

SECTION 460 STRUCTURAL CONCRETE

460.1 DESCRIPTION

This work consists of falsework and form construction, and the furnishing, handling, placing, curing, and finishing of concrete for bridges, box culverts, and miscellaneous structures.

460.2 MATERIALS

Materials shall conform to the following Sections:

- A. **Cement:** Section 750. Type II cement shall be used for all Class A40 (A28), Class A45 (A31), and Class A50 (A35) concrete.
- B. **Fine Aggregate:** Section 800.
- C. **Coarse Aggregate:** Section 820.
- D. **Water:** Section 790.
- E. **Admixtures:** Sections 751 and 752.
- F. **Reinforcing Steel:** Section 1010.
- G. **Curing Materials:** Section 821.
- H. **Joint Filler:** Section 860.
- I. **Joint Sealer:** Section 870.
- J. **Fly Ash:** Sections 605 and 753.

460.3 CONSTRUCTION REQUIREMENTS

- A. **Concrete Quality and Proportioning:** When the Contractor proposes to use aggregate from sources not previously tested by the Department, the Contractor shall submit preliminary samples to the laboratory to determine its acceptability.

For the purpose of determining a laboratory design mix, samples of acceptable materials proposed for use, excluding water, shall be submitted to the laboratory at least 40 days prior to their use. When fly ash is substituted for a portion of the cement in the mix, the samples shall be submitted at least 40 days prior to use. Aggregate samples for this purpose shall be obtained from stockpiles of acceptable material that will be incorporated into the work.

A maximum of two laboratory mix designs per contract will be made by the Department. When the Contractor requests additional mix designs, they will be at the expense of the Contractor.

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The Contractor shall proportion the materials in accordance with the laboratory design mixes. Class A40, A45, and A50 design mixes will be based on a design strength of 4000, 4500, and 5000 psi respectively (A28, A31 and A35 design mixes will be based on a design strength of 28, 31, and 35 MPa respectively). If satisfactory plasticity, workability, and strength are not secured using the designated design mix, the Engineer may alter the proportions. Adjustment will not be made in the compensation due to the contractor because of design mix alterations.

The slump of the concrete at the time of placement shall be maintained between 1 and 4-1/2 inches (25 and 115 mm). The slump of concrete used in bridge decks, **including barrier curbs** shall be maintained between 1 and 3-1/2 inches (25 and 90 mm) at time of placement.

Concrete shall contain 6.5 ± 1.5 percent entrained air. Concrete used in bridge decks, **including barrier curbs** shall contain 6.5 ± 1.0 percent.

- B. Equipment:** Equipment shall be at the job site in advance of the start of construction operations to allow for thorough examination by the Engineer.
- 1. Batching Equipment:** Batching plant structures shall be leveled so the accuracy of the weighing mechanism is maintained.

Hoppers shall fully discharge without jarring the scales.

Clearances between scale parts, hoppers, and bin structure shall be maintained to avoid displacement of, or friction between, parts due to materials accumulations, vibration, or other cause. Pivot mountings shall be designed so parts will not jar loose, and constructed to assure unchanging spacing of knife edges under all circumstances. Scales shall be designed so exposed fulcrums, clevises, and similar working parts may readily be kept clean.

Weighing hoppers and other parts that are effected by wind action shall be protected by means of shelters or wind breaks.

The scale dials shall be completely enclosed in weather proof cases and provided with glass opening to permit observation and reading.

Dial scales shall be provided with markers to indicate the position of the dial indicator for predetermined loads. Beam scales shall be equipped with an over and under indicator which will show the beam in balance at zero load at any beam setting. The indicator shall have an over and under travel equal to not more than five percent of the capacity of the beam.

The scales for weighing aggregates, cement, water, and admixtures shall be of the beam or springless dial type designed as an integral part of the batch equipment. The scales shall be accurate within 0.5 percent at any point throughout the range of the scale. Scale graduations shall be not greater than 0.1 percent of the capacity of the scale. The scales shall be sensitive to the weight indicated by one graduation.

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When water is measured by volume, means shall be provided for determining the accuracy of the measuring device.

Computerized Batching Equipment: The following provisions shall apply to all Class A or Class M (Class I) furnished to projects within the city limits of Sioux Falls and to all other concrete batched by computerized ready mix plants:

A printed, computer generated, ticket shall be automatically produced for each load of concrete batched. The printed computer ticket shall accompany each load of concrete to the project and shall be presented to the Engineer prior to discharging the load at the project site.

Batching equipment shall be automatic. Manual operations will be permitted when automatic controls fail provided concrete meeting specified results is produced. However, the automatic operation shall be restored before work may commence the day following the failure.

The printed ticket must contain the following minimum information:

Truck Number

Date and Time batched

Total volume of the load, in cubic yards (cubic meters)

Mix Identification [ID]

Actual weight (mass) or volume of each component of the mix:

coarse aggregate

fine aggregate

cement

fly ash

water

admixtures

The above information must be automatically printed in such a manner that the Engineer may verify that the mix adheres to the proportions specified by the design mix.

- Mixing and Hauling Equipment:** Mixers and agitators shall have attached in a prominent place, the manufacturer plate or plates showing the various uses for which the equipment is designed and the capacity of the drum or container in terms of volume of mixed concrete.

The pickup and throw over blades in the drum shall be restored or replaced when any

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part or section is worn down 3/4 inch (20 mm) or more below the original height of the manufactured design. A copy of the manufactured design, showing dimensions and arrangement of blades in reference to original height and depth, shall be available. Mixers that have an accumulation of hard concrete or mortar shall not be used.

Mixers, except truck mixers, shall be equipped with an approved timing device which automatically locks the discharge lever when the drum has been charged and releases it at the end of the mixing period. The timing device shall be equipped with a bell or other suitable warning device adjusted to give a signal each time the lock is released.

Truck mixers shall be equipped with counters to record the number of revolutions of the drum or blades. **The revolution counter on the truck mixers shall be set to zero as each new load is batched.** The counters shall be automatically actuated at the time mixing starts at mixing speed.

Mixers shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and uniformly discharging the concrete.

The hauling bodies of nonagitating equipment shall be smooth, mortar tight metal containers equipped with gates that permit uniform control of the discharge of the concrete.

3. **Forms and Falsework:** Forms and falsework shall conform to Section 423.
- C. **Handling, Measuring and Batching Materials:** The separate aggregate components shall not become intermixed prior to being weighed and the weigh hopper or hoppers shall be charged so the batched weights are within the following tolerances:
1. When fine and coarse aggregates are weighed cumulatively, the aggregate batching equipment shall be operated within a delivery tolerance of 0.5 percent of the net weight of the total aggregate batch.
 2. When fine and coarse aggregates are weighed separately, the aggregate batching equipment shall be operated within a delivery tolerance of two percent of the weight of the material being weighed.
 3. Cement shall be measured by the sack or by weight. When cement is weighed, separate scales and hoppers shall be used with a device to indicate positively the complete discharge of the batch of cement into the batch box or container. The cement batching equipment shall be operated within a delivery tolerance of one percent of the net weight of the cement per batch.
 4. Water may be measured by volume or by weight. The measuring equipment shall be operated within a delivery tolerance of one percent of the net weight or volume of water per batch.

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5. Air entraining or other admixtures shall be measured by volume or by weight. The measuring equipment shall be operated within a delivery tolerance of three percent of the net weight or volume of admixture per batch.

D. Mixing Concrete: Concrete shall be mixed at a central stationary plant site or in truck mixers.

Mixers shall not be charged in excess of the rated capacity.

When a concrete batch is transported in a truck mixer or agitator and the batch is smaller than 60 percent of the rated capacity of the truck mixer or agitator, the following percentage of additional cementitious material shall be added to the batch:

40% to 60% rated cap	5%
20% to 39% rated cap	10%
10% to 19% rated cap	15%
0% to 9% rated cap	20%

The above provisions regarding extra cementitious material shall also apply to the mixing of small batches in central plants.

Mixing and agitating speeds shall be as designated by the manufacturer of the equipment.

1. **Central Plant Mixing:** Manual operation of mixers shall be permitted only in case of failure of the automatic timing device. Automatic operation must be restored before work may commence the day following the failure.

The batch shall be charged in the drum so a portion of the mixing water enters in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period.

Concrete shall be mixed for a period of not less than one minute after all materials, are in the mixer.

Concrete mixed less than the specified mixing time shall be discarded and disposed of.

2. **Truck Mixing:** Mixing time for truck mixed concrete shall be not less than 70 nor more than 100 revolutions of the drum or blades at mixing speed after all ingredients, including water, are in the drum. Additional mixing beyond 100 revolutions, shall be done at agitating speed.

The mixing water shall be added at the time of batching. Additional water or cement may be added to the batch after completion of the original mixing, provided slump, air, and water/cement ratio criteria are met. When additional water is added the batch shall be mixed an additional 30 revolutions at mixing speed. The Contractor shall provide means to accurately measure the amount of water added.

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3. **Water-Cement Ratio:** The water cement ratio of concrete used for bridge decks shall not exceed 0.45 by weight.

E. Volumetric Batching and Continuous Mixing:

1. **Equipment:** The proportioning and mixing equipment shall be a self-contained, mobile, continuous mixer meeting the following requirements:

- a. The mixer shall be capable of carrying sufficient unmixed dry bulk cement, fine aggregate, coarse aggregate, admixtures, and water in separate compartments to produce not less than six cubic yard (4.5 cubic meters) of concrete.

For full depth bridge deck placements, the production capacity shall be a minimum of 60 cubic yards (45 cubic meters) per hour. More than one mixer may be required to provide a satisfactory placement rate.

- b. The mixer shall be capable of positive measurement of cement being introduced into the mix. A visible recording device, equipped with a ticket printout, shall indicate this quantity.
- c. The mixer shall provide positive control of water introduced into the mixer. Water flow shall be coordinated with the cement and aggregate feeding mechanisms, and shall be readily adjustable to provide for minor variations in aggregate moisture. Water flow shall be controlled by a calibrated metering device.

In addition to the metering device, mixers used for bridge deck concrete, low slump concrete, and latex modified concrete shall be equipped with recording water meters recording the number of gallons (liters) introduced into the mixer to the nearest 0.1 gallon (0.1 liter).

- d. The mixer shall be capable of being calibrated to automatically proportion and blend all components on a continuous or intermittent basis.
- e. The mixer shall provide positive control of admixtures introduced into the mix. Admixture flow shall be coordinated with the feeding mechanisms of the other ingredients and shall be readily adjustable. The admixture injection system shall meet the mixer recommendations of the manufacturer regarding type and design.
- f. When mixing latex modified concrete, the mixer shall be equipped with recording meters capable of recording, to the nearest 0.1 gallon (0.1 liter), the number of gallons (liters) of latex emulsion introduced into the mix.

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2. Equipment Calibration:

- a. Calibration and inspection by the Department will be required for each mixer before the start of the first project on which the mixer will be used each year. The calibration will establish the meter count, e.g., the number of revolutions and discharge time in seconds required to dispense 94 pounds (43 kilograms) of cement. Gate openings and pointer adjustments for aggregates and general operating condition of the equipment will also be inspected.

The Contractor shall have a representative to witness the calibration, and a qualified mixer operator. The Contractor shall furnish all scales, containers, stop watches, mixer operating manuals, materials, and equipment necessary for the calibration and inspection.

- b. A materials discharge verification check may be ordered whenever conditions warrant. Individual components may be ordered verified. On latex modified mixtures, cement, and latex emulsion discharge shall be verified prior to the first placement on each project.
- c. Proportioning of individual components shall be within the following tolerances:

Cement (weight percent).....	0% to +4%
Fine aggregate (weight percent).....	±2%
Coarse aggregate (weight percent).....	±2%
Water (weight or volume percent).....	±1%
Latex emulsion (weight percent).....	±1%
Yield (volume percent).....	±2%

The discharge time interval for components, other than aggregates, shall be the time established for the discharge of 94 pounds (43 kilograms) of cement. A lesser discharge time may be used for aggregates. Individual components used during discharge checks shall be from the sources to be used on the project. When performing materials discharge checks, manufacturer recommendations relative to minimum quantities of materials in the bins shall be adhered to. If the cement discharge is not within tolerance a new meter count and discharge time shall be established using calibration form DOT-293.

3. Proportioning and Mixing: The operations of proportioning and mixing concrete shall comply with the following requirements:

- a. The proportioning and mixing equipment operator shall be thoroughly familiar with the equipment and its operation.
- b. Mixers shall be clean and ingredients accurately proportioned.

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- c. Concrete shall be mixed at the site in accordance with the specific requirements for the equipment used.
 - d. Concrete discharged from the mixer shall be uniform in composition and consistency. Mixing capability shall be such that finishing operations can proceed at a steady pace and the final finishing is completed before the formation of a plastic surface film.
- 4. Termination of Use:** Permission for continued use of a mixer may be rescinded for failure to maintain acceptable production or inability to meet the specifications.
- F. Limitations of Mixing:** Concrete shall be mixed in the quantities required for immediate use and shall be placed before initial set has occurred. Concrete in which initial set has begun prior to beginning placement shall be wasted at the Contractors expense. Retempering of concrete will not be allowed.

Concrete shall not be mixed and placed unless the natural light is sufficient for finishing operations, or an adequate artificial lighting system is provided.

Mixing water shall not be heated above 160EF (71EC). Aggregates shall not be heated above 100EF (38EC) and shall be free of frozen lumps, ice, and snow.

- G. Delivery Requirements:** When concrete is continuously agitated in the hauling unit, it shall be discharged within 90 minutes, **and discharged and screeded within 105 minutes** after the cement has been placed in contact with the aggregates. When the concrete temperature is 80EF (27EC) or above, the time limitation shall be **reduced to discharged within 45 minutes, and discharged and screeded within 60 minutes.**

When concrete is not continuously agitated in the hauling unit, it shall be **discharged within 45 minutes, and discharged and screeded within 60 minutes** after the cement has been placed in contact with the aggregates. When the concrete temperature is 80EF (27EC) or above, **the time limitation shall be reduced to discharged within 30 minutes, and discharged and screeded within 45 minutes.**

The rate of delivery of concrete shall be uniform. The interval between batches shall not exceed 30 minutes.

- H. Placing Concrete:** The Contractor shall give sufficient notice before starting to place concrete to permit inspection of forms, reinforcing steel, and preparation for placing. Concrete shall not be placed without approval of the Engineer.

Placement of concrete on a frozen foundation will not be permitted. The surface temperature of forms, steel, and adjacent concrete which will come in contact with the concrete being placed shall be raised to a temperature above freezing prior to placement.

The temperature of concrete immediately after placing shall be not less than 50EF (10EC). nor

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more than 90EF (32EC). The top limit for bridge deck concrete shall be 80EF (27EC) except as indicated below.

During periods of extreme and sustained hot weather it may become extremely difficult to maintain the 80EF (27EC) maximum concrete temperature for bridge deck concrete. When such conditions exist the Engineer may authorize the maximum concrete temperature to be raised to 85EF (29EC) provided the following conditions are met:

1. The aggregate piles must be flushed with water.
2. A minimum rate of pour of 40 cubic yards (30 cubic meters) per hour must be maintained.
3. Wet burlap and poly must be placed as soon as possible after the pour.
4. If the ambient temperature is 80EF (27EC) or less the concrete shall be cured with a linseed oil base emulsion curing compound, as specified in 460.3 N. Whenever the ambient temperature exceeds 80EF (27EC), in lieu of the linseed oil base emulsion curing compound, a continuous fogging shall be applied from the time of initial strike off until the wet burlap is in place. In addition a linseed oil treatment, as specified in Section 461, shall be applied at no additional cost to the Department.

Fogging equipment shall be capable of applying a fine mist, NOT A SPRAY, under pressure through an atomizing nozzle. The fogging option will not be allowed when wind conditions preclude complete coverage.

Placement of concrete for bridge decks, including barrier curbs, will not be permitted during the period from November 1 to April 1, without written authorization from the Engineer. Authorization will be given only if there is a distinct advantage to the Department.

Before placing concrete, sawdust, chips, debris, and extraneous matter shall be removed from the interior of forms. Temporary struts, stays, and braces holding the forms in the correct shape and alignment, shall be removed when the fresh concrete has reached an elevation rendering their service unnecessary. These temporary members shall not be buried in the concrete.

The slope of chutes for concrete placement shall allow the concrete to flow slowly without segregation. The delivery point of the chute shall be as close as possible to the point of deposit. Chutes and spouts shall be kept clean and shall be thoroughly flushed with water before and after each run. The flush water shall be discharged outside the forms.

Free fall of concrete shall not exceed five feet (1.5 meters). In thin walls or columns where the reinforcement prohibits the use of chutes the method of placement shall prevent objectionable separation of coarse aggregate.

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The sequence of placing concrete, including the location of construction joints, shall be as specified. Concrete shall be placed in continuous horizontal layers. Each layer shall be placed before the preceding layer has attained its initial set.

The concrete shall be consolidated by vibrating internally or externally, or both without displacement of reinforcing or forms. The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete without causing segregation, localized areas of grout or damage to concrete, forms, and reinforcement.

Vibration shall not be applied directly to reinforcement which extends into sections or layers of concrete which are not plastic under vibration. Vibrators shall not be used to move concrete over distances or to transport concrete in the forms.

Accumulations of mortar splashed upon the reinforcing steel and the surfaces of forms shall be satisfactorily removed. Care shall be exercised not to injure or break the concrete to steel bond at and near the surface of the concrete while cleaning the reinforcing steel. Dried mortar chips and dust shall be removed and not left in the unset concrete.

I. Underwater Concrete Placement:

- 1. Tremie:** The tremie pipe shall be a minimum of 0.25 inch (6.35 mm) thick wall steel pipe, with a minimum inside diameter of 7 3/4 inches (196 mm). The tremie pipe shall be smooth and thoroughly cleaned of any hardened concrete, rust, and all other contaminants. The tremie pipe shall be marked to allow determination of depth to the mouth of the tremie. Joints between sections of tremie pipe shall be gasketed and bolted to be watertight under placement conditions. Instead of bolted joints, welded joints may be used if a smooth finish is maintained on the inside of the tremie pipe at the weld location.

A crane or other lifting device shall be available to remove the tremie from the water for resealing or horizontal relocation.

Placement of underwater concrete shall be a continuous operation. If an interruption in placement occurs, the interruption shall not exceed 30 minutes without removal of the tremie and restarting the concrete placement according to the paragraph below. An interruption in concrete placement shall not exceed the time for initial set of the concrete. If the concrete placement is completed, concrete placement shall cease and the concrete shall be rejected and removed.

Starting/Restarting of the concrete placement by tremie shall begin by sealing the bottom of the tremie with a watertight seal before placing the tremie into the water. The watertight seal shall prevent water from entering the tremie, yet will be dislodged when concrete flow is initiated. The empty tremie pipe shall be sufficiently heavy to be negatively buoyant when empty. The tremie pipe shall be sealed, lowered to the bottom of the form or excavation, and completely filled with concrete. Fill the tremie slowly to

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avoid entrapped air and bridging. When full, the tremie shall be slowly lifted six inches (150 mm) off the bottom to start concrete flow. The concrete supply shall be continuous until soundings indicate the tremie has the required embedment. After being dislodged, the sealing device shall either remain on the bottom or be retrieved by the Contractor.

The mouth of the tremie shall always remain embedded in the fresh concrete unless the tremie is being completely removed from the water. At no time shall the concrete be allowed to fall through water. Embedment shall be a minimum of five feet (1500 mm).

A tremie shall not be moved horizontally while concrete is flowing through it. To relocate a tremie, lift it from the water, reseal, relocate, and restart as required above.

All vertical movements of the tremie shall be made slowly and shall be carefully controlled to prevent loss of seal. If loss of seal occurs, placement through that tremie shall be halted immediately. The tremie shall be removed, resealed, replaced, and restarted as described above.

- 2. Concrete Pump:** Concrete pumps can be used for underwater concrete placement if surging of the pump line can be controlled to keep the pump line sufficiently embedded into the fresh concrete. If surging of the line cannot be controlled, a concrete pump shall not be used.

The pump line shall be not less than four inches (100 mm) in diameter. The portion of the pump line that penetrates the deposited concrete shall be a rigid steel line (pipe).

An approved plug shall be inserted into the pump line, near the pump, in such a way that there is fresh concrete against the plug, with no air or water between the plug and concrete. The plug shall be advanced down the pump line, using pressure from the concrete pump, to the bottom of the form or excavation.

Placement shall begin with the pump line within six inches (150 mm) of the bottom of the form or excavation. After pumping begins, the pump line shall be kept within six inches (150 mm) of the bottom until soundings indicate that the pump line is embedded at least five feet (1500 mm) into fresh concrete. The end of the pump line may be raised with the rising column of concrete as long as the end of the pump line remains embedded at least five feet (1500 mm) into the concrete. At no time shall the concrete be allowed to fall through water.

Placement of concrete shall be a continuous operation. Interruptions of placement shall not exceed 30 minutes or the time of initial set of the concrete whichever is shorter. If the time of initial set is exceeded, the concrete shall be rejected and removed.

If the pump line is allowed to come out of, or is removed from, the concrete once placement has begun, placement through the pump line shall be restarted. A watertight

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seal shall be installed on the end of the pump line. The line shall then be filled with concrete before the pump line is lowered into the water. The pump line shall be filled in such a way as to eliminate air or water in the line. Once filled, the pump line shall be embedded a minimum of five feet (1500 mm) into the concrete and pumping resumed. The sealing device shall be retrieved by the Contractor after pumping has been restarted.

- J. Protection of Concrete:** The following provisions apply to all Class A concrete in addition to the requirements for curing contained in Section 460.3 N.

Concrete for sidewalks, curb and gutter, drop inlets, manholes, ditch checks, pipe headwalls, sleeper slabs, approach slabs, pavement, etc. shall be maintained above 32EF (0EC) until it has attained 1500 psi (11 MPa) compressive strength. The compressive strength will be checked according to SD 409.

Enclosures for protection of concrete shall be capable of maintaining the temperature specified and permit free circulation of artificial heat. The use of salamanders or other types of open flame heating unit is prohibited.

Form insulation shall be bats of fiberglass, rockwool, balsam wool, or similar commercial insulation material. Insulation shall remain in place for the full protection period. The forms may be loosened slightly to control the temperature of the concrete below the maximum value specified.

The Contractor shall drill holes in the forms and provide thermometer wells ½ inch (13 mm) to one inch (25 mm) in depth at locations established by the Engineer, to determine the temperature of the concrete.

Concrete for bridges, box culverts, retaining walls, anchor blocks, median barriers, light and signal footings, and other structures shall be maintained at a temperature of 50EF (10EC) or above for the first 72 hours after the concrete has been placed. The concrete shall be maintained at a temperature of 40EF (4EC) or above for the next 48 hour period. If low temperatures are recorded during this protection period, one extra day of protection time above 40EF (4EC) shall be added to the original five days of protection for each day that the minimum concrete temperature falls below the specified temperature.

If an additional bag of cement per cubic yard (56 kilograms of cement per cubic meter) is used, or if high early strength cement is permitted, the concrete shall be maintained at a temperature of 60EF (16EC) or above for 72 hours. If temperatures less than 60EF (16EC) are recorded during this protection period, the protection time required shall revert back to that in the preceding paragraph with its provision for low temperatures also being applicable.

Until one of the protection periods have been satisfied, cold weather protection shall continue, falsework shall remain in place, live loads shall not be applied and the concrete temperature shall be maintained above 35EF (2EC).

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At the end of the protection period, the concrete temperature shall not be permitted to fall more than 40EF (4EC) for each 24 hour period.

The temperature of concrete protected by housing and heating or insulated forms shall not exceed 100EF (38EC) during the protection period.

It will be permissible to flood concrete to a minimum depth of one foot (300 mm) for 10 days after the concrete is placed maintaining a water temperature which prevents freezing of the water in contact with the concrete.

- K. Removal of Formwork and Construction of Superimposed Elements:** Methods of falsework and form removal likely to cause overstressing of the concrete shall not be used. Supports shall be removed so the concrete uniformly and gradually takes the stresses due to its own weight.

Falsework and forms shall not be removed and superimposed concrete placed without the approval of the Engineer. The following table will be used by the Engineer to determine when these operations may proceed. The following periods are exclusive of days when the temperature is below 40EF (4EC).

Falsework and forms may be removed from the affected concrete and placement of superimposed concrete may proceed when the concrete reaches the strength or exceeds the time specified in the following table:

Structural Elements	Time	Formwork Removal		Superimposed Concrete Placement	
		Concrete Strength psi (MPa)	Time	Concrete Strength psi (MPa)	Time
Footings	24 hrs.	800 (6)	72 hrs.	1600 (11)	
Columns	24 hrs.	800 (6)	12 days	2000 (14)	
Pier & Bent Caps	15 days	2400 (17)	20 days	3000 (21)	
Abutment & Sills	24 hrs.	800 (6)	20 days	3000 (21)	
Deck Slabs for					
Concrete Bridges	15 days	2400 (17)	48 hrs.	1200 (8)	
Other Deck Slabs & Top Slab of RCBC	12 days	2000 (14)	48 hrs.	1200 (8)	
Vertical Surfaces not Carrying Load	24 hrs.	800 (6)			
Concrete Diaphragms	24 hrs.	800 (6)	12 days	2000 (14)	

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- L. Backfilling and Application of Liveload:** All concrete shall attain full design strength and all falsework shall be removed prior to backfilling and applying highway live loads to the structure. Construction vehicles, materials, and equipment weighing less than 4,000 pounds (1,800 kg) in total will be allowed on any span, provided the most recently placed concrete has attained a compressive strength of 2,400 psi (17 MPa). Loads over 4,000 pounds (1,800 kg) will not be allowed until the concrete has attained design strength and all falsework has been removed.

The only exceptions are that footings, columns, curb and gutter, and sidewalks (sidewalks on bridge decks are not included) shall not be backfilled until permission has been given by the Engineer. The approach slabs may be opened to traffic when they have attained a compressive strength of 4000 psi (28 MPa).

- M. Joints:** When placing fresh concrete against concrete which has already set at a construction joint, the concrete in place shall have all loose material removed.

- N. Curing Concrete:** Concrete surfaces shall be kept continuously wet by ponding, spraying or covering with materials that are kept continuously and thoroughly wet. Such materials shall consist of burlap or other materials which do not discolor or damage the concrete. Forms shall be considered as adequate cover for curing the formed surface as long as the forms remain in place without loosening. Curing shall continue for not less than seven days after placing the concrete. Other precautions to insure development of strength shall be taken as the Engineer may direct.

In lieu of the above method of curing, membrane curing compound may be used. The compound shall be uniformly applied immediately after the final finishing operations are completed and the free water has left the surface. The curing compound may be applied in one or two applications in accordance with the directions of the manufacturer. If applied in two coatings, the second shall be applied within 30 minutes of the first.

Equipment, workmen, and materials will not be allowed on the surface for a minimum of seven days after application of the curing compound, unless the surface is adequately protected with an approved material. This protection shall not be applied for at least eight hours after application of the curing compound. If the membrane film is broken or damaged within the seven day curing period, the areas affected shall be given a duplicate treatment of the curing material, at the same application rate as the first treatment.

Surfaces which are to receive a finish as per Section 460.3 O.1. shall not be treated with curing compound, curing shall be accomplished with burlap mats or polyethylene sheeting. Membrane curing compound will not be allowed on any surface to which concrete is to be bonded.

Bridge decks and approach slabs shall be cured as follows:

As soon as bridge deck and approach slab concrete has received the final surface finish, linseed oil base emulsion curing compound shall be uniformly applied at the specified

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rate. This application is not a substitute for curing with burlap mats and polyethylene sheeting but is required for moisture retention until the burlap mats and polyethylene curing materials can be placed. The burlap mats and polyethylene sheeting curing materials shall be in place not later than four hours after completion of deck finishing or, for portions of the deck on which finishing is completed after normal working hours, the burlap mats and polyethylene sheeting shall be applied not later than the following morning. The concrete surfaces which are to have superimposed concrete placed upon or against them shall be protected from the curing compound and shall be cured with cotton or burlap mats and white polyethylene sheeting. All reinforcing steel shall be protected from the compound application.

1. **Application of Curing Compound:** Application of linseed oil base emulsion curing compound shall conform to the following requirements:
 - a. Prior to and during application, the material shall be mixed to a uniform consistency without the use of air, violent agitation, or thinning.
 - b. The material shall be maintained above 50EF (10EC) during application.
 - c. The material shall be applied, with a spray applicator of sufficient capacity and with spray nozzles of proper size and design to provide a uniform application at the specified rate, immediately after the concrete has received the final finish.
 - d. The minimum application rate shall be as follows:
 - 1) Carpet drag or broom finish - 1 gallon per 150 square feet (1 liter per 4 square meters).
 - 2) Groove finish - 1 gallon per 125 square feet (1 liter per 3 square meters).
2. **Mats and Polyethylene:** Surfaces **cured with burlap mats** and polyethylene sheeting shall be cured in the following manner:
 - a. The surface to be cured shall be entirely covered **with burlap mats**. The mats shall cover the entire surface with sufficient material beyond the periphery of the area to assure adequate curing of the edges. The mats shall be thoroughly saturated with water and shall be placed with the wettest side down. As an alternate method, the deck may be flooded with water, the burlap placed immediately on the flooded deck and the burlap thoroughly saturated.
 - b. Immediately after placement, the mats shall be entirely covered with white polyethylene sheeting. Adjacent sheets shall be lapped at least 18 inches (450 mm). The sheeting shall be placed and weighted down to assure contact with the surface.

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- c. Curing shall be maintained for seven days. The mats shall be kept moist by periodic applications of water.
- O. Surface Finish:** The surfaces of all concrete masonry shall be worked during placing. The working shall force all coarse aggregate from the surface and thoroughly work the mortar against the forms to produce a smooth finish relatively free of water, air pockets, and honeycombing.

As soon as the concrete has set sufficiently, the forms on all exposed surfaces shall be carefully removed and all depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in the same proportions as the concrete being treated. All fins and rough corners on the surfaces shall be removed to present a neat and uniform appearance.

Additional finishing will be required as follows:

- 1. **Rubbed, Brushed, and Commercial Texture Finishes:** One of these three finishes will be required for all railing, curbs, parapets, wings, and other surfaces not subject to wear which are visible to the traveling public **unless otherwise designated in the plans.** The selected finish shall be used throughout the entire structure, except the finish for the top and inside of the curb may be different than that used for the other parts of the structure. These finishes will not be required on wing walls and parapets of box culverts and wingwalls and backsides of curbs on bridges which do not have traffic passing beneath them, provided the forms result in a smooth unblemished surface.

- a. **Rubbed Finish:** As soon as the pointing has set sufficiently, the surfaces to receive a rubbed finish shall be thoroughly wetted with a brush and rubbed with a medium coarse carborundum stone or an abrasive of equal quality using a small amount of mortar on stone face. The rubbing shall be continued until all form marks and projections are removed, producing a relatively smooth clean surface free from pits or irregularities.

The final finish shall be obtained by rubbing with a fine carborundum stone or an abrasive of equal quality. This rubbing shall continue until the entire surface has a smooth texture and a uniform color.

- b. **Brushed Finish:** This finish will be permitted only if it is accomplished within 12 hours of concrete placement. The forms shall be removed as soon as the concrete is able to stand firm without slumping. The surface shall be worked with a rubber float which may be dipped in a very wet three to one fine sand and cement grout mixture. Immediately after the surface is worked into a lather, a soft bristle brush shall be used to smooth the surface, leaving a fine grained, smooth, but sanded texture. A "plastering" job resulting from the use of an excess of grout on the surface will not be permitted.

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- c. **Commercial Texture Finish:** This finish shall consist of an application of latex or acrylic based bonding agent mixed with a standard or commercial packaged mortar. This finish shall be applied with a rubber float.

The Department will maintain a list of approved materials and mixes for use. If the bonding agent material and mixture proposed for use are not on the approved list, the Contractor shall have the material and mixture tested by a recognized commercial testing laboratory in accordance with Department procedures. The commercial texture finish work shall not be started until the material and mixture have been approved.

The mixture shall be applied in sufficient thickness to completely cover the original surface with a one coat application, but shall not be so thick as to cause runs, sags, or a plastered effect. The final dried surface shall be uniform in color and texture, with no evidence of laps or breaks in continuity.

Corrective work, at the expense of the Contractor, will be required on areas which have not been satisfactorily finished, including as much adjacent area as necessary to provide a uniform appearance.

Application of the commercial texture finish shall not be started until other work which might mar the finish has been completed. If the Contractor elects to commence with the finishing operation prior to completion of any work that might damage the surface, provisions shall be taken to protect the finished surface. The finishing operation shall be carried on continuously from beginning to completion on any one surface.

2. **Special Surface Finish:** A special surface finish will be required on the concrete surfaces designated in the plans. The objective is to obtain a surface that is reasonably smooth and uniform in texture and appearance. Repairing surface blemishes to prevent "show through" prior to application of the special surface finish is required.

The surface finishing shall be performed using an approved mixture of commercial packaged mortar, latex or acrylic based bonding agent, and latex or acrylic based paint. The materials used for the mixture shall be compatible with each other, and shall produce a mixture suitable for the purpose intended.

The Department maintains a list of approved materials and mixes for Contractor use. The work in conjunction with the special surface finish shall not start until the material and mixture have been approved. The same materials and application method shall be used for all surfaces specified on any one structure.

The special surface finish shall be mixed and applied according to manufacturer recommendations. A copy of the manufacturer recommendations shall be provided to the Engineer.

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The surfaces to receive the finish shall be sandblasted to break the surface film and to remove all laitance, form release agent, and all other foreign matter, including the curing compound.

All surfaces shall be thoroughly flushed with clean water not more than 24 hours before applying the finish. The concrete surfaces shall not be wet or damp when the special surface finish is applied.

The mixture shall be applied by spraying. The mixture shall cover the original surface with a one coat application. The one coat application shall not be too thick to cause runs, sags, or a plastered effect. After drying, the final surface shall be uniform in color and texture, with no laps or breaks in continuity. The finished surface shall be lighter in color than the original concrete, but not white, unless otherwise specified in the plan notes.

The application of the special surface finish shall not be started until all other work that could damage the surface finish has been completed. The finishing operations shall be carried on continuously from beginning to completion on any one surface.

Corrective work, at the Contractor's expense, will be required over any areas which have not been satisfactorily finished, including as much adjacent area as may be necessary to achieve uniform appearance.

3. **Float Finish:** Unformed surfaces, except bridge decks, shall be given a float finish. 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.
4. **Bridge Deck and Approach Slab Finish:** The concrete shall be placed slightly higher than the finished surface of the deck or approach slab. Immediately after the concrete has been placed and consolidated as required by Section 460.3 H., the surface shall be struck off and finished with an approved finishing machine. For bridge decks the finishing machine shall meet the following minimum requirements:

The finishing machine shall be a self-propelled rotating cylinder type, with one or more rotating steel cylinders and augers. The machine shall span the concrete placement width. The cylinders and augers shall spread and consolidate the concrete to the established profile by traversing the placement width, transverse to the roadway centerline. The machine shall be capable of forward and reverse motion under positive control, and be capable of raising all cylinders and augers to clear the surface when traveling in reverse. Any modifications to the factory product will require approval by the Engineer. The portion of the deck adjacent to curbs shall be neatly finished to a true surface with a wooden hand float.

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Before the concrete has attained its initial set it shall be given a final finish by transverse brooming or carpet drag to provide a surface micro texture.

The surface of the concrete bridge deck **and approach slab** shall be given a grooved finish. Grooves shall be a nominal 1/8 inch (3 mm) deep with effective spacing from 3/4 inch (20 mm) to one inch (25 mm). Care shall be taken to avoid overlaps of the passes in the grooving operation. The 12 inch (300 mm) width of the deck next to curb shall be left ungrooved.

After the concrete has hardened, the surface and joints shall be tested with a 10 foot (three meter) straightedge. The permissible longitudinal and transverse surface deviation shall be 1/8 inch (3 mm) in 10 feet (three meters). Any portion of the deck **and approach slab** showing variation from the template of more than 1/8 inch (3 mm) shall be either ground to an elevation that will be within the permissible deviation or be accepted under the provisions of Section 5.3.

Necessary grinding shall be accomplished with specially prepared circular diamond blades mounted on a horizontal shaft.

Areas that have been ground shall not be left smooth or polished, but shall have a uniform texture equal in roughness to the surrounding unground concrete.

- P. Pre-pour Inspection Requirements for Concrete Bridge Decks:** Pre-pour inspections will be conducted for all new concrete bridge decks. The Contractor shall advise the Engineer 24 hours in advance of the time when deck preparation will be complete and ready for inspection. The following items of work shall have been completed at the time of inspection:
- 1. Formwork:** Formwork and decking shall be complete and joints made mortar tight.
 - 2. Reinforcing Steel:** Reinforcing steel shall be accurately placed, secured, and tied according to specifications.
 - 3. Screed:** Screed rails shall be set and adjusted for final grade.
 - 4. Finishing Machine:** Finishing machine shall be adjusted for crown slope and placed upon the screed rails.
 - 5. Safety:** Necessary walkways and safety railing shall have been installed.
 - 6. Inspections:** A responsible Contractor employee shall be designated to accompany the Engineer during the pre-pour inspection.

Following the pre-pour inspection, corrective work shall be completed during the normal work shift and shall not extend into the late evening hours. Violation of this provision will be cause to postpone the scheduled deck placement.

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Q. Construction Tolerances: Construction tolerances and reinforcing steel placement tolerances shall be in accordance with the latest edition of ACI 117, Standard Tolerances for Concrete Construction and Materials.

R. Grout: Grout used to set anchor bolts and construct bearing pads shall be proportioned as follows:

Water.....5.5 gal/bag (21 L/bag) of cement
Sand.....285 lbs/bag (129 kg/bag) of cement

460.4 METHOD OF MEASUREMENT

Structural concrete will be measured in accordance with the neat line dimensions shown on the plans, unless changes are ordered in writing.

Structural concrete will be computed to the nearest 0.1 cubic yard (0.1 cubic meter).

Deductions will not be made for the volume of concrete occupied by utility conduit, six inch (150 mm) or smaller drainage pipe, reinforcing steel, encased structural steel, pile heads, anchors, sleeves and encased grillage, or for volume of concrete displaced by weep holes, joints, drains and scuppers or for fillets, chamfers or scorings, one inch square (10 square centimeters) or less in cross section.

Concrete approach and sleeper slabs will be measured to the nearest 0.1 square yard (0.1 square meter).

Concrete used for foundation seals will not be measured for payment.

The special surface finish will be measured along the neat line dimensions shown in the plans for the surfaces designated. The special surface finish will be computed to the nearest square foot (0.1 square meter).

460.5 BASIS OF PAYMENT

The accepted quantities of concrete will be paid for at the contract unit price per cubic yard (cubic meter).

Concrete approach and sleeper slabs will be paid for at the contract unit price per square yard (square meter).

Payment will be full compensation for labor, equipment, tools, materials, and other items of work required.

Reinforcing and structural steel will be paid for separately.

When a bid item for concrete is provided, it will be considered full compensation for excavation necessary to construct the structure, unless a separate item is provided for such excavation.

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The special surface finish will be paid for at the contract unit price per square foot (0.1 square meter).