and other foreign material from the forms.

Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorages for fastening forms or form supports to concrete will not be permitted.

Backforms may be omitted with the approval of the Engineer in cases involving footings which can be placed in the dry without the use of cribs or coffer dams. In such cases, the entire excavation shall be filled with concrete to the required elevation of the top of the footing. The additional concrete required shall be placed at the expense of the Contractor, except when footings are poured out to rock. Extra concrete required to pour footings out to rock will be allowed in the concrete quantities, provided that no allowance will be made for any concrete extending more than 6 inches in any direction beyond the neat lines of the footings as shown on the plans.

- (c) *Form Lumber.* Form lumber for all exposed concrete surfaces shall be dressed at least on one side and two edges and shall be constructed so as to produce mortar-tight joints and smooth, even concrete surfaces. 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, such as girders and copings, to assure easy removal.

Unless otherwise specified, forms for exposed surfaces shall be constructed with triangular fillets $\frac{3}{4}$ inch by $\frac{3}{4}$ inch at all exterior corners.

- (d) *Metal Ties.* Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least $\frac{1}{2}$ inch from the face without injury to the concrete. When wire ties are used the wires shall be cut back at least $\frac{1}{4}$ inch from the face of the concrete upon removal of the forms. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and uniform in color.
- (e) *Walls.* Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

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- (f) *Surface Treatment.* All forms shall be treated with oil prior to placing reinforcement except that an approved nonpetroleum base form release agent shall be used for surfaces which are to receive Class 5, Masonry Coating Finish. Wood forms shall be thoroughly moistened with water immediately before placing the concrete.

For rail members or other members with exposed faces, the forms shall be treated with an approved form release agent to prevent the adherence of concrete. Material which will adhere to or discolor the concrete shall not be used.

All concrete forms for surfaces to which Structural Concrete Coating is to be applied shall be treated with a water based concrete form release agent prior to placing reinforcement.

- (g) *Metal Forms for General Use.* The specifications for forms, regarding design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse and oiling, apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt 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 do not line up properly shall not be used. Metal forms shall be free from rust, grease or other foreign matter. Permanent steel bridge deck forms shall be as described in subsection 601.10.
- (h) *Removal of Forms.* The forms for any portion of the structure shall not be removed until the concrete is strong enough to withstand damage when the forms are removed.

Unless controlled by beam or cylinder tests, the following minimum periods of times, exclusive of days when the ambient temperature is below 40 °F, may be used as a guide for removal of forms and supports.

Forms and supports for cast-in-place concrete box culverts (CBCs) shall not be removed until the concrete compressive strength exceeds 1800 pounds per square inch for CBCs with spans up to and including 12 feet , and 2000 pounds per square inch for CBCs with spans exceeding 12 feet but not larger than 20 feet. Forms for CBCs with spans larger than 20 feet shall be removed in accordance with the second paragraph of subsection 601.11(e).

Portion of Structure	Type II Cement	Type V Cement
Centering under beams and girders	14 days	—
Sides of beams, walls or Sides of beams, walls or other forms that do not resist dead loading bending	12 hours	18 hours
Columns	24 hours	36 hours
Deck slabs	7 days	—

When field operations are controlled by beam or cylinder tests, the removal of forms, supports and housing, and the discontinuance of heating and curing may begin when the concrete is found to have the required compressive strength.

If high-early-strength (Type III) cement or accelerating admixtures are used, the above periods may be reduced as approved.

Forms for median barrier, railing or curbs, may be removed at the convenience of the Contractor after the concrete has hardened.

All forms shall be removed except permanent steel bridge deck forms and forms used to support hollow abutments or hollow piers when no permanent access is available into the cells. When permanent access is provided into box girders, all interior forms and loose material shall be removed, and the inside of box girders shall be cleaned with an industrial vacuum.

- (i) *Patching.* The mixed formula for patch mortar shall be determined by trial to obtain a good color match with the concrete when both patch and concrete are cured and dry.
- (j) *Re-use of Forms.* The shape, strength, rigidity, watertightness and surface smoothness of reused forms shall be maintained at all times. Warped or bulged lumber shall not be used.
- (k) *Precast Panel Deck Forms.* Working drawings for precast panel deck forms shall be submitted to the Engineer in conformity with subsection 105.02.

Prestressing for precast panel deck forms shall be in accordance with subsection 618.07(a).

Concrete for precast panel deck forms shall be cured in accordance with subsection 618.12.

Precast panel deck forms shall be stored and transported in a horizontal position and shall conform to the requirements of subsections 618.14(c) and 618.15.

When precast panels are erected, the fit of mating surfaces shall have no more than a $\frac{1}{8}$ inch gap to prevent concrete leakage. If such fit cannot be provided, the joint shall be filled with grout or sealed with an acceptable caulking compound prior to the placing of the cast-in-place portion of the slab.

Precast panels and their accessories, including components to set grade, shall not be attached by welding to steel girders or other structural steel elements or reinforcing steel. Welding, including arc strikes or grounding on any structural steel element is prohibited. The Engineer will inspect all girder flanges for blemishes from arc strikes. All identified blemishes shall be repaired in

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accordance with AWS D1.5 Section 3.10. Repair of all blemishes shall be at the Contractor's expense.

Support angles or other steel components that will be left in place and exposed to the atmosphere in the final product shall be galvanized in accordance with subsection 509.11.

601.10 Permanent Steel Bridge Deck Forms.

- (a) *General.* Permanent steel bridge deck forms for concrete deck slab may be used as an alternate to removable forms pursuant to this specification and when specified on the plans. Permanent steel bridge deck forms shall not be used in the cantilever portions of the deck slab.
- (b) *Materials.* Permanent steel bridge deck forms and supports shall be fabricated from steel conforming to ASTM A 653 (Grades A through E) having a galvanized coating designation of Z600 (G 165) according to ASTM A 653.
- (c) *Design.* The following criteria shall govern the design of permanent steel bridge deck forms:
 - 1. The steel forms shall be designed on the basis of dead load of form, reinforcement and plastic concrete plus 50 pounds per square foot for construction loads. The unit working stress in the steel sheet shall be not more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 36,000 pounds per square inch.

If permanent steel bridge deck forms are used, the depth of slab shown on the plans shall be provided above the forms. The weight of additional concrete to fill form flutes and the steel form dead load shall not exceed a total of five pounds per square foot from edge to edge of flanges in each bay and from front face to front face of abutments.

- 2. Deflection under the mass of the forms, the plastic concrete and reinforcement shall not exceed 1/180 of the form span or 1/2 inch whichever is less, but in no case shall the design loading be less than 120 psf 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 2 inches 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 reinforcing steel shall have a minimum concrete cover of 1 inch.
 6. Permanent steel bridge deck form shall not be used in panels where longitudinal deck construction joints are located between stringers.
 7. Permanent steel bridge deck forms and their accessories shall not be attached by welding to steel girders or other structural steel bridge elements or reinforcing steel. Welding, including arc strikes or grounding, on any structural steel element is prohibited. Blemishes, when found, shall be removed in accordance with AWS D1.5 Section 3.10. Determination that a blemish exists will be made by the Engineer and the repair shall be at the Contractor's expense.
 8. The Contractor shall submit two sets of the fabricator's shop and erection drawings to the Engineer. The drawings shall be designed and sealed by the Contractor's Engineer. The drawings will not be approved or returned to the Contractor. The drawings shall indicate the grade of steel, the physical and section properties of all permanent steel bridge deck form sheets, and attachment details.
- (d) *Construction.* All forms shall be installed in accordance with fabrication and erection plans submitted to the Engineer in accordance with subsection 601.10(c)8.

Form sheets shall not be permitted to rest directly on the top of the girder flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 inch at each end. Form supports shall be placed in direct contact with the girder flange. All attachments shall be made by bolts, clips or other approved means. Welding will not be permitted to flanges.

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-641d, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds need not be touched up.

Transverse construction joints shall be located at the bottom of a flute and ¼ inch weep holes shall be field drilled at not more than 12 inches on center along the line of the joint.

- (e) *Placing of Concrete.* Concrete shall be placed with proper vibration of the concrete to avoid honeycomb and voids, especially at construction joints, expansion joints, valleys, and ends of form sheets. Placement sequences, procedures and mixes shall be approved by the Engineer. Calcium chloride or any other admixture containing chloride salts shall not be used in the concrete placed on permanent steel bridge deck forms.

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- (f) *Inspection.* If the Engineer determines that the procedures used during the placement of the concrete warrant inspection of the under-side 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. This will 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 two days, the concrete shall be tested for soundness and bonding of the forms by sounding with a hammer as directed. If areas of doubtful soundness are disclosed by this procedure, the Contractor shall remove the forms from such areas as ordered, for visual inspection. If corrective action is not required, the cost of form removal will be borne by the Department. If corrective action is required, the cost of form removal and corrective action shall be borne by the Contractor.

The Contractor shall provide inspection platforms or other approved means of stationary support from which the above visual inspection can be made.

601.11 Falsework.

- (a) *General.* Falsework is defined as any temporary construction used to support vertical loads for a structure until it becomes self-supporting. Formwork is the temporary structure or mold used to retain plastic or fluid concrete in its designated shape until it hardens.

The Contractor shall be responsible for designing and constructing falsework which provides the necessary rigidity, supports the loads imposed, and produces in the finished structure the lines and grades indicated on the plans.

The Contractor shall have a Professional Engineer determine whether falsework drawings are or are not necessary. When falsework drawings are determined to be unnecessary, the Contractor shall submit a written statement signed by the Contractor's Professional Engineer so stating. All falsework drawings, including revisions, prepared by the Contractor's Professional Engineer shall meet the requirements of subsection 601.11 and shall be provided by the Contractor to the Engineer for record purposes only. The drawings shall be approved by, and contain the seal and signature of, a Professional Engineer registered in the State of Colorado. These drawings shall be approved and signed by the Contractor prior to providing them to the Engineer. The drawings will not be approved by the Engineer.

- (b) *Certification.* Prior to placement of any concrete supported by falsework, the Contractor's Engineer shall certify that falsework materials and construction have been inspected and that all falsework design, materials, and construction conform to the requirements of the Contract and are safe for the placement of concrete. A

copy of the certification on an acceptable form shall be submitted to the Engineer for record purposes.

(c) *Falsework Design.*

1. The falsework design drawings shall show the stresses and deflections in all load supporting members, and anticipated total settlement of falsework footings and joint take-up. Anticipated settlements shall not exceed 1 inch. The maximum deflection used in the design of the falsework shall be $1/270$ of clear span, irrespective of the fact that the deflection may be compensated for by camber strips.
2. The design of falsework shall be based on the use of loads and conditions which are no less severe than those described in this section. The stresses listed are based upon the use of undamaged, high quality materials and such stresses shall be reduced by the Contractor if lesser quality materials are to be used. The Contractor is responsible for the proper evaluation of the falsework materials and design of the falsework to safely carry the actual loads imposed.
3. The design load for falsework shall consist of the sum of dead and live vertical loads and an assumed horizontal load.
 - A. Dead loads shall include the weight of concrete, reinforcing steel, forms, and falsework. The weight of concrete and reinforcing steel shall be assumed to be at least 150 pounds per cubic foot for normal concrete and at least 120 pounds per cubic foot for lightweight concrete.
 - B. Timber dead load is 50 pounds per cubic foot. The dead load of timber forms may be assumed at 10 pounds per square foot for members smaller than 6 inch x 6 inch. Dead load for steel and steel forms shall be 490 pounds per cubic foot. The weight of any other forming materials shall be specified on the drawings.
 - C. Live loads shall consist of the actual weight of any equipment to be supported by falsework applied as concentrated loads at the points of contact and a uniform load of not less than 50 pounds per square foot applied over the area supported.
4. The assumed horizontal load to be resisted by the falsework bracing system shall be the sum of the actual horizontal loads due to equipment, construction sequence or other causes and an allowance for wind; however, the assumed horizontal load to be resisted in any direction shall not be less than 2 percent of the total dead load for falsework up to 30 feet high, and four percent for falsework over 30 feet high. The falsework shall be designed so that it will have sufficient rigidity to resist the horizontal load prior to the placement of concrete.

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5. The entire bridge superstructure cross-section, except railing, shall be considered to be placed at one time except as provided herein. Girder stems and connected bottom slabs, if placed more than five days prior to the top slab, may be considered to be self supporting between falsework posts at the time the top slab is placed, provided that the distance between falsework posts does not exceed four times the depth of the portion of the girder placed in the first pour.
6. Falsework footings shall be designed to carry the load imposed upon them without exceeding the estimated soil bearing values and anticipated settlements.
7. Foundations for individual towers where the maximum leg load exceeds 30 kips shall be designed and constructed to provide uniform settlement under all legs of each tower under all loading conditions.
8. If the concrete is to be post-tensioned in the field, the falsework shall be designed to support all increased or readjusted loads caused by the prestressing forces, as shown on the plans.
9. The falsework design drawings shall include the following minimum information:
 - (1) Type and grade of structural materials.
 - (2) Allowable material stresses in bending, compression, and shear.
 - (3) Modulus of elasticity, "E".
 - (4) Stress factors if used for short term duration loading (timber only).
 - (5) Summary of critical tower leg loads and locations on falsework drawings.
 - (6) Weight of deck finishing machine and wheel or support spacing.
 - (7) References for load data used for standardized falsework components.
 - (8) Specification references for design criteria.
 - (9) The bearing value of the soil as determined by the Contractor when footing type foundations are to be used.
10. Falsework design shall be based on the current edition of one of the following applicable specifications. However, it shall be based on AASHTO Specifications if highway traffic is to be supported.

AASHTO American Association of State Highway and Transportation Officials, Standard Specifications for Highway Bridges.

AISC American Institute of Steel Construction, Manual of Steel Construction.

ACI American Concrete Institute, Formwork for Concrete SP4 Building Code Requirements for Reinforced Concrete.

NFPA National Forest Products Association, National Design Specifications for Stress Grade Lumber.

AITC American Institute of Timber Construction Manual.

11. Manufactured Assemblies. Loading of jacks, brackets, columns, joists and other manufactured devices shall not exceed the manufacturer's recommendations or 40 percent of the ultimate load carrying capacity of the assembly based on the manufacturer's tests or additional tests as necessary. The maximum allowable dead load deflection of joists shall be limited to 1/500 of their spans.

The Contractor shall furnish catalog or equivalent data showing the manufacturer's recommendations or perform tests, as necessary, to demonstrate the adequacy of any manufactured device proposed for use. The Contractor shall not substitute other manufacturer's components unless the manufacturer's data encompasses such substitutions or field tests affirm the integrity of the system.

12. Connection details shall be so designed that structural shoring members are secure for all loading conditions.

- (d) *Falsework Construction.* The falsework shall be constructed in accordance with the falsework drawings. Suitable jacks, wedges, or camber strips shall be used to set the forms to the required grade or camber and to take up any settlement in the formwork either before or during the placing of concrete. Supports for deck slab forms shall be constructed so as to prevent settlement relative to the girders. The amount of camber to be used to represent the behavior of the permanent structure is shown on the plans.

Falsework shall be constructed so that any concentrated loads applied to steel girder webs shall be applied within 6 inches of a flange or stiffener. Where loads are applied to steel girder webs, they shall be applied in a manner that will not produce distortion to the web.

Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girders and to prevent appreciable relative movement between the edge of deck forms and the adjacent steel girder. Where the deck overhang exceeds $\frac{1}{3}$ of the distance between the girders, the exterior girder shall be braced to prevent rotation due to the weight of the overhang support falsework and concrete placement operation.

The Contractor shall provide tell-tales attached to the forms and readable from the ground, in enough systematically placed locations, to determine the total settlement of the entire portion of the structure where concrete is being placed.

Should unanticipated events occur, including settlements that deviate more than $\pm\frac{3}{8}$ inch from those indicated on the falsework drawings, which in the opinion of

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the Engineer would prevent obtaining a structure conforming to the requirements of these specifications, the placing of concrete shall be discontinued until the corrective measures satisfactory to the Engineer are provided. In the event satisfactory measures are not provided prior to initial setting of the concrete in the affected area, the placing of concrete shall be discontinued at a location determined by the Engineer. All unacceptable concrete shall be removed.

- (e) *Falsework Removal.* Falsework supporting any span of a simple span bridge shall not be released until after the last concrete, excluding concrete above the bridge deck, has attained the compressive strength of at least 80 percent of the required 28 day strength, $0.80f'_c$, but in no instance prior to five days after the placement of the concrete.

Falsework supporting any span of a continuous or rigid frame bridge shall not be released until after the last concrete, excluding concrete above the bridge deck, has been placed in all spans and has attained the compressive strength of at least 80 percent of the required 28 day strength, $0.80f'_c$, but in no instance prior to five days after placement of the concrete.

Falsework for arch bridges shall be removed uniformly and gradually, beginning at the crown, to permit the arch to take its load slowly and evenly.

Falsework supporting overhangs and deck slabs between girders shall not be released before five days after the deck concrete has been placed.

Falsework for pier caps which will support steel or precast concrete girders shall not be released before five days after the cap concrete has been placed unless the compressive strength of at least 80 percent of the required 28 day strength, $0.80f'_c$, is obtained. Girders shall not be erected onto such pier caps until the concrete in the cap has attained the compressive strength of at least 80 percent of the required 28 day strength, $0.80f'_c$, shown on the plans.

If authorized, test hammer results may be used in lieu of test cylinders for form removal determinations only. The test hammer must be calibrated against similar concrete of known strength from the same aggregate source prior to use.

Falsework for cast-in-place prestressed portions of structures shall not be released until after the pre-stressing steel has been tensioned.

601.12 Placing Concrete.

- (a) *General.* A preplacement conference shall be held with selected Contractor and Department personnel prior to placement of concrete bridge decks to discuss the method and sequence of placing concrete.

At the pre-placement conference, the Contractor shall present a concrete winter protection plan for acceptance by the Engineer. The accepted concrete winter protection plan shall contain information on the number and type of heat sources

to be used, a sketch detailing the enclosure materials, and all other pertinent information. Sufficient equipment shall be supplied to continuously maintain the specified temperature uniformly in all parts of the enclosure. Insulated blankets on top of the bridge deck and freely circulated artificial heat below the deck will be permitted.

Concrete shall not be placed until forms have been completed and materials required to be embedded in the concrete have been placed, and the Engineer has inspected the forms and materials. The forms shall be cleaned of all debris before concrete is placed.

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

- (b) *Hot Weather Limitations.* Placing of concrete during hot weather shall be limited by the temperature of the concrete at the time of placing. Mixed concrete which has a temperature of 90 °F or higher, shall not be placed.

The Contractor shall provide fogging equipment and keep the concrete surface moist at all times by fogging with an approved atomizing nozzle until the curing material is in place.

The aggregate stockpiles shall be kept moist at all times.

- (c) *Cold Weather Limitations.* The mixed concrete temperature shall be between 50 and 90 °F at the time of placement. Water, aggregates, or both shall be heated when necessary under such control and in sufficient quantities to avoid fluctuations in the temperature of the concrete of more than 10 °F from batch to batch.

To avoid the possibility of flash set when the water is heated to a temperature in excess of 100 °F, the water and the aggregates shall be charged into the mixer before the cement is added.

Heating equipment or methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The equipment shall be capable of heating the materials uniformly. Aggregates and water used for mixing shall not be heated to a temperature exceeding 150 °F. Materials containing frost or lumps of frozen material shall not be used.

Stockpiled aggregates 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.

When aggregates are heated in bins, steam-coil or water-coil heating, or other methods which will not be detrimental to the aggregates may be used. The use of live steam on or through binned aggregates will not be permitted.

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Concrete shall not be placed on frozen ground. Before concrete placement, all ice, snow, and frost shall be completely removed from within formwork. Salt shall not be used to thaw ice, snow, or frost.

- (d) *Chutes and Troughs.* Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.

Concrete shall not be dropped more than 5 feet, unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and strain shall not be placed on the ends of projecting reinforcement.

Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.

Concrete shall not be pumped through aluminum alloy pipe.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete.

- (e) *Vibrating.* Unless otherwise directed, the concrete shall be consolidated with suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate consolidation.

Vibrators shall be of a type and design approved by the Engineer. They shall be capable of frequencies of at least 10,000 vibrations per minute, in air.

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

- (f) *Depositing Concrete Under Water.* Concrete, except for cofferdam seals, shall not be deposited under water, unless approved by the Engineer. If approved, care shall be exercised to prevent the formation of laitance. Concrete shall not be deposited until all laitance, which may have formed on concrete previously placed, has been removed. Pumping shall be discontinued while depositing foundation concrete if it results in a flow of water inside the forms. If concrete, except for cofferdam seals, is deposited under water, the proportion of cement used shall be increased at least 25 percent at the Contractor's expense. Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie. The discharge or bottom end of the tremie shall be

lowered to contact the foundation at the start of the concrete placement and shall be raised during the placement at a rate which will insure that the bottom or discharge end of the tremie is continuously embedded or buried in fresh concrete a minimum of 12 inches. Air and water shall be excluded from the tremie pipe by keeping the pipe continuously filled. The continuity of the placement operation shall be maintained without breaking the seal between the concrete mass and the discharge end of the tremie until the lift is completed. The concrete placement shall not be disturbed after it has been deposited.

- (g) *Placement.* Concrete shall be placed in horizontal layers not more than 18 inches thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and consolidated before the preceding batch has taken initial set. Each layer shall be so consolidated as to avoid the formation of a construction joint with a preceding layer which has not taken initial set. Bridge deck concrete on superelevation or grade that exceeds 2 percent, shall be placed from the low point upward.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. The top surfaces of concrete adjacent to the forms shall be smoothed with a trowel to minimize visible joints upon exposed faces. Work shall not be halted within 18 inches of the top of any face, unless provision has been made for a coping less than 18 inches thick, in which case the construction joint may be made at the under side of the coping.

Immediately after the work of placing concrete is halted, all accumulations of mortar splashed upon the reinforcement and surfaces of forms shall be removed before the concrete takes its initial set. Care shall be taken when cleaning reinforcing steel to prevent damage to or breakage of the concrete-steel bond.

Where Class DT concrete is used for patching, repair, or topping of existing concrete, the area that the Concrete Class DT contacts shall be prepared by shotblasting $\frac{1}{8}$ to $\frac{3}{16}$ inch deep or rotomilling. If Class DT concrete is not placed within one week of the shotblasting or rotomilling the area shall then be sandblasted and cleaned of all sand, concrete fragments, dirt, and other foreign material within one week of placement. The area shall be moistened two to four hours before placement and shall be free of standing water at the time of placement.

- (h) *Placing Sequence.* Unless otherwise shown on plans, or ordered, the concrete placing sequence shall be as follows:

Concrete in columns shall be placed in one continuous operation. The concrete in columns shall be allowed to set at least 12 hours before caps are placed. Each span of simple span concrete slab and girder bridges less than 30 feet in length shall be placed in one continuous operation.

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Concrete for simple or continuous girder spans greater than 30 feet shall be placed in two operations; the first operation shall consist of placing the girder stems and any slab at the bottom of the stems, and the second operation shall consist of placing the top deck slab. The second pour shall not be made until the first pour has reached a compressive strength of twice the design unit stress shown on the plans.

Transverse construction joints shall be located as shown on the plans, or as approved.

Concrete slabs on simple span steel girder bridges shall be poured in one continuous operation for each span. If approval is given to place the deck of the entire structure, the Contractor shall use an approved retarder, when necessary, to retain the workability of the concrete and to obtain the desired finish.

Concrete slabs on continuous span steel girder bridges shall be placed in accordance with the placing sequence shown on the plans. The Contractor may place the deck of the entire structure in one operation, when approved. An approved retarder shall be used, when necessary, to retain the workability of the concrete and to obtain the desired finish. The leading edge of the freshly placed concrete shall be kept parallel to the substructure so that the girders will be loaded evenly during the placing and screeding operation.

- (i) *Drainage and Weep Holes.* Drainage and weep holes shall be constructed at locations shown on the plans or as ordered. Ports or vents for equalizing hydrostatic pressure shall be placed below low water.

Forms for weep holes shall consist of approved form material. Wooden forms shall be removed after initial set of concrete has taken place.

Inlets of weep holes shall be surrounded with 1 cubic foot of filter material in a burlap sack, securely tied.

- (j) *Construction Joints.* Construction joints shall be made only where located on the plans or shown in the placing schedule, unless otherwise approved.

All construction joints shall be cleaned of surface laitance, curing compound, and other foreign materials before fresh concrete is placed against the surface of the joint. Abrasive blast methods shall be used to clean construction joints between concrete girders and adjoining deck slabs. When the optional construction joints shown on the plans are used, any additional reinforcing steel shall be furnished and placed by the Contractor at no expense to the Department.

Surfaces on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

Where construction joints are allowed on visible surfaces, chamfer strips attached to the forms or other approved methods shall be utilized to provide an even joint appearance.

When the plans show new concrete to be joined to existing concrete by means of bar reinforcing dowels placed in holes drilled in the existing concrete, the diameter of the holes shall be the minimum needed to place non-shrink grout or epoxy grout and the dowel. Immediately prior to placing the dowels, the holes shall be cleaned of dust and other foreign material and sufficient grout placed in the holes so that there are no voids in the drilled holes after the dowels are inserted.

- (k) *Float Finish on Horizontal Surfaces.* All freshly placed concrete on horizontal surfaces shall be given a float finish except as otherwise provided in the plans. Bridge decks and bridge sidewalks shall be finished in accordance with subsection 601.15(e). A float finish shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating tool. 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.
- (l) *Loading Piers and Abutments.* Superstructure dead loads shall not be applied until piers and abutments have attained a compressive strength of $0.8f'_c$.

The Contractor shall provide an as constructed survey of the abutments and piers prior to girder erection. The Contractor shall submit to the Engineer a copy of the survey notes detailing the girder seat elevations, anchor bolt locations and projections, and span distances from centerline of bearing to centerline of bearing. The survey notes shall indicate all adjustments necessary for bearing device dimensions other than those shown on the plans. The Contractor shall submit details for all adjustments to the Engineer for approval.

- (m) *Opening to Traffic.* Concrete structures shall remain closed to traffic, and shall not carry Contractor's equipment, for 21 days after placement of the concrete deck is completed. The structure may be opened to traffic earlier if the concrete deck and all other concrete has attained the Field Compressive Strength given in Table 601-1. The minimum compressive strength shall be determined from test cylinders made and cured at the structure site in accordance with AASHTO T 23 and tested in accordance with AASHTO T 22.

In addition, for cast-in-place prestressed bridges, construction vehicles whose gross weight exceeds 2,000 pounds, shall not be allowed on any span until prestressing steel for that span has been tensioned.

- (n) *Epoxy Bonder.* An epoxy bonder meeting the requirements of subsection 712.10 shall be used where epoxy bonder is called for on the plans.

601.13 Curing Concrete Other Than Bridge Decks. When the ambient temperature is below 35 °F the Contractor shall maintain the concrete temperature

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above 50 °F during the curing period. It shall be the Contractor's responsibility to determine for himself the necessity for undertaking protective measures.

The minimum curing period shall be determined by one of the following methods. The Engineer shall review for adequacy, the Contractor's determination of the curing period.

- (1) The minimum curing period shall be 120 hours
- (2) The minimum curing period shall be from the time the concrete has been placed until the concrete has met a compressive strength of 80 percent of the required field compressive strength. The Contractor shall cast information cylinders on the final portion of a placement and store as close to the structure as possible. The information cylinders shall receive similar thermal protection as the structure. The contractor shall protect the information cylinders from damage. In-place strength shall be determined by at least two cylinders. If the information cylinders are destroyed in the field, the minimum curing period shall be 120 hours.
- (3) The minimum curing period shall be from the time the concrete has been placed until the concrete has met a compressive strength of 80 percent of the required field compressive strength. The Contractor shall develop a maturity relationship for the concrete mix design in accordance with ASTM C 1074. The Contractor shall provide the maturity meter and all necessary thermocouples, thermometers, wires and connectors. The Contractor shall place, protect and maintain the maturity meters and associated equipment. Locations where the maturity meters are placed shall be protected in the same manner as the rest of the structure. The Contractor shall install the thermocouples at locations designated by the Engineer. The Contractor shall monitor the temperature at intervals acceptable to the Engineer.

Enclosures with artificial heat sources will be permitted. If enclosures are used the Contractor shall monitor the structural integrity of the enclosure. Artificial heat sources shall not be placed in such a manner as to endanger formwork or expose any area of concrete to drying due to excessive temperatures. At the end of the curing period, the protection shall remain in place until it can be removed without permitting the concrete temperature to fall more than 50 °F in a 24-hour period. Sudden changes of concrete temperature shall be prevented.

Immediately after placing fresh concrete, all concrete shall be cured by one of the following methods. The Engineer shall review for adequacy, the curing method proposed by the Contractor.

- (a) *Water Method.* All surfaces other than slabs shall be protected from the sun and the whole structure shall be kept wet throughout the curing period. Surfaces requiring a Class 2 finish may have the covering temporarily removed for

finishing, but the covering must be restored as soon as possible. All concrete slabs shall be covered as soon as possible with suitable material so that concrete is kept thoroughly wet for at least five days. The concrete surface shall be kept moist at all times by fogging with an atomizing nozzle until the covering is placed.

- (b) *Membrane Forming Curing Compound Method.* Curing compound may be applied only to those surfaces, which are to receive a Class I or Class 4 final finish. A volatile organic content (VOC) compliant curing compound conforming to AASHTO M 148, Type 2 shall be used on surfaces where curing compound is allowed, except that Type 1 curing compound shall be used on exposed aggregate or colored concrete, or when directed by the Engineer. Curing compound shall not be used on construction joints. The rate of application of curing compound will be in accordance with the manufacturer's recommendation, but shall not be more than 300 square feet per gallon. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after stripping of forms and acceptance of the concrete finish. If the surface is dry, the concrete shall be thoroughly wet with water and the curing compound applied just as the surface film of water disappears. The second application shall be applied after the first application has set. During curing operations, all unsprayed surfaces shall be kept wet with water. The coating shall be protected against marring for a period of at least ten days after application. Coating marred, or otherwise disturbed, shall be given an additional coating. Should the surface coating be subjected continuously to injury, the Engineer may require that water curing, as described in subsection 601.13(a) be applied at once. When using a curing compound, the compound shall be thoroughly mixed within an hour before use. If the use of a curing compound results in a streaked or blotchy appearance, its use shall be discontinued. Water curing, as described in subsection 601.13 (a), shall then be applied until the cause of the defective appearance is corrected.
- (c) *Form Method.* Concrete shall be protected by forms during the curing period. Forms shall be kept moist, when necessary, during the curing period to insure the concrete surface remains wet.
- (d) *Blanket Method.* Electrically heated curing blankets or insulation blankets may be used in cold weather to maintain specified curing temperature and to retain moisture in concrete. Blankets shall be lapped at least 8 inches and shall be free of holes. Blankets shall be secured at laps and edges to prevent moisture from escaping.
- (e) *Potential Frost Damage.* The following procedures shall be followed if the temperature of the concrete structure falls below 32 °F before the concrete reaches 80 percent of the required field compressive strength:
- (1) The Contractor will take cores at locations designated by the Engineer.

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- (2) The Engineer will take immediate possession of the cores and submit the cores to a petrographer for examination in accordance with ASTM C 856.
- (3) All costs associated with coring, transmittal of cores, and petrographic examination shall be born by the Contractor regardless of the outcome of the petrographic examination.
- (4) Concrete damaged by frost as determined by the petrographic examination shall be removed and replaced at the Contractor's expense.

601.14 Finishing Hardened Concrete Surfaces.

- (a) *General.* Unless otherwise authorized, all formed surfaces shall be finished with Class 1 finish. Generally, for form cured surfaces, this finish will be constructed immediately following curing.

Where curing compound is allowed by subsection 601.13(b), the Class I finish shall be applied immediately after the forms are removed and forms may be removed for only that portion of the work that can be finished in the remainder of a work day. The exposed concrete shall be kept damp during the finishing period and covered with the curing compound immediately following the completion of the finishing.

Structural Concrete Coating shall be the final finish for all concrete surfaces designated on the plans and in these specifications.

- (b) The various classes of finish are described as follows:
 1. Class 1, Ordinary Surface Finish. All fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. On all surfaces, the cavities produced by form ties, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned, moistened with water and carefully pointed and trued with a mortar consisting of cement and fine aggregate and the surface left sound, smooth, even and uniform in color. Mortar used in pointing shall be not more than 30 minutes old. The mortar patches shall be cured as specified in subsection 601.13 or other approved methods. 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.
 2. Class 2, Rubbed Finish. After completion of Class 1 Ordinary Surface Finish, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work the concrete shall be moistened with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the same proportions 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 has been obtained. The paste 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 the entire surface is of a smooth texture and uniform color.

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

3. Class 4, Sand Blasted Finish. The cured concrete surface shall be sand blasted with hard, sharp sand to produce an even fine-grained uniform surface in which the mortar has been cut away. An exposed aggregate finish will not be required. However, aggregate exposed incidental to achieving the specified surface will be acceptable.
4. Structural Concrete Coating. Unless otherwise shown on the plans, the coating shall be applied to all exposed concrete elements of the structure above the ground line, including the tops of all pier caps and abutment seats, and shall extend 1 foot below the finished ground line. Bridge bearing devices, curb and barrier cover plates, fence, and steel bridge rail shall be masked or otherwise protected to prevent structural concrete coating from coming into contact with them.

The final color of the Structural Concrete Coating shall have the Engineer's written approval prior to batching and application on the project. Approval of the final color of the coating will be determined by the Engineer as follows:

- (1) A 1 foot by 1 foot sample of each color required by the plans, shall be submitted to the Engineer. The sample coating shall be applied to surfaces similar in texture to the concrete surfaces to which the coating will be applied on the project. The sample coating shall be applied by the same methods to be used in field application.
- (2) At least three weeks prior to beginning application of the Structural Concrete Coating, 100 square foot test panels shall be prepared for each color selected by the Engineer. The test panels shall be produced on the actual concrete surface on which the final product will be placed, at a location designated by the Engineer where all the required color and texture combinations may be viewed adjacent to each other. The coatings shall be applied to the test panels by the same methods to be used in the final field application. The Engineer shall be allowed one week after application of the last test panel for review and approval.

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Concrete surfaces to which the structural concrete coating will be applied shall be prepared as follows:

- (1) Following curing of the concrete in accordance with Subsection 601.13, all projections and bulges shall be removed and the surface sandblasted. Sandblasting shall profile the concrete surface, remove all form release agents, and all other deleterious materials that would inhibit the bond of the Structural Concrete Coating. The profile of the sandblasted concrete surface shall be equivalent to Concrete Surface Profile Three (CSP 3) as defined in Technical Guideline No. 03732, "Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays" by the International Concrete Repair Institute. The Contractor shall provide a CSP 3 chip for use on the project.
- (2) A mortar mix, proportioned by volume, consisting of one part portland cement, two to three parts sand (conforming to the requirements of ASTM C 144), and an approved bonding agent shall be used to patch all holes produced by form ties, honeycombing, voids ½ inch or larger in any dimension, broken corners and edges, and other defects. The mortar mix shall include an approved bonding agent. The quantity, and application procedure of the bonding agent shall be in accordance with the recommendations of the manufacturer of the bonding agent. Areas to be patched shall be moistened with water before the mortar is applied, and the patched area shall be float finished and left flush with the concrete surface without checking or cracking of patches. Patching shall be done when the ambient temperature is at least 40 °F. Holes deeper than ¾ inch shall be filled in layers that do not exceed ¾ inch in thickness.
- (3) Within 24 hours prior to applying Structural Concrete Coating, the concrete surface to be coated shall be cleaned by water blasting at a minimum pressure of 3,000 psi to remove dust, dirt, and other materials that would inhibit bonding of the coating. If the surface is contaminated before application of the coating, it shall be recleaned as required prior to application of the coating.

New concrete shall be at least 28 days old or as approved in writing by the coating manufacturer before the coating is applied.

The coating shall be applied at a rate that will provide a minimum dry film thickness of 10 to 12 mils without texturing agent. The coating shall be mixed by a mechanical mixer and applied by spraying. Workmanship shall be such that the final coated surface is colored and textured uniformly and presents a pleasing appearance. All areas determined by the Engineer to be insufficiently coated shall be recoated.

The coating shall be applied only when the ambient temperature is between 40 °F and 90 °F, and is anticipated to remain above 40 °F for a minimum of 24 hours. The surface to be coated shall be dry and free of frost.

601.15 Bridge Deck Placing, Consolidating and Finishing. The Contractor shall prepare a written Quality Control Plan (QCP) which defines the quality control measures the Contractor will use to ensure the placing, consolidating, and finishing, curing and weather protection of the bridge deck conforms to the Contract requirements. The Contractor may refer to the Structural Concrete Pre-Pour Conference Agenda in the department's Construction Manual for examples of items that should be included in the QCP. It shall also identify the Contractor's method for ensuring that the provisions of the QCP are met. The Contractor shall submit the QCP to the Engineer for written approval before the pre-pour conference.

A Pre-Placement Conference shall be held at a time mutually agreed upon before the initial placement of Class H, Class HT or Class S50 concrete. Representatives of the ready mix producer and the Contractor shall meet with the Engineer to discuss the following topics:

- (1) Concrete Mix Ingredients and Proportions (cement content, effect of admixtures, etc.)
 - (2) Work Schedule
 - (3) Applicable Specifications and Special Notes
 - (4) Delivery Details
 - (5) Planned Construction Joint Locations
 - (6) Role of All Personnel
 - (7) Construction Details - surface preparation, finish, joint locations, etc.
 - (8) Testing Requirements
 - (9) Acceptance Criteria
 - (10) Contingency Plans for Wind, Rain, Breakdown, etc.
 - (11) Curing Details
- (a) *Surface Preparation.* Tops of girders, precast deck panels, pier caps, and abutments that will come into contact with bridge deck concrete shall be heated to raise the temperature above 35 °F prior to concrete placement. The proposed preheating method is subject to approval by the Engineer.

Prior to placement of a Class HT concrete overlay, the deck shall be prepared as follows:

1. Newly Placed Decks or Existing Decks That Have Been Used as the Final Driving Surface. The deck shall be shot blasted in preparation for a mechanically bonded surface. Shot blasting shall remove the upper surface of the deck down to the coarse aggregate, which requires removing approximately $\frac{1}{8}$ to $\frac{3}{16}$ inch of the concrete.

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2. Existing Decks Covered with One or More Layers of Bituminous Pavement. The deck shall be planed in accordance with subsection 202.09 to remove all overlying bituminous pavement, bridge deck membrane, and the upper $\frac{1}{4}$ inch of the deck concrete.

If Class HT concrete is not placed within one week of shot blasting or planing, the area shall then be sandblasted and cleaned of all sand, concrete fragments, dirt, and other foreign material within one week before placement. The area shall be moistened at least two hours before placement in order that the substrate concrete is saturated. The substrate concrete shall be allowed to dry and shall be saturated surface dry and free of visible water at the time of placement.

- (b) *Test Slab.* At least seven days prior to initial placement of Class H, Class HT or Class S50 concrete on or in a deck, the Contractor shall have prepared, placed, and cured one test slab of at least 4 cubic yards to verify mix design, demonstrate the ability to perform placement, finishing & curing operations, and to check quality control. The test slab shall be approximately the same thickness as the concrete to be placed. Additional test slabs shall be placed as necessary to verify changes in design or procedures at the contractor's expense. Test slabs that are placed as acceptable work in segments of sidewalks, or as approach slabs, or other locations acceptable to the Engineer, will be paid for as the pay item for that element of the contract.
- (c) *Placing.* Concrete shall be placed in accordance with the requirements of subsection 601.12 except for the following:

Concrete shall be placed in such manner as to require as little rehandling as possible and at sufficient depth to provide adequate material for screeding and finishing operations. The concrete shall be discharged as near its final location as practicable. The pattern of placement shall be such that lateral flow will be minimized. Concrete shall be placed against the leading edge of fresh concrete where practicable.

Class H, Class HT and Class S50 concrete shall be placed only when the concrete mix temperature is between 50 °F and 80 °F at the time of delivery. Class H, Class HT and Class S50 concrete shall not be placed in or on bridge decks when the air temperature exceeds 80 °F or the wind velocity exceeds 10 mph as determined by a digital thermometer and anemometer provided on site by the Contractor. If the Engineer can determine from the Contractor's data that the evaporation rate is less than 0.20 pound per square foot per hour, in accordance with figure 2.1.5 in ACI 305, then Class H and HT concrete may be placed under these conditions.

Longitudinal joints for a Class HT concrete overlay will be allowed only at the locations of lane lines and must be approved by the Engineer.

Transverse joints may be utilized when the Engineer determines that the work is not progressing in a satisfactory manner, or when required by change in weather conditions. The Engineer may approve transverse joint locations to accommodate phased overlay construction.

- (d) *Consolidating.* Consolidation shall conform to subsection 601.12(e) and to the following:

The Contractor shall provide suitable mechanical vibrators to disperse the batch at the point of discharge and to densify the concrete within the forms. The bond of fresh concrete to concrete previously placed shall be achieved by vibrating the new concrete together with the old. Immersion vibrators shall operate at a speed of at least 10,000 vibrations per minute in air. Internal vibration may be used along the edges of forms and in areas of congested reinforcing. A combination of immersion vibration and surface consolidation shall be used.

- (e) *Finishing.* Following consolidation, the concrete shall be struck off and finished by mechanical longitudinal floating, mechanical rolling, surface vibration, or a combination of any of these methods. Surface vibrators shall be of the low frequency, high-amplitude type, operating at a speed of 3000 to 4500 vibrations per minute.

A paver's steel scraping straightedge or lute, 4 inch maximum width, shall be the only hand tool permitted on deck surfaces, except for a minimum use of hand floats and edgers along the forms and in areas where machine finishing cannot be effectively used. Only minimum hand finishing will be permitted. If the surface of the deck slab becomes dry immediately following finishing operations, due to an excessive evaporation rate, it shall be covered with wet burlap or fogged with water covering the entire deck surface using pneumatic atomizing nozzles. The fog spray shall be just enough to retard surface evaporation and shall not change the water-cement ratio. During periods of excessive drying, a cover of wet burlap or plastic sheeting shall be maintained on the slab at all times until final cure is placed. Monomolecular film coatings applied to the surface of the slab to retain moisture may be used provided they effectively retard surface evaporation and are adequately maintained until the final cure is placed.

Surfaces of bridge decks and bridge approach slabs that will be the final riding surface shall be finished as follows:

1. *Final Finish.* For the final finish a seamless strip of plastic turf shall be dragged longitudinally over the full width of bridge deck after a seamless strip of burlap or other approved fabric has been dragged longitudinally over the full width of bridge deck to produce a uniform surface of gritty texture.

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The drags shall be mounted on a bridge other than the bridge to be furnished for Department use. The dimensions of the drags shall be such that a strip of material at least 3 feet wide is in contact with the full width of pavement surface while each drag is used. The drags shall consist of sufficient material and be maintained in such a condition that the resultant surface finish is of uniform appearance and reasonably free from grooves over $\frac{1}{16}$ inch in depth. Where more than one layer of burlap drag is required, the bottom layer shall be approximately 6 inches wider than the layer above. Drags shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags installed.

2. Texturing. When posted speeds are 40 mph or higher, the finish shall be a grooved finish conforming to the following:

After the Engineer has accepted the finished surface, and after concrete has cured for at least seven days, the bridge deck surface shall be textured by grooving with a mechanized saw (sawed grooves). Grooving shall be done prior to the application of the concrete sealer. Only multi-blade saw cutting equipment furnished with circular blades may be used. Single blade equipment may be authorized by the Engineer where multi-blade assemblies do not allow sawing a distance one foot from obstructions.

The grooving shall be rectangular and conform to the following:

Depth: $\frac{1}{8}$ inch \pm $\frac{1}{32}$ inch
Width: $\frac{1}{8}$ inch \pm $\frac{1}{32}$ inch
Spacing: $\frac{3}{4}$ inch \pm $\frac{1}{32}$ inch center to center

Grooves shall be longitudinal and parallel to the centerline of the roadway. Overlapping of grooves by succeeding passes will not be permitted. The grooves shall terminate 1.5 feet from the face of curb or bridge rail on each side of the overlaid bridge deck.

Grooving to bridge joint system. For joint systems that are perpendicular to the roadway centerline, grooving shall extend to 9 inches \pm 3 inches from the armor of the joint.

For the joint systems that are not perpendicular to the centerline of the roadway, grooving shall remain parallel to the centerline and shall not be nearer than 6 inches to the joint armor nor farther than 4 feet from the joint armor. The distance between grooves, from one side to other of the joint system, shall not exceed 5 feet.

The Contractor shall maintain the grooving equipment so that aggregate particles or cement build-up on the saws is promptly cleared or cleaned so

that the grooves are neat, true and in conformance with the specified dimensions.

(f) *Surface Smoothness.*

1. All Bridge Deck Surfaces. Acceptability of the deck surface will be determined as follows: The Contractor shall furnish a 10 foot straightedge or other approved device. When the concrete is sufficiently hard, the Contractor shall test the bridge deck surface with the 10 foot straightedge or other approved device. Areas showing high spots of more than $\frac{1}{8}$ inch but not exceeding $\frac{1}{2}$ inch in 10 feet shall be marked. The marked area shall be immediately ground with an approved grinding tool so that the surface deviation will not be in excess of $\frac{1}{8}$ inch in 10 feet. Grinding shall not reduce the concrete cover on reinforcing steel to less than $1\frac{3}{4}$ inches, ($2\frac{3}{4}$ inches for bare decks without an overlay). Decks that require additional corrective action shall be corrected with a concrete overlay approved by the Engineer.
2. All Bridge Deck Final Riding Surfaces. Bare deck, or any concrete overlaid final surface is subject to an incentive payment. The Contractor shall provide the Engineer with the following for incentive payment only: The longitudinal finished surface smoothness of structures and approach slabs including concrete deck and any overlaid surface shall be tested with the profilograph method in accordance with subsection 105.07(b). Bridge Deck shall be subject to an incentive payment in accordance with the following Table 601-2. Incentive Payments will be based on the Lane Profile Index (LPI) before diamond grinding of bumps or any corrective work has been done.

**Table 601-2
BRIDGE DECK SMOOTHNESS (INCHES/MILE)
0.1 INCH BLANKING BAND**

Pavement Smoothness Category ¹	Incentive Payments		Corrective Work Required
	LPI (inches per mile)	Concrete \$ per square yard	
All Bridge Decks	0-12 or	1.20	In accordance with subsection 601.15(f)1.
	12.1-15	0.90	
	15.1-18	0.60	
	18.1-22	0.30	
	22.1-25	0.00	

¹ This category will be used only on new construction or complete reconstruction of bridge deck.

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- (g) *Movable Bridges.* Movable bridges or platforms shall be provided by the Contractor and moved as directed to allow the inspectors to work over the freshly placed plastic concrete. A movable bridge shall be kept as close to the finishing screed as practical. The deck of the movable bridges shall be a minimum of 24 inches wide and no more than 24 inches above the surface of the concrete and shall be capable of supporting two people. The Contractor shall provide additional movable bridges as appropriate for the work.
- (h) *Concrete Bridge Sidewalks.* Bridge sidewalks shall receive a final transverse broom finish.
- (i) *Crack Repair.* If cracks in the deck concrete with a width of 0.035 inches or greater occur within two weeks of placement, those cracks shall be repaired at the Contractor's expense. Cracks will be measured by the Engineer by insertion of a wire gauge at any time and temperature within the two weeks. The repair shall consist of filling the cracks with a low viscosity, two part, methacrylate or an approved equal. The repair shall be in accordance with the recommendations of the manufacturer of the crack filling material.

601.16 Curing Concrete Bridge Decks. Except for Class H and HT concrete, the minimum curing period shall be 120 hours. The concrete surface shall be kept moist at all times by fogging with an approved atomizing nozzle or applying a monomolecular film coating to retard evaporation until the curing material is in place.

For Class H and HT concrete the minimum curing period shall be 168 hours and from May 1 and until September 30 the water cure method as described below shall be used without the membrane forming curing compound.

Concrete bridge decks, including bridge curbs and bridge sidewalks shall be cured as follows:

- (a) Decks placed from May 1 to September 30 shall be cured by the membrane forming curing compound method followed by the water cure method as follows:
 - 1. Membrane Forming Curing Compound Method. A volatile organic content (VOC) compliant curing compound conforming to AASHTO M 148, Type 2 shall be uniformly applied to the surface of the deck, curbs and sidewalks at the rate of 1 gallon per 100 square feet. The curing compound shall be applied as a fine spray using power operated spraying equipment. The power operated spraying equipment shall be equipped with an operational pressure gage and a means of controlling the pressure. Before and during application the curing compound shall be kept thoroughly mixed by recirculation or a tank agitator. The application shall be within 20 feet of the deck finishing operation. When the finishing operation is discontinued, all finished concrete shall

be coated with curing compound within ½ hour. The curing compound shall be thoroughly mixed within one hour before use.

2. Water Cure Method. The water cure method shall be applied as soon as it can be without marring the surface and shall be continued for five days. The surface of the concrete, including bridge curbs and bridge sidewalks, shall be entirely covered with cotton, burlap, or combination polyethylene sheeting and burlap mats. Approved combinations of a barrier and a water retaining layer may be used. Prior to being placed, the mats shall be thoroughly saturated with water. The mats shall extend at least twice the thickness of the bridge deck beyond the edges of the slab and shall be weighted to remain in contact with the surface. The mats shall remain in contact and be kept wet for a minimum of five days after concrete placement.
- (b) Decks placed between November 1 and March 31 shall be cured by application of a membrane forming curing compound followed by the blanket method as follows:
1. Membrane Forming Curing Compound Method. This method shall be applied in accordance with subsection 601.16(a)1 above.
 2. Blanket Method. Curing blankets with a minimum R-Value of 0.5 shall be placed on the deck as soon as they can be without marring the surface. Blankets shall be loosely laid (not stretched) and adjacent edges suitably overlapped with continuous weights along the lapped joints. The blankets shall remain in place for a minimum of five days after placement.
- (c) Decks placed in April or October may be cured in accordance with either subsection 601.16(a) or 601.16(b) above.
- (d) For decks placed above an elevation of 8,000 feet above mean sea level, the Engineer may modify the time of year requirements for the cure methods defined in subsection 601.16(a) and 601.16(b) above.
- (e) Class H, Class HT and Class S50 concrete shall be cured as follows:
1. The concrete surface shall be kept moist at all times by fogging with approved atomizing nozzles until the surface has been covered by the final cure.
 2. At least two atomizing nozzles shall be in operation at all times.
 3. From October 1 and until April 30 continuous fogging will not be required if the evaporation rate is less than 0.10 pound per square foot per hour. Ambient temperatures during initial curing shall be warm

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enough that the water from fogging does not freeze before insulating blankets are applied. The internal concrete temperature shall be determined by using thermocouples and a continuous recording device. The Contractor shall provide the thermocouples and a continuous recording device and install the thermocouples at locations designated by the Engineer. The continuous recording device connected to the thermocouple shall be calibrated to provide accurate temperature readings. During the cure period the continuous recording device shall be visible, show visible readings, and the Contractor shall continuously monitor the concrete temperature and provide the recorded data to the Engineer after the monitoring of temperature for that placement is complete.

- (f) When the ambient temperature is below 35 °F, the Contractor shall maintain the internal concrete temperature above 50 °F during the curing period, except the last 48 hours of the curing period the internal concrete temperature may be kept above 40 °F.

Internal concrete temperature shall be determined by using thermocouples. Thermocouple wire, connectors, and hand held thermometer will be supplied by the Engineer. The Contractor shall install the thermocouples at locations designated by the Engineer.

During the curing period, the Contractor shall monitor the enclosure at intervals acceptable to the Engineer. The Contractor shall monitor concrete temperature, and the structural integrity of the enclosure. Artificial heat sources shall not be placed in such a manner as to endanger formwork or expose any area of concrete to drying due to excessive temperatures.

During the curing period, for each day that the internal concrete temperature falls below the specified temperature, the protection shall remain in place and one extra day of curing time above 40 °F shall be added to the original days of protection.

If the internal concrete temperature at any location in the bridge deck concrete falls below 32 °F during the first 24 hours of the curing period, the Engineer may direct the Contractor to core the areas in question at the locations indicated by the Engineer. The Engineer will take immediate possession of the cores. The Engineer will submit the cores to a petrographer for examination in accordance with ASTM C 856. Concrete damaged by frost, as determined by the petrographer, shall be removed and replaced at the Contractor's expense. All costs associated with coring, transmittal of cores, and petrographic examination shall be born by the Contractor regardless of the outcome of the petrographic examination.

At the end of the protection period, the protection shall remain in place until it can be removed without permitting the concrete temperature to fall more than 50 °F in a 24 hour period. Sudden changes of temperature shall be prevented.

601.17 Acceptance and Pay Factors. These provisions apply to all concrete.

- (a) *Air Content.* At any time during the placement of the concrete, when a batch deviates from the minimum or maximum percent of total air content specified, the following pro-cedure will be used to analyze the acceptability of the concrete.
1. A batch that deviates from the specified air content by more than one percent and all Class D concrete placed in bridge decks with air content exceeding eight percent will be rejected. Portions of loads incorporated into structures prior to determining test results which indicate rejection as the correct course of action shall be subject to acceptance at reduced price, no payment, or removal as determined by the Engineer.
 2. A batch that deviates from the specified air content by one percent or less, may be incorporated into the project at a reduced price, calculated as follows: The first batch that deviates from the specified air content by $\frac{1}{2}$ percent or less, will be accepted at full price. The first batch that deviates from the specified air content by more than $\frac{1}{2}$ percent and up to 1 percent, which the Contractor elects to place, will be accepted at a reduced price. The second and third successive batches of a series that deviate from the specified air content by 1 percent or less, which the Contractor elects to place, will be accepted at a reduced price. The fourth and all other successive batches of a series that deviate from the specified air content will be rejected. The rejected batch count will stop with a batch that is within the specified air content, and deviation batch count will resume at one with the next batch that deviates from the specified air content.
- (b) *Slump.* Slump acceptance, but not rejection, may be visually determined by the Engineer. During the placement of the concrete, when a batch exceeds the maximum slump specified, the following procedure shall be used to analyze the acceptability of the concrete.
1. A batch that exceeds the maximum slump specified by more than 1 inch will be rejected. Portions of loads incorporated into structures prior to determining test results which indicate rejection as the correct course of action shall be subject to acceptance at reduced price, no payment, or removal as determined by the Engineer.
 2. A batch that exceeds the maximum slump specified by 1 inch or less, may be incorporated into the project at a reduced price, calculated as follows: The first batch that exceeds the maximum slump specified by $\frac{1}{2}$ inch or less, will be accepted at full price. The first batch that exceeds the maximum slump specified by more than $\frac{1}{2}$ inch and up to 1 inch, which the Contractor elects to place, will be accepted at a reduced price. The second and third successive batches of a series that exceed the maximum slump specified by 1 inch or less, which the Contractor elects to place, will be accepted at a reduced

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price. The fourth and all other successive batches of a series that exceed the maximum slump specified shall be rejected. The rejected batch count will stop with a batch that has less than the maximum slump, and will resume at one with the next batch that exceeds the maximum slump.

- (c) *Strength (When Specified)*. The concrete will be considered acceptable when the running average of three consecutive strength tests is equal to or greater than the specified strength and no single test falls below the specified strength by more than 500 psi. A test is defined as the average strength of three test cylinders cast in plastic molds from a single sample of concrete and cured under standard laboratory conditions prior to testing. If the compressive strength of any one test cylinder differs from the average by more than 10 percent that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two test cylinders.

When the average of three consecutive strength tests is below the specified strength, the individual low tests will be used to determine the pay factor in accordance with Table 601-3. If less than three strength tests are available the individual low tests, if any, will be used to determine the pay factor in accordance with Table 601-3. The pay factor will be applied to the quantity of concrete represented by the individual low test. For concrete having a specified strength of less than 4500 psi, when the compressive strength test is below the specified strength by more than 500 psi, the concrete represented will be rejected. For concrete having specified strength of 4500 psi or greater, when the compressive strength test is below the specified strength by more than 500 psi but not more than 1000 psi, the concrete represented will be evaluated by the Department for removal, corrective action, or acceptance at a reduced price. All costs of the evaluation shall be at the Contractor's expense. When the compressive strength test is below the specified strength by more than 1000 psi, the concrete represented will be rejected.

The Contractor may take cores at its own expense and in accordance with Colorado Procedure 65 to provide an alternative determination of strength. Price reduction for strength will be based on the 28 day compressive strength of acceptance cylinders or corresponding cores strength, whichever is greater.

Class HT concrete overlays shall not be opened to traffic, including construction traffic, for at least 14 days after placement. At the Engineer's discretion, the overlay may be opened to construction traffic sooner than 14 days but not until after the curing period has elapsed and the average strength of two field cured cylinders has reached 4500 psi. The field cured cylinders shall be made in accordance with AASHTO T 23 Making and Curing Concrete Test Specimens in the Field.

- (d) *Pay Factors*. The pay factor for concrete which is allowed to remain in place at a reduced price shall be according to Table 601-3 and shall be applied to the unit price bid for Item 601, Structural Concrete.

If deviations occur in air content, slump, and strength within the same batch, the pay factor for the batch shall be the product of the individual pay factors.

**Table 601-3
PAY FACTORS**

* Percent Total Air Deviations From Specified Air (Percent)	Slump		Strength							
	Pay Factor (Percent)	Maximum Slump Exceeded by (Inches)	Below Specified Strength (psi) [< 4500 psi Concrete]	Pay Factor (Percent)	Below Specified Strength (psi) [≥ 4500 psi Concrete]					
0.0-0.2	98	¼	1-100	98	1-100					
0.3-0.4	96	½	101-200	96	101-200					
0.5-0.6	92	¾	201-300	92	201-300					
0.7-0.8	84	1	301-400	84	301-400					
0.9-1.0	75	Over 1	401-500	75	401-500					
Over 1.0	Reject		Over 500	Reject						
*Class D bridge deck concrete with air content over 8% will be rejected.										
									65	501-600
									54	601-700
									42	701-800
									29	801-900
			15	901-1000						
			Reject	Reject	Over 1000					

601.17

- (e) *Bonding of Bridge Deck Overlay.* After the curing period for Class DT and HT concrete has elapsed, the overlay shall be “sounded” by the Contractor in accordance with ASTM D 4580 Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding to determine if the Class DT and HT concrete has bonded to the bridge deck. In areas where the Class DT and HT concrete has not bonded to the bridge deck, it shall be removed and replaced at the Contractors expense.

601.18 Unless otherwise stated in the plans or specifications, tolerances for concrete construction and materials shall be in accordance with ACI 117.

Cast in place bridge decks and bridge slabs shall be no more than ½ inch thicker nor more than ¼ inch thinner than the cross-sectional vertical dimension shown on the plans.

METHOD OF MEASUREMENT

601.19 Concrete will be measured by the cubic yard in accordance with the dimensions shown on the plans. Plan quantities reflect deductions for all voids designed into the structure except, deductions will not be made for the volume occupied by pipes or conduits less than 3 inches in diameter, ducts for pre-stressing steel, reinforcing steel, anchors, weep holes, piling, and form liner textures and nominal chamfers.

Concrete of the various classes will not be remeasured, but will be the quantities shown on the plans. Exceptions for each class for each structure will be: (1) when field changes are ordered, or (2) when it is determined that there are discrepancies on the plans in an amount plus or minus 2 percent of the plan quantity for the structure.

Class 5 finish will be measured by the square foot, without deduction for areas occupied by bridge rail base plates, other anchorages, or weep holes. Class 5 finish will not be remeasured but will be the quantity shown on the plans. Exceptions for each structure will be: (1) when field changes are ordered, or (2) when it is determined that there are discrepancies on the plans in an amount plus or minus 2 percent of the plan quantity for the structure.

Bridge concrete shall consist of structural concrete, of the designated class, required for bridge construction shown on the plans, completed and accepted.

Box culvert concrete shall consist of structural concrete, of the designated class, required for concrete box culvert construction including wingwalls, shown on the plans, completed and accepted.

Wall concrete shall consist of reinforced structural concrete, of the designated class, required for the construction of walls which are not part of bridges or box culverts, completed and accepted.

Miscellaneous concrete shall consist of the structural concrete of the designated class shown on the plans, except bridge, box culvert or wall concrete, completed and accepted.

Bridge Deck Finish (Sawed Grooves) will be measured by the square yard. The area includes the length of the bridge and approach slabs, with deductions for areas occupied by expansion devices as specified, multiplied by the width of the roadway between the faces of curb or bridge rail on each side, less 3.0 feet. Bridge Deck Finish (Sawed Grooves) will not be remeasured but will be the quantity shown on the plans. Exceptions for each structure will be: (1) when field changes are ordered, or (2) when it is determined that there are discrepancies on the plans in an amount of plus or minus 2 percent of the plan quantity for the structure.

When permanent deck forms are optional, bridge deck concrete and reinforcing steel shown on the plans, which are based on a conventionally reinforced deck, will be paid for in accordance with Sections 601 and 602, under Pay Item 601, Structural Concrete, and Pay Item 602, Reinforcing Steel. Quantities of bridge deck concrete and reinforcing steel will not be remeasured, but will be the quantities shown on the plans, except when a plan change is ordered or when it is determined that there are discrepancies in an amount of plus or minus 2 percent of the plan quantity.

When permanent deck forms are required, bridge deck concrete and reinforcing steel will be paid for in accordance with Section 601 and 602, under Pay Item 601, Structural Concrete, and Pay Item 602, Reinforcing Steel. Quantities of bridge deck concrete and reinforcing steel will not be remeasured, but will be the quantities shown on the plans, except when a plan change is ordered or when it is determined that there are discrepancies in an amount of plus or minus 2 percent of the plan quantity.

When precast panel deck forms are required, they will be measured and paid for in accordance with Section 618. Concrete and all reinforcing or prestressing steel required for the panels will not be measured and paid for separately, but shall be included in the work.

Structural Concrete Coating will not be remeasured but shall be the surface area quantity shown on the plans; except that measurements will be made when field changes are ordered, or for an error of plus or minus 5 percent of the plan quantity for each structure to be coated.

Maturity meters, thermocouples and information cylinders will not be measured and paid for separately, but shall be included in the work.

BASIS OF PAYMENT

601.20 The accepted quantities will be paid for at the contract unit price per unit of measurement for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

601.20

Pay Item	Pay Unit
Concrete, Class ____ (Bridge)	Cubic Yard
Concrete, Class ____ (Box Culvert)	Cubic Yard
Concrete, Class ____ (Wall)	Cubic Yard
Concrete, Class ____ (Miscellaneous)	Cubic Yard
Class 5 Finish	Square Foot
Bridge Deck Finish (Sawed Grooves)	Square Yard
Structural Concrete Coating	Square Yard

Payment will be full compensation for all work necessary to complete the designated Pay Item in accordance with subsection 109.02.

Payment for structural concrete coating will be full compensation for all work and materials necessary to complete the item and shall include, but is not limited to:

- (1) Water based form release agent.
- (2) Sample preparation.
- (3) Abrasive blasting.
- (4) Patching materials and application.
- (5) Structural Concrete Coating and application.

When requested by the Engineer, the Contractor shall provide the Engineer with a certified invoice from the coating supplier indicating the total volume of Structural Concrete Coating supplied to the project.

Epoxy bond material when specified on the plans will not be paid for separately but shall be included in the work.

When permanent steel bridge deck forms are specified or allowed by the Contract, they will not be paid for separately but shall be included in the work, including all labor and additional concrete and other materials required to use these forms.

Preparation of designated surfaces for application of Class 5 finish will not be paid for separately but shall be included in the work. Concrete finish is included in the work unless a separate pay item is included in the bid schedule.

SECTION 602 REINFORCING STEEL

DESCRIPTION

602.01 This work consists of furnishing and placing reinforcing steel in accordance with these specifications and in conformity with the plans.

MATERIALS

602.02 Reinforcing steel and welded wire fabric that will be furnished either uncoated or epoxy coated shall meet the requirements of subsection 709.01. The coating material shall be a light colored powdered epoxy resin which will highlight rusting of untreated bar areas.

Reinforcing steel that requires welding shall conform to ASTM A 706. Welding shall be done in accordance with ANSI/AWS D1.4.

All accessories, including reinforcing steel supports, ties, and splicers used in conjunction with epoxy coated reinforcing steel, shall be plastic or epoxy coated.

Reinforcing steel not identified on the plans as epoxy coated may be supplied as epoxy coated, at the Contractor's option, at no additional cost to the Department. Length of lap splices for epoxy coated reinforcing steel shall be in accordance with *AASHTO Standard Specifications for Highway Bridges*, unless otherwise specified.

CONSTRUCTION REQUIREMENTS

602.03 Bar List. Two copies of a list of all reinforcing steel and bending diagrams shall be furnished to the Engineer at the site of the work at least one week before the placing of reinforcing steel is begun. Such lists will not be reviewed for accuracy. The Contractor shall be responsible for the accuracy of the lists and for furnishing and placing all reinforcing steel in accordance with the details shown on the plans.

Bar lists and bending diagrams which are included on the plans, do not have to be furnished by the Contractor. When bar lists and bending diagrams are included on the plans, they are intended for estimating approximate quantities. The Contractor shall verify the quantity, size and shape of the bar reinforcement against those shown on the plans and make all necessary corrections before ordering.

602.04 Protection of Materials. Reinforcing steel and its epoxy coating shall be protected at all times from damage. When placed in the work, the reinforcing steel shall be free from dirt, loose mill scale, paint, oil, loose rust, or other foreign substance.

602.05 Bending. Unless otherwise permitted, all reinforcing bars shall be bent cold. Bars partially embedded in concrete shall not be field bent except as shown on plans or permitted. Bars shall not be bent or straightened in a manner that will injure the material or the epoxy coating. Should the Engineer approve the application of heat for

602.05

field bending reinforcing bars, precautions shall be taken to assure that the physical properties of the steel will not be materially altered.

Hooks and bends shall conform to the provisions of the AASHTO *Standard Specifications for Highway Bridges*.

Bars which are shown as “hooked” on the plans shall have “standard hooks” unless otherwise indicated. The term “standard hook” as used herein shall mean one of the following:

- (1) A 180 degree turn plus an extension of four bar diameters but not less than 2½ inches at the free end of the bar, or
- (2) A 90 degree turn plus an extension of 12 bar diameters at the free end of the bar, or
- (3) For stirrup and tie anchorage only
 - (i) No. 5 bar and smaller, 90 degree turn plus an extension of six bar diameters at the free end of the bar.
 - (ii) No. 6, 7, and 8 bar, 90 degree turn plus an extension of 12 bar diameters at the free end of the bar.
 - (iii) No. 8 bar and smaller, 135 degree turn plus an extension of six bar diameters at the free end of the bar.

The inside diameter of bend measured on the inside of the bar, other than for stirrups and ties, shall be as follows:

Bar Size	Grade60
No. 3 thru No. 8	6 bar dia.
No. 9, No. 10, and No. 11	8 bar dia.
No. 14, and No. 18	10 bar dia.

The inside diameter of bend for stirrups and ties shall not be less than four bar diameters for sizes No. 5 and smaller, and five bar diameters for No. 6 to No. 8 inclusive.

Inside diameter of bend in welded wire fabric, smooth or deformed, shall not be less than four wire diameters for deformed wire larger than D6 and two wire diameters for all other wires. Bends with inside diameter of less than eight wire diameters shall not be less than four wire diameters from the nearest welded intersection.

602.06 Placing and Fastening. The minimum spacing center to center of parallel bars shall be 2½ times the diameter of the bar. However, the clear distance between the bars shall not be less than 1½ times the maximum size of the coarse aggregate or 1½ inches, whichever is greater.

Bundle bars shall be tied together at not more than 6 foot centers.

All reinforcement shall have a clear coverage of 2 inches, except as shown on the plans. Clear coverage shall be measured from the surface of the concrete to the outside of the reinforcement.

Reinforcement used in post-tensioned concrete shall be adjusted or relocated during the installation of prestressing ducts or tendons, as required, to provide location and planned clearances to the prestressing tendons, anchorages, jacks and equipment as approved by the Engineer.

All reinforcement shall be tied at all intersections except where spacing is less than 1 foot in each direction, in which case alternate intersections shall be tied.

In concrete bridge decks the upper mat of bars shall be tied to the lower mat of bars at 4 foot maximum spacing in each direction. Slab bolsters for the bottom mat and high chairs for the top mat shall each be placed at a maximum spacing of 4 feet on centers.

Welding on reinforcing bars will not be permitted except as noted on the plans. Reinforcement placed in any member shall be inspected and approved before any concrete is placed.

The placing, fastening, splicing and supporting of reinforcing steel and wire mesh or bar mat reinforcement shall be in accordance with the plans and the latest edition of "CRSI Recommended Practice for Placing Reinforcing Bars." In case of discrepancy between the plans and the CRSI publication stated above, the plans shall govern. Automated tie wire devices may be used. The total cross-sectional area of the automated tie wire wrap shall roughly equal the total cross-sectional area of a manually installed tie wire wrap. The tie wire shall be epoxy coated or plastic coated for use with epoxy coated reinforcing steel. All epoxy coating on the reinforcing steel that is damaged from the use of automated tie wire devices shall be repaired at the Contractor's expense.

Precast concrete blocking or other approved blocking material shall be used to support footing bars and bars in slabs on grade. All other reinforcing steel shall be supported with steel chairs or precast mortar blocks. All chairs coming in contact with forms shall be CRSI Class 1 or Class 2, Type B.

The location of splices, except where shown on the plans, shall be based upon using 60 foot stock length bars for No. 6 bars and larger and 40 foot stock length bars for No. 4 and No. 5 bars (this does not preclude the use of 60 foot). Minimum splice lengths are as shown on the plans. Where bars of different size are spliced together, the splice length for the smaller bar will govern.

Unless otherwise shown on the plans or approved, splices in adjacent lines of reinforcing bars shall be staggered. The minimum distance between staggered splices for reinforcing bars shall be the length required for a lapped splice in the bar.

Lapped splices will be permitted only at locations where the concrete section is sufficient to provide a minimum clear distance of 2 inches between the splice and the nearest adjacent bar. The clearance to the surface of the concrete shall not be reduced.

Reinforcing bars may be continuous at locations where splices are shown on the plans. Reinforcing bars No. 14 and No. 18 shall not be spliced by lapping, but shall be

602.06

joined by butt welding in accordance with AWS D1.4 in such a way as to develop at least 125 percent of the specified yield strength of the bar in both tension and compression. Alternate systems of welding or mechanical butt splices may be submitted for approval.

Epoxy coated bars shall be placed on plastic supports or steel supports fully coated with plastic or epoxy. Care shall be taken to prevent coated bars from coming into contact with other steel items.

METHOD OF MEASUREMENT

602.07 The weight of reinforcing steel for payment will not be measured but shall be the quantities designated in the Contract; except, measurements will be made for revisions requested by the Engineer, or for an error of plus or minus 2 percent of the total weight shown on the plans for each structure.

Prospective bidders shall verify the weight of reinforcing steel before submitting a proposal. Adjustment will not be made in the weight shown on the plans, other than for approved design changes or for an error as stipulated above, even though the actual weight may deviate from the plan weight.

The computed weight of epoxy coated reinforcing bars will be based on the nominal weight before application of the epoxy coating. Nominal weights for various bar sizes are shown below.

Bar Size	Weight per Linear Foot in Pounds	Bar Size	Weight per Linear Foot in Pounds
¼ inch	0.167	No. 8	2.670
No. 3	0.376	No. 9	3.400
No. 4	0.668	No. 10	4.303
No. 5	1.043	No. 11	5.313
No. 6	1.502	No. 14	7.650
No. 7	2.044	No. 18	13.600

BASIS OF PAYMENT

602.08 The accepted quantities of reinforcing steel will be paid for at the contract unit price per pound. No allowance will be made for supports, clips, wire or other material used for fastening reinforcement in place.

Payment will be made under:

Pay Item	Pay Unit
Reinforcing Steel	Pound
Reinforcing Steel (Epoxy Coated)	Pound

SECTION 603 CULVERTS AND SEWERS

DESCRIPTION

603.01 This work consists of the construction of culverts, storm drains, and sanitary sewers hereinafter referred to as “conduit,” and nestable semicircular pipe for encasement in accordance with these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

603.02 Materials shall meet the requirements shown on the plans and in the following subsections:

Corrugated Steel Pipe and Pipe Arches	707.02
Corrugated Steel Pipe Nestable	707.02
Corrugated Aluminum Pipe	707.06
Reinforced Concrete Pipe	706.02
Nonreinforced Concrete Pipe	706.01
Pipe Joint Sealing Compounds	705.04
Plastic Pipe	712.13
Vitrified Clay Pipe	706.06
Ductile Iron Pipe	707.01
Gaskets	705.03
Resilient Compression Ring Material	705.05
Reinforced Concrete Pipe (Jacked)	706.02

Plastic end sections shall not be used. When plastic pipe is to be installed with end sections, steel end sections conforming to Standard Plan M-603-10 shall be used.

CONSTRUCTION REQUIREMENTS

603.03 General. Pipe shall be protected during handling against impact shocks and free fall.

When new sanitary sewer facilities interfere with the existing flow of sewage, the Contractor shall provide satisfactory bypass facilities at no expense to the Department.

Sanitary sewers and all appurtenances shall be thoroughly cleaned before final acceptance of this work.

603.04 Excavation. Trenches shall be excavated in accordance with the requirements of Section 206 to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill material under and around the conduit.

The completed trench bottom shall be firm for its full length and width. The trench for cross drains shall have a minimum longitudinal camber of 1 percent of the length of the pipe. Camber may be increased to suit height of fill and supporting soil.

603.04

When conduits are to be installed in new embankments, the embankment shall first be constructed to the required height of at least 0.3 times the outside diameter or raise of the conduit, and for a distance each side of the conduit location of not less than 5 times the diameter or span of the conduit, after which the trench shall be excavated and the conduit installed.

Excavation shall be by open cut from the surface, except when pipe jacking is specified or directed in writing by the Engineer.

When pipe is to be jacked, trenching will not be permitted. Pipe must be jacked without disrupting traffic. Methods of installing pipe other than by jacking may be used only with written approval from the Engineer. Methods that may cause damage to the embankment or roadway area will not be approved. Damage to the pipe or installation area caused by jacking operations shall be repaired or replaced at the Contractor's expense. The area around the outer surface of the pipe shall be thoroughly grouted. The grout mixture shall consist of one part portland cement and three parts of fine aggregate by volume, or it may be determined by prior documented experience with similar materials, equipment, and field conditions. The grout shall be thoroughly mixed with the minimum quantity of water needed to obtain the proper consistency for the existing soil conditions.

603.05 Bedding for Concrete or Clay Conduit. Bedding shall be prepared in accordance with details as shown on the plans. The bed shall consist of a layer of loose structure backfill not less than 3 inches in thickness. Recesses shall be made to accommodate the bell of bell-and-spigot pipe. Adjustments to line and grade shall be made by scraping or filling under the body of the conduit. Wedging or blocking the bell will not be permitted.

603.06 Placing Conduit. The conduit laying shall begin at the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the prepared bedding throughout its full length. Bell or groove ends of concrete or clay conduits and outside circumferential laps of metal or plastic conduits shall be placed facing upstream.

Paved or partially lined conduit shall be placed so that the longitudinal center line of the paved segment coincides with the flow line.

Elliptical shaped pipe and circular pipe with elliptical reinforcement shall have the top clearly marked with paint or with imprinted letters and with lifting eye holes in which laying pins can be used. Holes shall be finished smooth with grout or with plugs. Conduits shall be placed with the vertical axis within five degrees of a vertical plane through the longitudinal axis of the conduit.

603.07 Joining Conduit.

- (a) *Concrete or Clay Conduit.* Conduit sections shall be joined in such manner that the ends are fully entered and the inner surfaces are reasonably flush and even.

At locations where rubber gaskets are specified in the Contract for conduits used for storm drains and cross culverts, rubber gaskets conforming to subsection 705.03 shall be used. At locations where the type of joint is not otherwise specified in the Contract for conduit used for storm drains and cross culverts, joints shall be made with joint sealing compound. Primer shall be furnished when recommended by the manufacturer of the joint sealing compound. Primer shall conform to and shall be applied in accordance with the manufacturer's recommendations to both surfaces of the conduit sections being joined, for the full circumference. Sealing compound shall be applied according to the manufacturer's recommendations. When a specific type of sealing compound is desired, it shall be as shown in the Contract.

Rubber gaskets conforming to subsection 705.03 shall be used for concrete pipe sanitary sewer joints.

Resilient pressure ring material conforming to subsection 705.05 shall be used for clay pipe sewer joints.

- (b) *Metal Conduit.* Corrugated metal pipe sections shall be placed and aligned to within $\frac{3}{4}$ inch of the adjacent section and shall be firmly joined with either one-piece or two-piece coupling bands. Pipe with helical corrugations shall be joined with the corrugations matched across the joints and with all corrugations of the pipe completely engaged by the corrugations or dimples of the coupling band.

Where existing corrugated metal pipe culverts are to be extended, damaged ends shall be cut off or repaired in an approved manner. All ends of pipes requiring extensions shall be cleaned within the area necessary for proper installation of connecting bands.

Arch culverts shall be extended with pipe having a compatible arch shape.

When special joint treatment is called for on the plans to prevent infiltration or exfiltration, the joints shall be made using a sealing compound conforming to subsection 705.04, with the connecting band.

- (c) *Plastic Conduit.* Couplings shall be as recommended by the conduit manufacturer.

603.08 Elongation. Where required by the plans, round metal and plastic conduit shall be preformed to an elliptical shape by elongating the vertical axis 5 percent.

603.09 Backfilling. After the conduit or section of conduit is installed, it shall be inspected before any backfill is placed. Conduit found to be damaged shall be replaced, and conduit found to be out of alignment or unduly settled shall be taken up and relaid. The trench shall then be backfilled with material in accordance with Section 206.

Sanitary sewer lines, when completed, shall be tested for water-tightness before any backfill is placed. The installation shall not show infiltration or exfiltration in

603.09

excess of 0.6 gallon per inch of internal pipe diameter per 100 feet of sewer line per hour when tested at 10 psi by hydraulic means. Testing of joints shall be performed by the Contractor in accordance with approved methods. Should any section of the sewer line fail to meet the test requirements, it shall be corrected at the Contractor's expense.

Special care shall be taken when backfilling around conduit to bring the backfill materials up on both sides of the conduit, evenly and simultaneously. Protection of conduits during construction shall be the Contractor's responsibility. Damage to the conduit due to Contractor's operations shall be repaired or replaced at the Contractor's expense.

Trenches in existing streets, except streets which are to be closed or abandoned, shall be resurfaced as soon as practicable with the type and thickness of bases and pavement shown in the Contract or as designated.

603.10 Repair of Damaged Culvert. Coating on corrugated steel pipe and pipe arches, and corrugated steel pipe nestable shall be repaired in accordance with the provisions of subsection 707.09. Damaged pipe shall not be repaired. The Engineer will determine when the pipe is either acceptable or unacceptable in accordance with the provisions of subsection 105.03. Unacceptable pipe shall be removed and replaced.

METHOD OF MEASUREMENT

603.11 Conduit used for culverts and storm drains of the different types and sizes and corrugated steel pipe nestable will not be measured but will be the net length of pipe called for on the plans, except when field changes are ordered or when there are errors on the plans. In case of exceptions, the quantity to be measured shall be the actual net length of conduit measured along the bottom centerline. Extra length of conduit due to joint creep will not be measured and paid for. Corrugated steel pipe nestable used for encasement will be measured as complete circular pipe.

Jacked pipe will be measured by the linear foot complete in place and accepted. Structure excavation, structure backfill, grout materials, and grouting operation for jacked pipe will not be measured and paid for separately but shall be included in the work.

End sections will be measured by the number of units installed.

The size designation of metal pipe arch and metal pipe arch end section shall refer to the diameter of round pipe normally used to fabricate the pipe arch or the pipe portion of the end section.

Relaid pipe will be measured and paid for in accordance with Section 210.

BASIS OF PAYMENT

603.12 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule. Except as otherwise indicated on the plans or in the special provisions, all joints, elbows, concrete collars, connecting bands and other connecting devices will not be paid for separately but shall be included in the work.

Payment will be made under:

Pay Item	Pay Unit
___ Inch Corrugated Steel Pipe	Linear Foot
___ Inch Corrugated Steel Pipe Nestable	Linear Foot
___ Inch Steel End Section	Each
___ Inch Equiv. Corrugated Steel Pipe Arch	Linear Foot
___ Inch Equiv. Arch Steel End Section	Each
___ Inch Corrugated Aluminum Pipe	Linear Foot
___ Inch Aluminum End Section	Each
___ Inch Equiv. Corrugated Aluminum Pipe Arch	Linear Foot
___ Inch Equiv. Arch Aluminum End Section	Each
___ Inch Reinforced Concrete Pipe	Linear Foot
___ Inch Reinforced Concrete End Section	Each
___ Inch Nonreinforced Concrete Pipe	Linear Foot
___ Inch x ___ Inch Reinforced Concrete Pipe Elliptical	Linear Foot
___ Inch x ___ Inch Reinforced Concrete End Section Elliptical	Each
___ Inch Vitrified Clay Pipe	Linear Foot
___ Inch Cast Iron Pipe	Linear Foot
___ Inch Plastic Pipe	Linear Foot
___ Inch Reinforced Concrete Pipe (Jacked)	Linear Foot
___ Foot x ___ Foot Concrete Box Culvert (Precast)	Linear Foot

Structure excavation and structure backfill will be measured and paid for in accordance with Section 206 except that any void in the structure excavation prism created by the removal of pipe or box culvert will be excluded from measurement and payment of structure excavation.

Repair of damaged coatings will not be paid for separately but shall be included in the cost of the item.

604.01

**SECTION 604
MANHOLES, INLETS,
AND METER VAULTS**

DESCRIPTION

604.01 This work consists of the construction of manholes, inlets, and meter vaults in accordance with these specifications, and in conformity with the lines and grades shown on the plans or established.

MATERIALS

604.02 Concrete for these structures shall meet the requirements of Section 601.

Other materials shall meet the requirements specified in the following subsections:

Clay or Shale Brick	704.01
Concrete Brick	704.02
Concrete Masonry Blocks	704.03
Frames, Grates, Covers, and Steps	712.06
Grade Ring	712.05
Reinforcing Steel	709.01
Precast Concrete Units	712.05

CONSTRUCTION REQUIREMENTS

604.03 Excavation. Excavation shall be in accordance with the requirements of Section 206.

604.04 Manholes, Inlets, and Meter Vaults.

- (a) *General.* Concrete construction shall conform to the requirements of Section 601. Masonry shall conform to the requirements for the respective type. When specified, the outside face of structures shall be plastered with a ½ inch thick cement-sand mortar coat. Unless otherwise provided, exposed surfaces of concrete and masonry shall be cured as defined in subsection 601.13.

Pipe sections on the inside of manholes or inlets shall be treated as shown on the plans, or as directed, and shall project outside sufficiently for proper connection with next pipe section. Masonry shall fit neatly and tightly around the pipe.

- (b) *Manholes.* Wherever directed by the Engineer, pipes of the proper type and size shall be built into a manhole where future laterals are to be connected. These pipes shall be sealed at their outer ends and an invert shall be built into each manhole for such lateral connections.

When a manhole is located in the pavement area, it shall not be constructed to final grade until the pavement has been completed.

- (c) *Inlets.* Where inlets are placed in existing curbs or gutters, the Contractor shall carefully remove sections of present curb, gutter, or curb and gutter. All damage

to sections to remain in place shall be repaired at the Contractor's expense. The top portion of inlets shall be constructed concurrently with the adjacent curb and gutter to insure proper alignment of grades unless otherwise permitted in writing.

- (d) *Meter Vaults.* Meter vaults shall be of sufficient size to properly accommodate the size of the meter installed including regulatory devices or fittings required for the utility supplied. Provisions for grounding, ventilation, drainage or other safety precautions shall be constructed as required. Meter vaults may be cast-in-place or precast and shall conform to the rules and regulations for the utility service supplied in the vault.
- (e) *Brick Masonry.* All bricks shall be thoroughly wetted, before being laid, either by immersion or in a manner satisfactory to the Engineer.

Special care shall be taken to make the face of the brick work smooth. All joints on the interior surface of the manholes and appurtenances shall be carefully struck.

Brick shall not be laid upon a concrete foundation until the concrete has set.

604.05 Backfilling. Unless otherwise directed, all excavations shall be backfilled immediately after the structures are built. Backfilling shall conform with Section 206 and as shown on the plans.

Resurfacing. Excavations in existing streets, except streets which are to be closed or abandoned, shall be resurfaced as soon as practicable with the type and thickness of bases and pavement shown on the plans or as designated.

Cleaning. The structures and all appurtenances shall be thoroughly cleaned before final acceptance of the work.

When the new facilities interfere with the existing flow of sewage, the Contractor shall provide satisfactory bypass facilities at the Contractor's expense.

METHOD OF MEASUREMENT

604.06 Manholes and inlets will be measured by the complete unit including ring and cover or grating and frame.

Manhole ring and cover used separately will be measured by the unit.

Inlet grating and frame used separately will be measured by the unit.

Manhole and inlet depth, "H," will be measured as shown on the plans. Measured depth and pay depth of manholes and inlets shall conform to the following.

604.06

Measured Depth	Pay Depth
0.0 to 5.0 feet	5 feet
5.1 to 10.0 feet	10 feet
10.1 to 15.0 feet	15 feet

(continued thus)

Meter vaults will be measured by the complete unit including ring and cover.

Structure excavation and structure backfill for manholes, inlets, and meter vaults will not be measured and paid for separately but shall be included in the work.

BASIS OF PAYMENT

604.07 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule. Except as otherwise indicated on the plans or in the special provisions, all connecting devices will not be measured and paid for separately but shall be included in the work.

Payment will be made under:

Pay Item	Pay Unit
Meter Vault	Each
Manhole _____ (_____)	Each
Inlet, Type _____ (_____Foot)	Each
Manhole Ring and Cover	Each
____ Inlet Grating and Frame	Each

SECTION 605 SUBSURFACE DRAINS

DESCRIPTION

605.01 This work consists of constructing underdrains, edge drains, geocomposite drains, and french drains, in accordance with these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

605.02 Materials shall meet the requirements specified in the following subsections:

Corrugated Steel Pipe	707.04
Bituminous Coated Corrugated Steel Pipe	707.05
Drain Tile	706.04
Vitrified Clay Pipe	706.06
Corrugated Aluminum Pipe	707.07
Plastic Pipe	712.11
Gaskets	705.03
Filter Material	703.09
Geotextiles	712.08
Geocomposite Drains	712.12

Pipe for subsurface drains shall be any type of pipe material listed above. When corrosion resistant pipe is specified on the plans, the materials shall conform to the requirements of Section 624 for the corrosion resistance number specified.

Subsurface drain outlet pipe may be perforated or nonperforated, and shall meet the requirements specified in subsections 707.04, 707.05, 707.07, or 712.11.

CONSTRUCTION REQUIREMENTS

605.03 Pipe Underdrain and Pipe Edge Drain. The trench shall be excavated to the dimensions and grade shown on the plans. Sufficient Geotextile (Drainage) (Class B) shall be placed along the bottom and sides of the trench as shown on the plans to provide the required overlap over the top of the filter material. Filter material of the class designated on the plans shall be placed in the bottom of the trench for its full width and length.

Perforated pipe shall be placed with the perforations down and the pipe sections shall be joined securely with the appropriate coupling fittings or bands. Joining shall conform to the applicable requirements of subsection 603.07 except as noted above.

After the pipe installation has been inspected and approved, the designated filter material shall be placed to a height of 12 inches above the top of pipe. Care shall be taken not to displace the pipe or the covering at open joints. The remainder of the filter material shall then be placed to the required height, the drainage geotextile folded over the top of the filter material, and the remainder of the trench backfilled.

605.04

605.04 Geocomposite Drains. The geocomposite drain for subsurface drainage behind a retaining wall shall be placed along the full length of the wall. It shall be attached to the wall with an approved adhesive or in accordance with the manufacturer's recommendations.

The trench for geocomposite underdrain and geocomposite edge drain, for subsurface drainage at pavement edge and elsewhere as specified on the plans, shall be excavated to the dimensions and grade shown on the plans. The geocomposite drain material shall then be placed along the downhill side, or the pavement side, of the trench and secured to the trench side.

Backfill shall be placed so as to avoid damage to the geocomposite drain material.

605.05 French Drain. The trench for french drain shall be excavated to the width and depth shown on the plans. The trench shall be lined with Geotextile (Drainage) (Class B) and filled with the designated filter material to the depth shown on the plans. The drainage geotextile shall be folded over the top of the filter material. Any remaining unfilled upper portion of trench shall be backfilled with embankment material.

605.06 Subsurface Drain Outlet. The trench for subsurface drain outlet shall be excavated to the width and depth necessary to place the pipe on a drainable grade, as shown on the plans or as directed. Pipe shall be laid in the trench with all ends joined securely with the appropriate couplings, fittings or bands. After inspection and approval of the pipe installation, the trench shall be backfilled and compacted in accordance with subsection 206.03.

Where the outlet pipe ends on a slope or ditch, it shall be constructed with an erosion control pad, and an animal guard. The location shall be marked with a delineator post that conforms to Section 612. The animal guard screen shall be held securely in place with a coupling or fastening band or by another approved method.

METHOD OF MEASUREMENT

605.07 Pipe underdrain and pipe edge drain will be measured by the linear foot of pipe of the size specified placed and accepted. French drain will be measured by the linear foot of trench excavated and filled with filter material and accepted. Geocomposite underdrain and geocomposite edge drain will be measured by the linear foot along the base of the geocomposite drain material for the full length installed and accepted. Geocomposite drain both with and without pipe will be measured by the square yard of geocomposite drain material placed on the vertical wall surface and accepted. Subsurface drain outlet will be measured by the linear foot of pipe placed and accepted from the end of a subsurface drain to the discharge end of the outlet pipe.

BASIS OF PAYMENT

605.08 The accepted quantities of subsurface drains will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

605.08

Pay Item	Pay Unit
___ Inch Perforated Pipe Underdrain	Linear Foot
French Drain	Linear Foot
Geocomposite Underdrain	Linear Foot
Geocomposite Drain without Pipe	Square Yard
Geocomposite Drain with Pipe	Square Yard
Geocomposite Edge Drain	Linear Foot
Pipe Edge Drain	Linear Foot
Subsurface Drain Outlet	Linear Foot

Payment shall be full compensation for all work and materials required to complete the item including drainage geotextile, drainage core, securing devices, adhesives, sewn seams, pipe, filter material, excavation, and backfill. Payment for subsurface drain outlet shall include the erosion control pad, the animal guard, and the delineator post.

606.01

SECTION 606 GUARDRAIL

DESCRIPTION

606.01 This work consists of the construction of guardrail in accordance with these specifications and in conformity with the lines and grades shown on the plans or established.

The construction of the various types of guardrail shall include the assembly and erection of all component parts and materials complete at the locations shown on the plans or as directed.

The types of guardrail are designated as follows:

Type 3 Guardrail - W Beam
Type 6 Guardrail - Thrie Beam
Type 7 Guardrail - F-Shape Concrete Barrier

Use of Type 4 Precast Concrete Barrier is not permitted.

MATERIALS

606.02 Materials shall meet the requirements specified in the following subsections:

"W" Beam Rail and Thrie Beam Rail	710.05
Guardrail Hardware	710.09
Guardrail Posts	710.08

Paint for field painting of guardrail shall conform to subsection 708.03, Structural Steel Bridge Paint.

Concrete for precast or cast-in-place barrier shall conform to the requirements of Section 601. Reinforcing steel, unless otherwise noted, shall conform to the requirements of Section 602. During production of slipformed barrier and subsequent to mix design approval the Contractor may adjust the mix proportion requirements as follows:

The range for air content may be adjusted to be 5 percent to 9 percent

The weights of coarse and fine aggregates may each be adjusted up to 10 percent.

These adjustments may be made at the Contractor's discretion and do not require approval of a revised mix design before use. The Contractor shall inform the Engineer in writing of each adjustment of aggregate proportions before concrete with the adjusted mix design is placed.

The Contractor may furnish either wood or steel posts and wood or FHWA approved synthetic material blocks for guardrail as shown on the plans. Except as designated on the plans, only one type of posts and blocks shall be furnished for the project.

Components on which the spelter coating has been burned by welding or otherwise damaged shall be either regalvanized, recoated in accordance with AASHTO M 36, or painted with one full brush coat of zinc rich paint meeting Military Specification DOD-P-21035A.

CONSTRUCTION REQUIREMENTS

606.03 Post and Rail Elements.

- (a) *Posts.* Posts shall be set firm and aligned with a tolerance of plus or minus $\frac{1}{4}$ inch from plumb, grades and lines as staked. All fittings and metal plates shall be placed securely in position to conform to designated dimensions and requirements.

Posts shall be set by one of the following methods:

- (1) Driven in place.
- (2) Set in dug holes.
- (3) Set in concrete base.
- (4) Posts on bridges shall be as shown on the plans.

Driving of posts shall be accomplished by methods and equipment that will leave the posts in their final position free from any distortion, burring or any other damage.

Excavated post holes shall have a firm bottom and be backfilled with acceptable material placed in layers and thoroughly compacted.

Dissimilar metal-to-metal or aluminum-to-concrete post or rail installations shall have contact surfaces separated by an approved protective coating.

Wood posts cut in the field shall have the cut surfaces protected with two coats of an approved preservative. When the cut surface is above ground, the treating solution to be used shall be the same type as was used in the original treatment.

- (b) *Rail.* Rail elements shall be erected in a manner resulting in a smooth, continuous installation. All bolts in the finished rail shall be drawn tight. Bolts shall be of sufficient length to extend beyond the nuts. Rail shall be shop bent for installations on horizontal curves having a radius of 150 feet or less.
- (c) *Temporary End Treatment.* In construction zones not closed to traffic, installation of rail element shall closely follow the setting of posts to keep the number of posts without rail at a minimum. When necessary to minimize potential hazards, the Engineer will specify the direction in which the rail installation is to advance and the number of posts installed ahead of rail installation. At the end of the Contractor's work day, the Contractor shall treat the ends of installed guardrail as follows:
- (1) If the end is at the location of a planned end section, install the end section.
 - (2) If the end is not at the location of a planned end section, the last rail section shall be installed with one end attached to the rail already in place and the

606.03

free end resting on the ground. The free end on the ground shall be restrained by tying the rail to the posts by ropes or cables. Guardrail shall not be left in this configuration more than 24 hours unless protected by an approved attenuating device.

606.04 Concrete. Where paving is removed or damaged due to the Contractor's operations, the Contractor shall furnish an acceptable mix and shall repair the paving as required, at the Contractor's expense.

In construction zones not closed to traffic, the Contractor shall treat the ends of installed concrete guardrail at the end of the work day as follows:

- (1) If the end is at the location of a planned end section, install the end section.
 - (2) If the end is not at the location of a planned end section, install a temporary impact attenuator or provide treatment as shown in the Contract.
- (a) *Permanent Concrete Barrier.* Permanent concrete barrier may be constructed by precast Type 7, cast-in-place or slipform methods. The trench for the base of the cast-in-place reinforced barrier end anchorages shall be excavated to the lines and grades shown on the plans or established. The bottom of the trench shall be compacted to the density specified in subsection 203.07 when tested according to AASHTO T 99. The compacted trench bottom shall be watered and approved before placing concrete. The 1 inch minimum deep keyway cut or formed in the pavement surface for the barrier base shall be cleaned and approved before placing concrete.

Concrete finish for all precast Type 7 barriers used as permanent installations, and all cast-in-place barriers shall be Class 1 in accordance with subsection 601.14. Slipform barriers shall not receive additional finishing unless permitted by the Engineer. Exposed vertical surfaces of slipformed barrier shall receive a vertical broom finish.

The Engineer may determine that the exposed surfaces of the guardrail shall be tested with a 10 foot straightedge laid along the exposed surface in a longitudinal direction. The Contractor shall furnish an approved 10 foot straightedge and provide an operator to aid the Engineer in testing the exposed surfaces. All surface tolerances shall be measured in a longitudinal direction. Deviation of any exposed surface in excess of the tolerance specified shall be corrected at the Contractor's expense.

Longitudinal surface tolerances for the top of the barrier and the sides of the barrier from the top to a line 7 inches below the top of the barrier are:

- (1) On tangent roadway alignments and curves with radius greater than 1000 feet: 0.25 inch from the edge of the straightedge.
- (2) On sharp vertical curves and horizontal curves with radius of 1000 feet or less: 0.25 inch from the edge of the straightedge with allowance made for curve deflection.

Longitudinal surface tolerances for the remaining surfaces of the barrier are:

- (1) On tangent roadway alignments and curves with radius greater than 1000 feet: 0.75 inch from the edge of the straightedge.
- (2) On sharp vertical curves and horizontal curves with radius of 1000 feet or less: 0.75 inch from the edge of the straightedge with allowance made for curve deflection.

The Contractor will be allowed a maximum of three days of slipform production if barrier being placed does not meet the specified tolerances. After the third day of placement of out of tolerance slipform barrier the Contractor shall stop production. The Contractor shall submit a corrective action plan to the Engineer for review. The plan shall address corrective actions to the equipment and materials and a time frame for completion of the corrective actions. The plan shall address methods and materials to be used to correct out of tolerance barrier. Patching will not be allowed to correct out of tolerance barrier. Further placement of barrier will not be allowed until all previously placed barrier which failed to meet tolerances is corrected or removed. Each occurrence of out of tolerance slipform barrier shall be subject to the same corrective cycle.

- (b) *Precast Type 7 Concrete Barrier.* Precast Type 7 Concrete Barrier (conforming to Standard Plan M-606-14) may be formed upside down to minimize air pockets and improve surface finish. Concrete finish for precast barriers shall be Class 1 in accordance with subsection 601.14. Each segment of the precast barrier shall not have spalls, corner breaks, and bottom spalls totaling more than 5 square feet of surface area which includes the base.

Connecting loops shall not be frayed, stretched, or deformed. Gaps between units shall not exceed the dimensions shown in the plans. Precast barrier units shall not be lifted or stressed in any way before they have developed the strength of the concrete specified. Units shall be supported at designated pickup points. Connecting loops shall not be used as pickup points. Care shall be taken during fabrication, storage, handling and transporting to prevent cracking, twisting, or other damage. Minor chips on edges may be patched with the approval of the Engineer. Breakage and chipping may be cause for rejection. Units damaged in such a way as to impair their appearance or suitability, in the opinion of the Engineer, shall be replaced at the Contractor's expense. Units rejected by the Engineer shall be marked on both sides with an orange painted "R" approximately 12 inches high and 6 inches wide.

The base for placing precast barrier shall be prepared to the lines and grades shown on the plans or established. When it becomes necessary to connect cast-in-place barrier sections to precast barrier installations during construction, the cast-in-place sections shall be constructed complete with connecting hardware in accordance with Standard Plan M-606-14 to join the cast-in-place sections to the abutting precast sections. A ten foot transition section shall be provided when attaching barriers of differing shapes.

606.05

METHOD OF MEASUREMENT

606.05 Guardrail will be measured by the linear foot along the centerline of the rail from end to end of completed and accepted rail as shown on the plans, excluding end anchorages, median terminals, and transitions.

End anchorages, median terminals and transitions will be measured by the actual number placed and accepted. Each end anchorage, median terminal, or transition shall include all concrete, reinforcing steel, anchor bolts, cable, rods, turnbuckles, backing rail, plates, bolts, nuts, washers and all other work and material necessary to complete the item.

Posts will be included in the quantities of guardrail of the specified type and not measured separately. Additional posts required for guardrail adjacent to bridges and obstructions, as shown on the plans, will not be measured and paid for separately but shall be included in the work.

BASIS OF PAYMENT

606.06 The accepted quantities of guardrail will be paid for at the contract unit price for the type specified.

Payment will be made under:

Pay Item	Pay Unit
Guardrail, Type ___	Linear Foot
End Anchorage, Type ___	Each
Guardrail, Type ___ (___ Post Spacing)	Linear Foot
Median Terminal	Each
End Anchorage (___)	Each
Transition, Type ___	Each

All work and materials necessary and incidental to the temporary treatment of guardrail ends will not be measured and paid for separately but shall be included in the work.

Partial payments will not be made for partially completed guardrail runs that do not conform to the end treatments specified in subsections 606.03(c) or 606.04.

**SECTION 607
FENCES**

DESCRIPTION

607.01 This work consists of the construction of fence and gates, and removal of temporary plastic fence in accordance with these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

607.02 Materials shall meet the requirements specified in the following subsections:

Woven Wire	710.02
Barbed Wire	710.01
Chain Link Fabric	710.03
Fence Posts	710.07
Snow Fence	710.04
Timber for Wood Sound Barrier	710.06

Reinforcing steel shall conform to Section 602.
Concrete shall conform to Section 601.

Foundation concrete for fence posts, braces, anchors and gates shall be Class B. Concrete with lightweight aggregates conforming to ASTM C 330 will be permitted. Field mixed concrete consisting of a minimum of one part cement to six parts of aggregate by volume may be used in lieu of Class B if approved.

Fence (Plastic) shall be orange colored material, at least 4 feet in height.

CONSTRUCTION REQUIREMENTS

607.03 The Contractor shall perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment.

Right of Way fence shall be constructed approximately 6 inches inside the boundary of the highway right of way shown on the plans or as staked. Anchorages, footings or fence appurtenances shall not extend beyond the limits of the highway right of way without the written consent of the abutting property owner.

At locations where breaks in a run of fencing are required, at intersections with existing fences, or at ditch, canal, or channel crossings, appropriate adjustments in fence alignment and post spacing shall be made to satisfy the requirements for the type of closure indicated or the conditions encountered.

When the plans require that posts, braces or anchors be embedded in concrete, they shall be securely braced to hold the posts in proper position until such time as the concrete has set sufficiently to hold the posts. Unless otherwise permitted, materials shall not be installed on posts, or stress placed on guys and bracing set in concrete until the concrete has set sufficiently to withstand the stress.

607.03

The tops of all posts shall be set to the required grade and alignment. Cutting of the tops or bottoms of treated timber posts will be allowed only with the approval of the Engineer. Posts cut in the field shall have the cut surfaces protected with two coats of an approved wood preservative.

Wire or fencing of the size and type required shall be firmly attached to the posts and braces in the manner indicated. All wire shall be stretched taut and be installed to the required spacing.

Wood sound barrier fence shall be constructed according to the details shown on the plans. All fence boards shall be tightly butted to minimize cracks.

Fence (Plastic) shall be placed as shown on the plans or as directed to define the limits of the work area beyond which no access is allowed to the surrounding wetlands or vegetation to be protected.

METHOD OF MEASUREMENT

607.04 Fence will be measured by the linear foot. Measurement will be along the base of the fence from outside to outside of end posts for each continuous run of fence including length of barbed wire gates, but excluding the length of driveway gates and walk gates.

Driveway gates and walk gates will be measured as complete units of the size and type specified. Gates shall be the same type and height as the adjacent fence unless otherwise designated.

End posts, corner posts and line brace posts required for chain link fence, barbed wire and combination wire fence will be measured by the actual number used.

End posts, corner posts and line brace posts for snow fence or barrier fence will not be measured and paid for separately but shall be included in the work.

Line posts required for reset fence will be measured by the actual number used.

Line posts required for new fence will not be measured separately, but shall be included in the contract unit price for new fence.

End Posts Special, Corner Posts Special, and Line Brace Posts Special required for Fence (Deer) will be measured by the actual number used.

Fence Wood (Sound Barrier) will be measured by the linear foot.

Fence (Plastic) will be measured by the linear foot. Posts will not be measured and paid for separately, but shall be included in the work.

Measurement will be along the base of the fence from outside to outside of end posts for each continuous run of fence, and shall include all wood, hardware, concrete,

607.05

reinforcing steel, excavation and backfill, and all other incidentals to the erection of the fence.

BASIS OF PAYMENT

607.05 The accepted quantities of fence will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Fence (____) (____ Inch)	Linear Foot
(____ Foot) Gate (____)	Each
Line Post	Each
End Post	Each
Corner and Line Brace Post	Each
End Post (Chain Link)	Each
Corner and Line Brace Post (Chain Link)	Each
End Post Special	Each
Corner and Line Brace Post Special	Each
Deer Gate	Each
Fence Wood (Sound Barrier) (____ Inch)	Linear Foot
Fence (Plastic)	Linear Foot

Payment for Fence (Plastic) shall be full compensation for furnishing, erecting, maintaining, removing, and disposing of all materials required. Fence (Plastic) shall remain the property of the Contractor.

608.01

SECTION 608 SIDEWALKS AND BIKEWAYS

DESCRIPTION

608.01 This work consists of the construction of bituminous or concrete sidewalks, bikeways, and curb ramps in accordance with these specifications and in conformity with the lines and grades shown on the plans or established.

MATERIALS

608.02 Materials shall meet the requirements specified in the following subsections:

Joint Fillers	705.01
Bed Course Material	703.07

Concrete for sidewalks, bikeways, and curb ramps shall be Class B, and meet the requirements of Section 601.

Bituminous material for sidewalks, bikeways, and curb ramps shall meet the requirements of Section 403.

Concrete and bituminous mixes will be subject to inspection and tests as required to assure compliance with quality requirements.

CONSTRUCTION REQUIREMENTS

608.03 Concrete Sidewalks and Bikeways.

- (a) *Excavation.* Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to a firm even surface conforming to the section shown on the plans or as staked. When the Engineer determines that material is uncompactable, the material shall be removed and replaced in accordance with subsection 206.03.
- (b) *Forms.* Forms shall be of wood, metal, or other suitable material, and shall extend for the full depth of the concrete. All forms shall be straight, free from warp and of sufficient strength to resist the pressure of the concrete without springing. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. A satisfactory slipform method may be used.
- (c) *Placing Concrete.* The foundation shall be thoroughly moistened immediately prior to the placing of the concrete. The proportioning, mixing and placing of the concrete shall be in accordance with the requirements for the class of concrete specified.
- (d) *Finishing.* The surface shall be floated with a wooden or magnesium float and given a transverse broom finish. Plastering of the surface will not be permitted.

All outside edges of the slab and all joints shall be edged with a $\frac{1}{4}$ inch radius edging tool.

- (e) *Joints.* Expansion joints, at intervals of not more than 500 feet, shall be filled with $\frac{1}{2}$ inch thick full depth, preformed expansion joint filler. The sidewalk or bikeway shall be divided into sections by dummy joints formed by a jointing tool or other acceptable means as directed. These dummy joints shall extend into the concrete for at least $\frac{1}{4}$ of the depth and shall be approximately $\frac{1}{8}$ inch wide. Dummy joints shall be spaced at intervals approximately equal to the width of the sidewalk or bikeway.

Construction joints shall be formed around all appurtenances such as manholes, utility poles, etc., extending into and through the sidewalk. Preformed expansion joint filler $\frac{1}{2}$ inch thick shall be installed in these joints. Expansion joint filler $\frac{1}{2}$ inch thick or the thickness indicated shall be installed between new concrete and any fixed structure such as a building or bridge. This expansion joint material shall extend for the full depth of the contact surface.

- (f) *Curing.* Immediately upon completion of the finishing, sidewalks and bikeways shall be moistened and kept moist for three days, or they shall be cured by the use of membrane forming curing compound. The method and details of curing shall be subject to the approval of the Engineer.

During the curing period all traffic, both pedestrian and vehicular, shall be excluded. Vehicular traffic shall be excluded for such additional time as the Engineer may direct.

608.04 Bituminous Sidewalks and Bikeways.

- (a) *Excavation and Forms.* Excavation and forms shall meet the requirements of subsection 608.03 (a) and (b).
- (b) *Bed Course.* Bed course material shall be placed in layers not exceeding 4 inches in depth and each layer shall be thoroughly compacted.
- (c) *Placing Bituminous Material.* Bituminous sidewalk and bikeway material shall be placed on the compacted bed course in one or more courses as indicated so as to give the required depth when rolled. When practicable, spreading, finishing, and compaction shall be accomplished by equipment conforming to the requirements of Section 401. When the Engineer determines such equipment is not practicable, bituminous material may be spread by small or special pavers, by spreader boxes or by blade graders and may be compacted by small self propelled rollers or vibratory compactors acceptable to the Engineer. In areas inaccessible to the roller, hand or mechanical tamping will be permitted. Bituminous material shall be uniformly compacted.

The Contractor shall state at the preconstruction conference what type of paving equipment will be used.

608.05

METHOD OF MEASUREMENT

608.05 Concrete sidewalks, bikeways, and curb ramps will be measured by the square yard of finished surface. Bituminous sidewalks, bikeways, and curb ramps will be measured by the ton of bituminous mixture placed.

BASIS OF PAYMENT

608.06 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule.

Payment will be made under:

Pay Item	Pay Unit
Concrete Sidewalk	Square Yard
Bituminous Sidewalk	Ton
Concrete Curb Ramp	Square Yard
Bituminous Curb Ramp	Ton
Concrete Bikeway	Square Yard
Bituminous Bikeway	Ton

Bed course material will be measured and paid for in accordance with Section 206.

All work necessary and incidental to the construction of sidewalks, bikeways, and curb ramps will not be measured and paid for separately but shall be included in the work.

SECTION 609 CURB AND GUTTER

DESCRIPTION

609.01 This work consists of the construction of curb, gutter or combination curb and gutter in accordance with these specifications and in conformity with the lines and grades shown on the plans or established.

The types of curb are designated as follows:

Type 2 Cast-in-Place Concrete Curb

Type 4 Dowelled Concrete Curb

Type 6 Sloping Curb

The section will be as shown on the plans.

MATERIALS

609.02 Except as provided below the materials used shall meet the requirements of the following subsections:

Bed Course Material	703.07
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Joint Filler	705.01
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Reinforcing Steel	709.01
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Concrete for curb shall be Class B, and meet the requirements of Section 601, except that when curb machines are used, a lesser slump will be permitted.

Bituminous curb shall be constructed of the same gradation of aggregate and the same grade of bituminous material as the top layer or top course of bituminous pavement used on the project.

Concrete and bituminous mixes will be subject to inspection and tests at the plants for compliance with quality requirements.

CONSTRUCTION REQUIREMENTS

609.03 Cast-in-Place Concrete Curb.

- (a) *Excavation.* Excavation and bedding shall conform to the requirements of subsection 608.03 (a).
- (b) *Forms.* Forms shall be of wood or metal, straight, free from warp and of such construction that there will be no interference to the inspection of grade or alignment. All forms shall extend for the entire depth of the curb and shall be braced and secured sufficiently so that no deflection from alignment or grade will occur during the placing of the concrete.
- (c) *Mixing and Placing.* Concrete shall be proportioned, mixed and placed in accordance with the requirements for the class of concrete specified.

609.03

Compaction of concrete curb, gutters or combination curb and gutter, placed in forms shall have thorough consolidation which shall be achieved by tamping and spading, vibrating or other acceptable methods. Forms shall be left in place until the concrete has set sufficiently so that they can be removed without injury to the curb. Upon removal of the forms, the exposed curb face shall be immediately finished to a uniform surface. For the purpose of matching adjacent concrete finishes or for other reasons, the Engineer shall approve methods of finishing. Plastering will not be permitted.

- (d) *Sections.* Curb shall be constructed in sections having a uniform length of 10 feet, unless otherwise ordered. Sections shall be separated by open joints $\frac{1}{8}$ inch wide except at expansion joints.
- (e) *Expansion Joints.* Expansion joints shall be formed at the intervals shown on the plans using a $\frac{1}{2}$ inch preformed expansion joint filler. When the curb is constructed adjacent to or on concrete pavement, expansion joints shall be located opposite the expansion joints in the pavement.

Expansion joints shall be installed between concrete curb and any fixed structure or bridge. Expansion joint material shall extend the full depth of contact surface.

- (f) *Curing.* Immediately upon completion of the finishing, the curb shall be moistened and kept moist for three days, or the curb shall be cured by the use of membrane forming curing compound. The method and details of curing shall be subject to the approval of the Engineer.
- (g) *Backfilling.* After the concrete has set sufficiently, the spaces in back of the curb shall be backfilled to the required elevation with suitable material which shall be thoroughly tamped.
- (h) *Curb Machine.* With the approval of the Engineer, the curb may be constructed by the use of a curb forming machine.
- (i) *Surface Tolerance.* The Engineer may determine that the exposed surfaces of the concrete curb, gutters, or combination curb and gutter shall be tested with a 10 foot straightedge laid along the exposed surface in a longitudinal direction. The Contractor shall furnish an approved 10 foot straightedge and provide an operator to aid the Engineer in testing the exposed surfaces. All surfaces shall be measured in a longitudinal direction. Deviation of any exposed surface in excess of that specified shall be corrected at the Contractor's expense.

Longitudinal surface tolerances for the top and face are:

- (1) On tangent roadway alignments and curves with radius greater than 1000 feet: 0.25 inch from the edge of the straightedge.

- (2) On sharp vertical curves and horizontal curves with radius of 1000 feet or less: 0.25 inch from the edge of the straight edge with allowance made for curve deflection.

609.04 (unused)

609.05 Bituminous Curb.

- (a) *Preparation.* Bituminous curb shall be placed on a clean dry surface. Immediately prior to placing of the bituminous mixture, the surface shall receive a tack coat of bituminous material of the type and grade approved by the Engineer. The rate of application of the tack coat material shall be 0.05 to 0.15 gallons per square yard of surface. In the application of this tack coat, the Contractor shall prevent the spread of this tack coat to areas outside of the area to be occupied by the curb.
- (b) *Placing.* Bituminous curb shall be constructed by use of a self-propelled curb machine or a paver with curb attachments.

The automatic curb machine shall meet the following requirements and shall be approved prior to its use:

- (1) The weight of the machine shall be such that compaction is obtained without the machine riding above the bed on which curb is constructed.
- (2) The machine shall form curb that is uniform in texture, shape and density.
- (3) The Engineer may permit the construction of curb by other means, when short sections or sections with short radii are required, or for such other reasons as warranted. The resulting curb shall conform in all respects to the curb produced by the use of the machine.

Upon completion of placement of bituminous curb, a fog coat of emulsified asphalt shall be placed on the exposed surfaces of the curb at the rate of approximately 0.1 gallon per square yard.

- (c) *Painting and Sealing.* When sealing or painting is required, it shall be performed only on a curb which is clean and dry and which has reached the ambient temperature.

METHOD OF MEASUREMENT

609.06 Curb will be measured by linear foot along the front face of the section at the finished grade elevation. Gutter will be measured along centerline of the gutter. Curb and gutter will be measured along the face of the curb. Deduction in length will be made for drainage structures, such as catch basins, drop inlets, etc., installed in the curb, gutter, or curb and gutter.

609.07

BASIS OF PAYMENT

609.07 The accepted quantities will be paid for at the contract unit price for each of the pay items listed below that appear in the bid schedule, including dowels and expansion joint material.

Payment will be made under:

Pay Item	Pay Unit
Curb, Type__ (Section____)	Linear Foot
Gutter, Type__ (____Foot)	Linear Foot
Curb and Gutter, Type__ (Section____)	Linear Foot

Bed course material will be measured and paid for in accordance with Section 206.

Fog coat and tack coat for Curb Type 6 will not be measured and paid for separately but shall be included in the work.