ALABAMA DEPARTMENT OF TRANSPORTATION

DATE: September 19, 2019 Special Provision No. 18-0599

EFFECTIVE DATE: December 1, 2019

SUBJECT: Structural Portland Cement Concrete.

Alabama Standard Specifications, 2018 Edition, SECTION 501 shall be replaced with the following:

SECTION 501
STRUCTURAL PORTLAND CEMENT CONCRETE

501.01 Description.

The work under this Section shall cover the furnishing of portland cement concrete to be used in constructing concrete structures. Structures shall include but are not limited to bridges of all types, box culverts, headwalls, retaining walls, and other miscellaneous structures.

501.02 Materials.

(a) General.

Handling, storage, and control of materials shall comply with appropriate portions of Section 106. All materials shall conform to the requirements set forth in Division 800, Materials. Specific reference is made to applicable portions of the following Sections:

Section 801 - Coarse Aggregate
Section 802 - Fine Aggregates
Section 806 - Mineral Admixtures
Section 807 - Water
Section 808 - Air Entraining Admixtures for Concrete
Section 809 - Chemical Admixtures for Concrete
Section 815 - Cement
Section 830 - Concrete Curing Material
Section 832 - Concrete Joint Fillers, Sealers and Waterstop Material
Section 835 - Steel Reinforcement

(b) Special Requirements.

Aggregates from different sources, which are to be used for concrete Class A and Class C as specified in Item 501.02(c)2, may be stockpiled together provided material from each source meets the requirements of Section 801 and the specific gravity of the aggregates from each source does not vary more than plus or minus 0.05.

In the event the coarse aggregate shows a tendency to segregate in the stockpile, the Engineer may order the coarse aggregate be furnished and batched in two fractions from two separate stockpiles.

The Contractor may be required to adjust the size of coarse aggregate for the concrete used around steel reinforcement of heavily reinforced members.

(c) Proportioning Materials.

1. Mixture Design.

The Contractor's concrete producer shall establish the proportion of materials for each class of concrete following the guidelines described in ALDOT-170, "Method of Controlling Concrete Operations for Structural Portland Cement Concrete". It shall be the responsibility of the concrete producer to request approval of concrete mixture design(s) for use in

Department's projects. The Contractor shall submit the proposed concrete mixture no later than 65 Calendar Days after the date of Notice to Proceed. The Department shall be allowed 28 Calendar Days to complete the review and approval of the concrete mixture.

2. Prequalification Requirements for Concrete Mixture Design.

PREQUALIFICATION REQUIREMENTS FOR CONCRETE MIXTURE DESIGN				
Concrete Class	Class A	Class B	Class C	Class D
Minimum 28-Day Compressive Strength (psi) {Mpa}	3,000 {21}	4,000 {28}	3,000 {21}	3,000 {21}
Maximum Water/Cementitious Materials Ratio	0.50	0.45	0.55	0.45
Range of Total Air Content (%)	2.5 – 6.0	2.5 – 6.0	2.5 – 6.0	2.5 – 6.0
Slump (in) {mm}	3.0 {75}	3.5 {90}	3.0 {75}	7.0 {180}
Maximum 28-Day Drying Shrinkage (%)	--	0.04	--	--
Largest Nominal Maximum Aggregate Size (in) {mm}	1.0 {25}	1.0 {25}	1.0 {25}	1.0 {25}
Notes	1, 4	1, 4	4	1, 2, 3, 4

The following notes are applicable to the table of PREQUALIFICATION REQUIREMENTS FOR CONCRETE MIXTURE DESIGN:

Note 1. Concrete mixtures used in marine environment, within 10 miles {16 kilometers} from coastline, completely or partially submerged in seawater, located within the tidal and splash zones, exposed to seawater spray, exposed to brackish water, or as shown on the plans shall have a maximum permeability of 2,000 coulombs and shall include mineral admixtures

Note 2. Seal concrete placed as an integral part of a bridge support system shall have Type II cement. Class "F" fly ash and/or ground granulated blast furnace slag shall be used as a substitute for a portion of the required Type II cement. The minimum substitution rate shall be 20 % for fly ash and 25 % for ground granulated blast furnace slag.

Note 3. Anti-washout admixtures shall be used when placing these mixtures through water.

Note 4. Coarse and fine aggregate gradations used shall meet the gradation requirements given in Section 801 and Section 802. Optimized gradations that do not meet the gradation requirements given in Section 801 and Section 802 shall be submitted to the Materials and Tests Engineer for approval prior to use. 3. Class of Concrete Required for Specific Structures.

Class A - Retaining walls, concrete safety barriers, headwalls, and inlets.

Class B – Box culverts, bridge substructures (poured in place), and bridge superstructures.

Class C - Machine laid curbs, gutters, combination curbs and gutters, slope paving, and miscellaneous concrete units.

Class D - Underwater concrete.

4. Substitution of Higher Strength Concrete and Aggregate Requirements.

Substitution of a higher strength mixture for one of a lower strength may be permitted provided all the prequalification requirements of the higher strength mixture are met and the proposed substitution is requested and approved in writing.

If requested in writing and approved by the Materials and Tests Engineer, the use of No. 357 or No. 467 aggregates may be permitted in Class D mixtures.

5. Mixture Design Prequalification Tests.

For concrete mixtures using portland cement only, the concrete producer shall submit data showing that the total alkali contribution from the cement in the concrete does not exceed 4.00 lb/yd^3 when calculated as follows:

$$lb\ of\ alkali\ per\ Yd^3 = \frac{(lb\ of\ cement\ per\ Yd^3) \times (\%\ Na_2O\ equivalent\ in\ cement)}{100}$$

Permeability tests shall be performed in accordance with the requirements given in AASHTO T 277, "Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration", using a moist-curing period of 56 days.

The 28-day shrinkage test shall be performed in accordance with the requirements given in AASHTO T 160, "Length Change of Hardened Hydraulic Cement Mortar and Concrete", using concrete prisms exposed to drying at a concrete age of 7 days. Three concrete prisms that are 3 x 3 x 11.25 inches {75 x 75 x 286 mm} in size shall be used. The initial reading for drying shrinkage calculations shall be the reading taken at the start of drying at a concrete age of 7 days ± 0.5 hours.

Compressive strength testing shall be performed in accordance with the requirements given in AASHTO T 22, "Compressive Strength of Cylindrical Concrete Specimens", using 6 x 12 inch {152 x 305 mm} cylinders.

Total air content shall be performed in accordance with the requirements given in AASHTO T 152, "Air Content of Freshly Mixed Concrete by the Pressure Method", using a Type "B" meter.

Slump test shall be performed in accordance with the requirements given in AASHTO T 119, "Slump of Hydraulic Cement Concrete".

6. Chemical Admixtures for Concrete.

Any chemical admixtures used in the concrete mixture shall be included in the mixture design proposal. Only approved chemical admixtures listed in List II-1, "Chemical Admixtures for Portland Cement Concrete", of the MSDSAR manual shall be used in Department concrete mixtures. The dosage of chemical admixtures may be adjusted in the field to obtain the desired results, provided the manufacturer's recommended dosage is not exceeded. The use of calcium chloride will not be permitted.

7. Air-Entraining Admixtures for Concrete.

Approved air entraining admixtures are listed in the MSDSAR manual, List II-1, "Chemical Admixtures for Portland Cement Concrete". The total air content shall be within the range of 2.5% to 6.0 % at the point of delivery.

Air content less than 2.5 % will be acceptable for structures that are completely embedded below the ground line or mud line.

The total air content of freshly mixed concrete shall be measured in accordance with the requirements given in AASHTO T 152 using a Type "B" pressure meter. All pressure meters used for measuring the total air content shall be calibrated prior to the beginning of concrete placement. The calibration of pressure meters shall be verified at least twice a week and anytime a questionable result is obtained.

8. Mineral Admixtures for Concrete.

Mineral admixtures may be used in any mixture design except where noted to be prohibited elsewhere. Substitution percentages are calculated by weight.

The maximum substitution of portland cement with mineral admixtures shall not exceed 50 percent. The following table shows the maximum substitution of portland cement with any one mineral admixture substitution.

MAXIMUM PERCENT MINERAL ADMIXTURE SUBSTITUTION FOR PORTLAND CEMENT (substitution by weight)	
MINERAL ADMIXTURE	PERCENTAGE SUBSTITUTION
Class C or Class F Fly Ash (See Note 1)	30 %
Ground Granulated Blast Furnace Slag (See Note 2)	50 %
Microsilica	10 %

Notes to the table of MAXIMUM PERCENT MINERAL ADMIXTURE SUBSTITUTION FOR PORTLAND CEMENT:

Note 1. Class "F" fly ash shall be used when fly ash is required to reduce the heat of hydration.

Note 2. The maximum substitution rate shall be twenty-five percent by weight {mass} when the ambient temperature is 45 °F or below.

9. Slump.

The Engineer may accept any concrete mixture delivered to the field with a slump less than the specified slump if the concrete mixture is workable.

A tolerance of plus 1.0 inches {25 mm} will be acceptable for the mixture delivered at the work site.

Approved Type "F", chemical admixtures may be used to chemically increase the slump of the concrete mixture from the maximum slump specified to a maximum slump of 6.0 inches {150 mm} for Class A, Class B, and Class C concrete. The plus 1.0 in {25 mm} tolerance will not be allowed when Type "F" chemical admixtures are used.

In no case shall the water to total cementitious material ratio specified be exceeded in order to increase the slump and/or adjust the mixture.

Slump shall be measured in accordance with the requirements given in AASHTO-T-119.

10. Concrete Production.

During the progress of the work, the relative proportions between the fine and coarse aggregates, and between aggregate and water, may be varied as needed for best results, but the water to total cementitious material ratio shall not be changed except as noted below:

If it is impossible to produce concrete having the desired consistency the total amount of cementitious material may be increased to achieve the desired consistency provided that the maximum water to total cementitious material ratio is not exceeded and there is no additional cost to the Department.

If the Engineer finds it advisable to increase the minimum design strength of the concrete and orders the cementitious factor increased, the State will reimburse the Contractor for the actual amount only of the additional cementitious material used, based on actual f.o.b. destination, with the additional quantity calculated from the theoretical cementitious factor determined by the Engineer and not from count of bags or weight {mass} used.

The concrete mixture designs shall use Type I, II, or Type IL cement unless otherwise specified. The Contractor may, for his own convenience and without additional compensation, substitute Type III portland cement, provided prior approval is given by the Materials and Tests Engineer.

It shall be the Contractor's responsibility to carry out uniform construction practices, which will produce concrete with the specified plastic concrete properties and of not less than the minimum specified compressive strength. Concrete with compressive strength below the minimum specified compressive strength will be investigated in accordance with ALDOT-170 prior to repairing or removing the affected concrete. Should low compressive strength occur consistently, the Materials and Tests Engineer may order corrective action as deemed necessary, without additional cost to the Department.

Where the conditions require the use of low tricalcium aluminate cement, the plans or proposal will designate Type II portland cement. In such case, if requested and approved in

writing, Type I or Type I/II portland cement or Type IL blended cement containing a maximum of eight percent tricalcium aluminate may be used. Should Type III portland cement be permitted, a maximum of eight percent tricalcium aluminate shall still apply.

(d) Sampling and Inspection.

Production of required aggregate gradation in the concrete mixture shall be the Contractor's responsibility.

Cement, aggregates, water, and chemical and mineral admixtures shall be accepted on the basis of requirements currently listed in the Department's Testing Manual.

The Department reserves the right to take samples of aggregates from stockpiles, cementitious materials from storage bins, and chemical admixtures from storage tanks at the mixing or batching plant and to make further tests as needed as the basis for continued acceptance of the materials.

The Contractor shall furnish, without extra compensation, samples of the materials and the concrete mixture for making tests and test specimens as required to comply with the Department's Testing Manual. Additional testing may be required if deemed necessary by the Engineer.

The Contractor shall furnish, without extra compensation, a protected environment for all concrete test cylinders produced incidental to any placement of concrete. This shall be accomplished by supplying a cylinder curing box with a minimum capacity of 22 test cylinders 6" X 12" {150 mm X 300 mm} in size, equipped with heating/cooling capabilities, automatic temperature control, and a maximum/minimum (high/low) temperature readout. The protective environment shall be capable of protecting all specimens within the following specification requirements and it shall be available at each site when concrete is placed and then maintained until such time that all specimens have been transported from the project to the testing facility. The Engineer, prior to beginning any concrete placement, shall approve each protective environment.

Immediately after being struck off, the concrete test specimens shall be moved to the protective environment where they shall remain for an initial curing period of not less than 24 hours or more than 48 hours. During the initial curing period, the specimens shall be stored in a moist environment at a temperature range between 60 ºF to 80 ºF {16 ºC to 27 ºC}, preventing any loss of moisture for up to 48 hours. At all times the temperature in and between concrete specimens shall be controlled by shielding the specimens from cooling/heating devices and direct rays of the sun.

A temperature record of the specimens shall be established by means of maximum/minimum (high/low) thermometers supplied by the Contractor. Only plastic molds shall be used for concrete specimens to be immersed in water.

Concrete specimens that are to be transported to the laboratory for standard curing within 48 hours shall remain in the molds in a moist environment, until they are received in the laboratory, removed from molds, and placed in standard curing.

Concrete specimens that are not transported to the laboratory for standard curing within 48 hours shall be removed from the molds within 24 ± 8 hours and standard curing used until transported to the laboratory. During the standard curing period, the specimens shall be stored at a temperature of 73 ± 3 ºF {23 ± 2 ºC} using the cylinder curing box defined above. Standard curing shall comply with AASHTO T 23 “Making and Curing Concrete Test Specimens in the Field”, Standard Curing section.

501.03 Construction Requirements.

(a) General.

All materials, labor, equipment, tools, and machinery necessary for forming, mixing, placing, finishing, and curing shall be available as required and all necessary equipment for the proper construction and completion of any section of the work shall be in satisfactory working condition before the Contractor will be permitted to start placing concrete.

All concrete batching plants supplying concrete shall be on List I-7, "Portland Cement Concrete Producers", of the MSDSAR manual. The concrete producer shall submit a valid BMT-75 and proof of NRMCA certification to the Area Materials Engineer prior to batching concrete.

All batching plants shall meet the requirements of the Specifications and ALDOT-352. Producers who request that their batching plants be placed on the list of evaluated ready-mix concrete plants will be charged a fee as specified by ALDOT-355, "General Information Concerning Materials, Sources, and Devices With Special Acceptance Requirements".

(b) Equipment.

1. General.

The Contractor shall furnish equipment capable of producing concrete meeting the requirements noted in this Section in sufficient quantities to provide for orderly construction of the project. All equipment must be in good working order and so maintained throughout the requirement for its use.

Specific requirements for certain types of equipment are designated in subsequent items of this Subarticle.

2. Mixing and Transporting Equipment.

Concrete for all major structure work (bridges, culverts, retaining walls, etc.) shall be "ready-mixed" concrete. Ready-mixed concrete is defined as portland cement concrete manufactured for delivery and delivered to the work site in accordance with AASHTO M 157 "Ready-Mixed Concrete" Modified* and the requirements written herein in other parts of these specifications. In case of discrepancy these specifications shall govern.

*Modification of AASHTO M 157. The requirements of Paragraph 8.1 shall include the following: "Should this method of measuring fly ash or other cementitious materials cumulatively with cement produce unsatisfactory results, it shall be discontinued and separate scales and hoppers provided for these ingredients."

Concrete for minor structure work (headwalls, inlets, junction boxes, and other miscellaneous individual concrete units requiring three cubic yards {3 cubic meters} or less of concrete, along with such items as slope paving, sidewalks, curbs, gutters, and combinations thereof) may be mixed in mixers as noted above or an approved type of mobile mixing plant designed with separate bins for fine aggregate, coarse aggregate, cement, water, additives, etc. that will automatically proportion all concrete aggregates either by weight {mass} or volume and be capable of combining the ingredients into a uniform mass and discharging such without segregation. It shall have approved equipment that will determine the volume of concrete dispatched. Said alternate type mobile mixing plant shall be capable of providing concrete complying with the mixture design requirements noted in Article 501.02. Prior written approval of such alternate equipment shall be obtained before it is allowed on the project. Basis for this approval will be upon the satisfactory performance of the equipment when checked in accordance with the provisions of AASHTO M 241 "Concrete Made by Volumetric Batching and Continuous Mixing". The costs of all materials and labor furnished to perform the above-mentioned test shall be absorbed by the Contractor,

If the Contractor requests to use portable concrete mixers equal or less than 15 cubic feet {0.5 cubic meter}, the Materials and Tests Engineer may approve their use and will furnish written requirements covering such mixers.

All mixing and transporting equipment shall be supplied in sufficient amounts to provide continuous delivery of the concrete as needed for an acceptable, satisfactory operation. The volume of concrete mixed or transported in a concrete truck mixer shall not be less than 15% of the gross volume of the drum.

Concrete transit mixers shall be equipped with either an in-line water meter or a sight gauge to accurately measure the amount of water discharged into the drum. In-line water meters shall be accurate to within ±1.0% of the designated quantity; sight gauges shall be accurate to within ±1.0 gallon. Water measuring devices shall be considered acceptable if the truck has been certified by NRMCA as part of their Delivery Fleet Inspection. The NRMCA Delivery Fleet Certification Card shall be affixed in a prominent location on the truck, such as the windshield or driver's side door. Trucks shall be recertified annually, in accordance with NRMCA policy. The concrete producer shall maintain a record of their NRMCA certified trucks, available for review by the Department at any time. Additionally, the accuracy of water meters and sight gauges shall be verified in accordance with ALDOT-407, "*Verification of Water-Measurement Devices for Concrete Delivery Vehicles*".

Each transit mixer shall be equipped with an approved automatic counter that will record the number of drum revolutions regardless of the drum speed.

3. Vibrators.

Vibrators shall be of an approved internal vibrating type and design, unless the Engineer gives special authorization for other types. Vibrators shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4500 impulses per minute. The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. At least one standby vibrating unit in workable order shall be available before the start of any placement of concrete.

(c) Addition of Water at Jobsite.

Field addition of water to concrete shall be allowed only upon arrival of the truck at the jobsite, if slump tests indicate the mix is too stiff. If water is added, the drum shall be turned an additional 30 revolutions prior to discharging any more concrete. In no instance shall the maximum water-cementitious ratio of the mixture design, or the maximum slump be exceeded. Tests for slump, total air content, temperature & compressive strength shall be run after the addition of water at the jobsite, regardless of any previous testing.

(d) Time, Light and Weather Limitations.

1. Time of Hauling and Placing Concrete.

The delivery and placement of ready-mixed concrete shall be completed within the time frames listed in the following table. These times are measured from the time at which water is added to the cement until the time at which placement of the load is completed.

TIME LIMITATIONS FOR THE DELIVERY AND PLACMENT OF CONCRETE		
Temperature of the Concrete	Mixtures without Retarding Admixtures	Mixtures with Retarding Admixtures
Less than 85 ºF {30 ºC}	1 Hour	1 Hour and 45 Minutes
85 ºF {30 ºC} or More	45 Minutes	1 Hour and 15 Minutes

If Type III portland cement is used, the time limits shall be reduced by 15 minutes. If requested, and approved in writing by the Materials and Tests Engineer, a hydration stabilizer can be used to extend the retardation of set time of concrete.

The Materials and Tests Engineer may permit mixing and the adding of the cement and additives at the work site in truck mixers, in order to meet the time limitation requirements.

When a ready-mixed truck is used for concrete delivery, the concrete shall be completely discharged from the mixing drum before the truck mixer has completed 300 revolutions and or before the above time limitations for placement have been exceeded; whichever happens first.

2. Light.

All concrete shall be placed and finished during daylight hours, unless written permission to the contrary is given. Such permission will not be given unless an adequate approved lighting system is available for all operations after sundown.

3. Weather.

a. General.

The temperature of the concrete, at the time of placing in the forms shall not be less than 50 °F {10 °C} nor more than 95 °F {35 °C}, except that for bridge deck slabs the temperature of the concrete at the time of placing shall not be more than 90 ºF {32 ºC }, unless otherwise provided or directed.

b. Cold Weather Operations.

No concrete shall be placed when the ambient air temperature is below 40 °F {5 °C} without written permission of the Engineer. If the Contractor proposes to place concrete during seasons when there is a probability of temperatures lower than 40 °F {5 °C}, the Contractor shall have available on the project such suitable approved equipment and materials as necessary to enclose the uncured concrete and keep the air

temperature inside the enclosure within the following ranges and for the minimum times noted hereinafter.

If there are indications there will be temperatures below 40 °F {5 °C} during the first three days after placement of concrete, it shall be protected from cold temperatures by keeping the surface at a temperature above 50 °F {10 °C} for the first 72 hours after placement and above 32 °F {0 °C} an additional 72 hours. However, the protective covering shall be retained in place until the temperature inside the protective covering reaches that of the surrounding atmosphere.

When the Contractor is permitted to place concrete at temperatures below 40 °F {5 °C}, the aggregates and/or mixing water shall be heated as necessary to keep the temperature of the plastic concrete above 50 °F {10 °C} from the time of placement to the time of initial set; however, in no case shall the materials be heated in excess of 150 °F {65 °C}, nor shall aggregates from frozen stockpiles be incorporated into the mixture. Materials entering the mixer shall be free from ice, snow, or frozen lumps. Salts, chemicals, or other materials shall not be incorporated in the concrete to prevent freezing. Care shall be taken to heat all materials uniformly and avoid hot spots that will burn or overheat the materials.

The Contractor shall assume all risk and added cost connected with mixing, placing and protecting of concrete during cold weather. Permission given by the Engineer to place concrete during such time will in no way relieve the Contractor of responsibility for satisfactory results. Should it be determined at any time that concrete placed under such conditions is found to be unsatisfactory, it shall be removed and replaced with satisfactory concrete by the Contractor without extra compensation.

c. Hot Weather Operations.

The following hot weather operations practices shall be followed for all concreting done between June 1 and September 15 of each year, and any other time when the temperature of the concrete may be above 95 ºF {35 ºC} or 90 ºF {32 ºC} for bridge deck slabs.

The Contractor shall submit in writing a proposed plan for controlling the concrete mixture temperature during hot weather operations. The hot weather concrete plan shall outline the Contractor's procedures to maintain the temperature of the concrete at or below the temperature requirements noted above, and the Contractor's procedures for transporting, handling, placing, finishing, and curing concrete during hot weather. The hot weather concrete plan shall be submitted at the pre-construction conference to the Area Materials Engineer for approval before any concrete placement is allowed.

During hot weather operations an approved retarder admixture shall be used in the concrete mixture, and the concrete shall be properly placed and finished with the procedures previously submitted by the Contractor. Cooling of the mixing water and/or aggregates or placement during the cooler part of the day may be required to meet the above maximum temperature requirements. In no instance shall a concrete bridge deck slab mixture be placed when the temperature of the plastic concrete is above 90 °F {32 °C}. When the temperature of the steel is greater than 120 ºF {50 ºC}, the steel forms and reinforcement steel shall be cooled prior to concrete placement. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete placing temperature.

(e) Handling and Placing Concrete.

1. General.

In preparation for the placing of concrete, all sawdust, chips, and other construction debris and extraneous matter shall be removed from the interior of forms. Temporary struts, stays, or braces serving to hold the forms in place until the concrete is placed shall be removed prior to being encased in the concrete. All permanent struts, stays, or braces shall be precast concrete struts or, at the Contractor's option, approved steel struts; no wooden struts shall be permitted.

During the placing of concrete, the Contractor shall continuously check the alignment of forms and immediately correct any yielding of the forms or falsework.

Concrete shall be deposited continuously for each monolithic section of the work by placing the fresh concrete in horizontal layers of approximately 12 inches {300 mm} in thickness. Each additional layer shall be placed and compacted before the preceding layer has taken its initial set, 45 minutes for mixtures without retarder and 60 minutes for mixtures with retarder.

For vertical members the maximum height of concrete placement shall not exceed 20 feet {6 m}, except for underwater concrete or when steel forms are used. When structurally sound steel forms are used, concrete placement may be made up to 30 feet {9 m} in height provided that an approved mortar tight downspout of sufficient length to reach within 5 feet {1.5 m} of the bottom of the placed concrete and a vibrator of sufficient length to provide good consolidation throughout the concrete placement are used. Any vertical member exceeding 20 feet {6 m} in height shall be broken into two or more approximately equal concrete placements unless the preceding requirements are met.

When succeeding concrete placements are necessary, the next concrete placement will not be permitted until the concrete in the underlying placed concrete has aged at least 12 hours or attained a minimum compressive strength of 2400 psi {17 MPa} from cylinders prepared in conformity with AASHTO T 23. When a set retarding admixture is used in the preceding concrete placement, the next concrete placement shall not be permitted until a 2400 psi {17 MPa} cylinder strength is attained.

The forms shall not be jarred nor shall any strain be placed on reinforcing bars partially encased in concrete that will cause damage to bond. All accumulations of mortar splashed on the reinforcing steel and surfaces of forms shall be removed before the next concrete placement.

When it is necessary to pump water from the excavation during placing of concrete to deposit the concrete in the dry, the sump for the intake hose shall be located outside the forms.

The use of aluminum pipes, chutes, or other devices made of aluminum that come into direct contact with the concrete shall not be utilized in the handling and placing operations.

a. Use of Chutes, Pipes or Belts.

Concrete shall not be dropped a distance of more than 5 feet {1.5 m} unless confined in an approved mortar tight downspout of not less than 4 inches {100 mm} in diameter. Downspouts shall be equipped with suitable hoppers at their inlet end and shall be provided in sectional lengths that will permit adjustment of the level of the outlet during placement.

The number of downspouts furnished shall be sufficient to ensure the concrete placement in horizontal layers. Depositing large quantities of concrete at one point in the form and running, flowing, or working the concrete along the forms will not be permitted.

In wall sections where a 4 inch {100 mm} downspout cannot be utilized without displacing the reinforcing steel, the concrete may be dropped in excess of the 5 feet {1.5 m} previously noted, provided such does not displace the reinforcing steel nor produce segregation of the concrete.

(1) Chutes, pipes, or power belts may be used to convey concrete from the concrete mixer or transporting vehicle to the forms, and they shall convey it to its final position without segregation and without displacing the reinforcing steel. If the use of this equipment results in honeycombed or otherwise substandard concrete, the Engineer will require it to be changed or its use discontinued.

(2) Chutes, pipes, and power belts shall be flushed with water after each run and this water shall be discharged free of the freshly placed concrete. All hardened concrete shall be promptly removed.

b. Pumping.

Direct placement of concrete by an approved pumping device will be permitted. The equipment shall be so arranged that no vibration result that might damage freshly placed concrete. The operation of the pump shall be such that a continuous stream of concrete

without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After each placement the equipment shall be cleaned to prevent improper results on subsequent operations.

c. Compacting and Vibrating.

Concrete, except underwater concrete, shall be thoroughly compacted by mechanical vibration applied internally, during, and immediately after depositing.

The application of a vibrator or vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms. Vibration shall be supplemented by as much spading as is necessary to ensure smooth surfaces and dense concrete.

The vibrators shall be methodically inserted and withdrawn from the concrete. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but vibrators shall be withdrawn before segregation and localized areas of grout result.

Vibration shall not be applied directly or through reinforcement to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. Vibrators shall not be used to make concrete flow in the forms over distances so great as to cause segregation.

2. Culverts.

See Section 524 for specific details not covered in this Section.

3. Retaining Walls.

See Section 529 for specific details not covered in this Section.

4. Bridges.

See Section 510 for specific details not covered in this Section.

5. Depositing Concrete Under Water.

a. General.

Concrete shall not be deposited in water unless provided for on the plans, or authorized as provided in Subarticle 503.03(g). Concrete placed under water shall be placed as hereinafter provided.

b. Control.

Seal concrete shall be placed continuously from start to finish ensuring the concrete placement being monolithic. The surface of the concrete shall be kept as nearly horizontal as practicable at all times. To ensure bonding, each succeeding layer of seal or foundation concrete shall be placed before the preceding layer has initially hardened. All laitance or other foreign matter shall be removed from the top surface of the concrete, and bonding of construction joints performed in accordance with the requirements given elsewhere in this Section.

c. Placing Methods.

Concrete specified to be deposited in water shall be seal concrete as provided in Article 501.02. To prevent segregation, it shall be carefully placed in a compact mass in its final position by means of a tremie, a bottom dump bucket, pumping, or other approved method. Concrete shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit as nearly as practical.

(1) Use of Tremie.

A tremie shall consist of a rigid, watertight tube of sufficient strength to withstand the stress to which it is subjected and be at least 8 inches {200 mm} in diameter. The tremie shall be supported so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The tremie shall be plugged at the start of work with an approved device capable of separating the concrete from the water until the tube is filled with concrete. The tremie tube shall be kept partially filled with concrete at all times during the concrete placement. When a batch is

dumped into the hopper, the flow of concrete shall be induced by slightly raising the tremie, always keeping the discharge end in the deposited concrete. The flow shall be as nearly continuous as possible and in no case shall it be intentionally interrupted until the entire seal concrete foundation work is completed.

(2) Use of Bottom Dump Bucket.

The bottom dump bucket shall have a capacity of not less than 0.5 cubic yards {0.5 m³} and be mechanically equipped to prevent dumping until it rests on the foundation or previously placed concrete. The bucket shall be completely filled and lowered very carefully until it rests upon the foundation or concrete already placed so as not to get a wash over the bucket top. It shall then be raised very slowly during the discharge travel, the intent being to maintain as nearly as possible, still water at the point of discharge and to avoid agitating the mixture; also to allow the concrete to be deposited by the time the bucket emerges from the concrete already on the foundation.

(3) Pumping.

In addition to the requirements given elsewhere in this Section, the following shall also apply for placing concrete under water by pumping. Concrete may be pumped into a tremie, or directly to the point of placement. If the concrete is pumped directly to the point of placement, a rigid pipe shall be provided that must extend a minimum of 5 feet {1.5 m} above the water level when resting on the bottom of the excavation. A flexible hose suitable for pumping concrete may be used from the top of the rigid pipe to the concrete pump. The method of placing and handling the concrete shall be as described elsewhere in this Section.

(f) Construction Joints.

1. General.

Construction joints shall be placed only at the locations shown on the plans or as directed. In case of an emergency, if a construction joint is permitted, it shall be placed as approved by the Engineer.

2. Horizontal Joints.

Generally, horizontal joints shall be made by placing the concrete slightly above the grade of the construction joint, and after the surface has reached its final set, the surface shall be prepared as outlined in Item 4 below. Insert formwork shall be used to obtain neat, horizontal lines.

3. Vertical Joints.

Vertical joints shall be formed with substantial bulkheads or headers as required. Feather-edged joints will not be permitted.

4. Bonding.

Before placing concrete against any construction joint, the surface of the hardened concrete shall be scarified in such a manner that all foreign matter, laitance, and loose material is removed to expose sound concrete. The prepared concrete at the construction joint shall be kept wet for a minimum of one hour prior to placing concrete against it. An approved epoxy, listed in the MSDSAR manual, List II-7, "Epoxy Resin Systems for Use with Portland Cement Concrete", shall be placed for bonding freshly mixed concrete to hardened concrete. Keyways and dowels shall be placed as shown on the plans or directed.

5. Water Stops.

Water stops shall be furnished and placed as required by the plans. They shall form continuous watertight joints.

(g) Expansion Joints.

All joints shall be constructed according to details shown on the plans, providing the design width designated for the expansion joint. The insertion and removal of joint forming material shall be accomplished without chipping or breaking the corners of the concrete. Expansion material, when required, shall be placed as shown on the plans.

(h) Forms.

1. General.

Reference is made to Article 105.02 concerning working drawings and other details that require submission.

Forms shall be substantial and unyielding and so designed and constructed that the finished concrete will conform to the plan dimensions and contours within tolerances listed in other portions of these Specifications.

Basic bridge plan design is for removable forms and plan concrete quantities computed accordingly. Hence, removable forms are to be used unless stay-in-place forms are allowed by contract plan notes and details. When shown by contract plan details, the Contractor will be allowed the option of using permanent steel forms under deck slabs between girders, beams or stringers provided the cost of extra concrete and materials required by this type of form is at the Contractor's expense.

2. Design.

a. Removable Forms.

All removable forms shall be designed so that they may be removed without damage to the concrete. Forms shall be so constructed that portions where finishing is required can be removed for that purpose without loosening supports or disturbing portions of forms that must still remain in place.

b. Permanent Steel Bridge Deck Forms.

The forms and supports shall be zinc coated (Galvanized) steel conforming to ASTM A 653 with coating Class of G165 according to ASTM A 525 and shall otherwise meet all requirements relevant to permanent steel forms and the placing of concrete as specified herein and as noted on the plans. Miscellaneous fastener hardware (bolts, nuts, metal screws, and washers) shall be common stock hardware items galvanized to provide a zinc coating equal to or better than that required by ASTM B 633.

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 {2.4 kN/m²} for construction loads. The unit working stress in the steel shall not be more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 36,000 pounds per square inch {250 MPa}. The uncoated thickness of the forms shall not be thinner than 0.0359 inch {0.9 mm}.

(2) Deflection under the weight {mass} of the forms, the plastic concrete, and reinforcement shall not exceed 1/180 of the form span or 0.5 inches {13 mm}, whichever is less, but in no case shall this loading be less than 120 pounds per square foot {5.7 kN/m²} 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 {50 mm} 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) The plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete deck shall be maintained. A minimum concrete cover of 1 inch {25 mm} shall be maintained for the bottom slab steel.

(6) Forms shall not be welded to any part of the structural steel main members (the definition of "main members" is given in Section 836. The installation of forms may be done by welding attachment straps together if backing plates are installed under the straps. The backing plates shall be thick enough to prevent burn-through. The width of the backing plates shall be at least one inch wider

than the width of the welded attachment straps so that the backing plates extend out at least one half inch beyond each edge of the welded straps.

3. Construction.

a. Removable Forms.

(1) Forms shall be mortar tight and placed and maintained true to designated lines and grades until the concrete has been placed and hardened. Forms found unsatisfactory in any respect shall not be used and, if rejected, shall be removed from the immediate work site.

(2) All moldings, panel work, and bevel strips shall be straight and true with neatly mitered joints and all corners in the finished work shall be true, sharp, and clean cut and of good workmanship. Forms shall be filleted and chamfered at all sharp corners except where angles exceed 90°, such as at the face of bridge curbs and deck overhangs. Unless otherwise shown on the plans, the equal sides on triangular molding or chamfer shall be 0.75 inches {19 mm}, except that for small members the width shall be 0.5 inches {13 mm}.

(3) For narrow walls, columns, et cetera, the Engineer may require daylight and inspection holes at vertical intervals as directed.

(4) Bolts or ties shall be used to prevent forms from spreading. All such bolts or ties shall be arranged so that at least 1 inch {25 mm} of that part adjacent to the concrete surface can be removed or broken off.

(5) Anchor devices may be cast in the concrete for later use in supporting forms only if they are detailed on approved formwork or falsework plans.

(6) The inside of all forms shall be coated with a non-staining oil or other approved material to prevent the concrete adhering to them. Extreme care shall be exercised to ensure that form oil does not come in contact with structural or reinforcing steel.

(7) The forms shall be inspected before placing the concrete and the interior dimensions carefully checked to ensure that the concrete will be of the form and dimensions shown on the plans. The inside faces of the form shall be thoroughly examined and any projections, ridges, depressions, offsets, spaces or other unevenness corrected so that the surface of the concrete will be smooth, even and true, and mortar tight. All forms shall be wetted immediately prior to placing the concrete, but no excess water shall remain in the forms.

(8) To permit proper surface finishing, forms shall be removed as soon after the concrete has set as is practicable and safe. In the determination of the time for the removal of forms, except those listed elsewhere in this Section, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the setting of the concrete, and the material used in the mixture. Methods of form removal likely to cause over-stressing of the concrete shall not be used. Forms shall not be removed without the approval of the Engineer.

b. Permanent Steel Bridge Deck Forms.

(1) All forms shall be installed in a manner acceptable to the Engineer.

(2) On steel members, form sheets will not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 inch {25 mm} at each end. Form supports shall be placed in direct contact with the flange of stringer or floor beam. The installation of attachment straps, shelf angles, and forms shall be carefully monitored to make sure that no welding (weld, arc strike, etc.) is done to the structural steel.

On concrete girders, form supports to be cast into the girders shall be shown on the shop drawings. All attachments to form supports shall be made by permissible welds, bolts, clips, or other approved means. Attachment by welding to form

supports may be performed by non-ALDOT qualified welders with welding electrodes recommended by the form manufacturer.

All form welds shall be cleaned of slag and wire brushed just prior to placing of the deck concrete.

(3) Any permanently exposed form metal where the galvanized coating has been damaged shall be thoroughly cleaned, wire brushed, and painted with two coats zinc oxide-zinc dust primer, Federal Specification TT-P-641, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds need not be touched up.

(4) Transverse construction joints shall be located at the bottom of a flute and 0.375 inch {10 mm} weep holes shall be field drilled at not more than 12 inches {300 mm} apart along the line of the joint. If a bridge is on a skew, or in a curve, a weep hole shall be drilled in the bottom of each flute the joint crosses.

(i) Falsework.

1. Design and Construction.

a. General.

For the purpose of this specification, falsework shall be divided into two classes as follows:

Class 1 - Common or simple falsework such as temporary bracing to provide stability for bridge girders, permanent steel bridge deck forms, deck overhang supports, screed rail support systems, or substructure supports attached to permanent parts of the structure (i.e. drilled shafts, columns, caps, etc.).

Class 2 - Unique or complex falsework such as that required for box girder construction, RCDG construction, structural cofferdams, or any falsework used in connection with steel erection.

The Contractor shall be responsible for designing and constructing safe and adequate falsework which provides the necessary strength and rigidity, supports all loads imposed, and produces a finished structure with lines and grades shown on the plans. Falsework shall be designed and constructed to withstand all imposed loads during erection, construction, usage, and removal.

The Contractor shall submit to the Construction Engineer working drawings and design calculations for falsework in accordance with Article 105.02.

For both classes of falsework drawings, the Construction Engineer will verify that the licensed Professional Engineer signature and stamp requirements of Subarticle 105.02(d) are met. Class 1 drawings will be stamped for distribution and then distributed. Class 2 drawings will be forwarded to the Bridge Engineer for review to determine if the results of the licensed Professional Engineer's calculations are in compliance with design criteria. If the design criteria are met, the submittal will be returned to the Construction Engineer to be stamped for distribution and then distributed.

All falsework will be inspected by the Project Manager using the distributed drawings. For all Class 2 falsework, the licensed Professional Engineer who signed the falsework submittal shall verify that the falsework as constructed meets all design criteria prior to any load being placed thereon. A signed statement from the licensed Professional Engineer covering the verification shall be furnished to the Project Manager by the Contractor.

When falsework of either class is to be used over highway, pedestrian, or railroad traffic, additional details will be required to provide for special protection to prevent debris from falling on the traffic below. These additional details will be required for both removal and construction work.

All falsework drawings shall include a description and size of all members, connections, and miscellaneous hardware. When pre-manufactured assemblies are used, all parts shall be easily identified as those shown on the drawings.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Screw jacks and/or

hardwood wedges shall be used to take up any settlement in the formwork either before or during the placing of concrete.

Any part of the permanent structure to which falsework will be attached shall attain a minimum compressive strength of 2400 psi {17 MPa} from cylinders prepared in conformity with AASHTO T 23 prior to the attachment.

Falsework that cannot be founded on a satisfactory footing shall be supported on piling, which shall be spaced, driven, and removed in an approved manner.

All spans shall be given a temporary camber to allow for deflection, shrinkage, and settlement. Bridges shall have a permanent camber only where so shown on the plans or directed.

b. Design Criteria.

Falsework shall be designed to withstand all imposed loads during erection, construction, usage, and removal. Designs shall be based on minimum loads, maximum stresses and deflections, and conditions in the following paragraphs. Allowable stresses are based on use of undamaged, high quality materials. The contractor shall reduce stresses if lesser quality materials are used.

Design Loads for falsework shall consist of the sum of dead and live vertical loads and assumed horizontal loads. Minimum total design load for any falsework shall not be less than 100 pounds per square foot {4.8 kN/m²} for the combined live and dead load regardless of slab thickness.

Dead Loads shall include weight {mass} of concrete, reinforcing steel, forms, and falsework. Weight {mass} of concrete, reinforcing steel, and forms shall not be assumed to be less than 160 pounds per cubic foot {25 kN/m³}.

Live Loads shall consist of the actual weight {mass} 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 20 pounds per square foot {0.960 kN/m²} applied over the area supported plus 75 pounds per linear foot {1.1 kN/m} applied at the outside edge of deck overhangs.

Horizontal Loads applied shall be the sum of the actual horizontal loads due to equipment, construction sequence, or other causes and an allowance for wind, but in no case shall the design horizontal load to be resisted in any direction be less than two percent of the total dead load. Falsework shall be designed of sufficient rigidity to resist the design horizontal load prior to placement of concrete.

Falsework Foundations shall be designed to carry the loads imposed on them without exceeding allowable soil bearing values and anticipated settlements.

Maximum allowable stresses, loadings, and deflections used in design of falsework shall be as follows:

TIMBER	
Compression perpendicular to the grain (Dense Select Structural Grade Southern Pine)	450 psi {3 MPa}
Compression parallel to the grain but not to exceed 1600 psi {11 MPa}	480,000/(L/D)^2 psi {3300/(L/D)^2 MPa}
Flexural stress reduced to 1500 psi {10 MPa} for members with a nominal depth of 8 inches {200 mm} or less.	1800 psi {12 MPa}
Horizontal shear (Dense Select Structural Grade Southern Pine)	90 psi {0.620 MPa}
Deflection due to weight {mass} of concrete.	1/240 of clear span irrespective of the fact that the deflection may be compensated for by camber strips.
Timber piles, maximum loading (12 inch {300 mm} Butt Diameter)	24 tons {213 kN}

STEEL	
Deflection due to weight {mass} of concrete irrespective of the fact that the deflection may be compensated for by camber strips.	1/240 of clear span
Stresses shall not exceed those specified in the Manual of Steel Construction as published by the AISC. When the grade of the steel cannot be positively identified, design stresses shall conform to either those specified in said AISC Manual for ASTM A 36 steel or the following:	
Tension, axial and flexural.	22,000 psi {152 MPa}
Compression, flexural (But not to exceed 22,000 psi {152 MPa})	12,000,000 / (LD/bt) psi {83 000/ (LD/bt) MPa}
Compression, axial.(Except L/r shall not exceed 120.)	16,000 - 0.38$(L/r)^2$ psi {110 - 0.38$(L/r)^2$ MPa}
Shear on gross section of the web of rolled shapes.	14,500 psi {100 MPa}
Web crippling for rolled shapes	27,000 psi {186 MPa}

In the foregoing formulas, L is the unsupported member length, D is the least dimension of rectangular columns, or the width of a square of equivalent cross sectional area for round columns, or the depth of beam, b is the width of member, t is the thickness of the compression flange and r is the radius of gyration of the member. E, modulus of elasticity, used for timber shall be 1.6 X 10^6 psi {11 GPa} and for steel shall be 30 X 10^6 psi {200 GPa}.

Any additional design criteria, which may be needed, shall be developed by the Contractor's licensed Professional Engineer designer and included with the calculations of the falsework submittal.

Falsework over or adjacent to roadways or railroads which are open to traffic during construction shall be designed and constructed such that it is stable if subjected to vehicular impact or features shall be provided to protect falsework supports from vehicular impact. Protection shall be designed such that it does not present a hazard to vehicular traffic.

Design criteria for permanent steel bridge deck forms shall be as shown elsewhere in this Section.

2. Removal of Falsework.

No falsework supporting concrete shall be removed or wedges loosened without the consent of the Engineer.

If adequate test cylinders have been made, falsework may be removed when the cylinders indicate that the concrete has developed a minimum compressive strength of 2400 psi {17 MPa}, otherwise falsework shall be removed according to the following time limitations.

Falsework may be removed after expiration of 14 days exclusive of days when for four hours or more the temperature is below 40 °F {5 °C}. Falsework under slabs of less than 6 foot {2 m} span may be removed after seven days with the same temperature limitations.

Falsework shall be gradually and uniformly released in such a manner as to avoid injurious stresses in any part of the structure. Wedges shall be removed first under slabs and transverse beams, starting at the center of the span and working both ways; then wedges under longitudinal girders and beams shall be removed also starting at the center of the span and working both ways simultaneously.

All falsework piles, at the time of removal or cleanup, shall be pulled out or cut off at an elevation not more than 6 inches {150 mm} above the bed of the stream. Piles not in water shall be removed or cut off flush with or below the ground surface of stream bed. Piles within roadbed limits shall be cut off at least 3 feet {1 m} below subgrade elevation. Other piles within roadway limits shall be cut off at least 12 inches {300 mm} below the finished surface of the front slope, ditch, or backslope.

(j) Curing Concrete.

1. Exposed Surfaces.

Whenever the Engineer determines that weather conditions are such that evaporation from the surface may cause shrinkage cracking, a fog or mist spray may be required at intervals as needed during and after finishing until curing material can be applied so that the surface will be at all times damp but not excessively wet.

The Contractor shall give careful attention to the proper curing of the concrete. All surfaces not covered by forms shall be protected with an approved membrane curing compound, from List II-30 of the MSDSAR manual, dampened burlap, Polyethylene Film* (White Opaque), White Burlap -Polyethylene Sheet*, cotton mats, or wetted sand, as soon after placing the concrete as possible without marring the surface, except for bridge deck slabs which shall be treated as noted in Item 2 below. Immediately upon removal of forms, other surfaces shall be treated by one of the approved curing methods.

Unless membrane curing compound is used, all curing materials shall be kept wet and shall remain in place for seven days, except that small portions may be temporarily removed during actual finishing operations.

*Note: When polyethylene film or white burlap-polyethylene sheeting is used, it shall be installed and maintained in such a manner that a complete, moisture-tight enclosure over the surface to be cured will be provided. These materials shall meet the requirements noted in Section 830.

2. Bridge Deck Slabs.

a. General.

Prior to placing a bridge deck slab, the evaporation rate shall be determined by use of the graph in Figure 1, "Evaporation Rate of Surface Moisture", and recorded on form BMT-171, *"Evaporation Rate Record"*. The Contractor shall furnish the equipment necessary to measure the air temperature (ambient), wind velocity, and humidity. The equipment or a manufacturer's certificate of calibration showing the equipment's model number and serial number shall be submitted to the Area Materials Engineer no less than 14 days prior to their use. The equipment shall consist of the following instruments with the following specifications.

(1) Anemometer:
Range – 0-25mph {0-40 km/hr}.
Accuracy – plus or minus 1.5%.
Units – U.S. Customary and Metric.

(2) Hygrometer:
Range – 10-95% relative humidity.
Accuracy – plus or minus 1.5%.
Units - U.S. Customary and Metric.
Certified and traceable to N.I.S.T.

(3) Thermometer:
Range – 0-140 °F {0-60 °C}.
Accuracy – plus or minus 2 °F {plus or minus 1 °C}
Units - U.S. Customary and Metric.

Combination instruments such as anemometer and thermometer or hygrometer and thermometer will be accepted provided they meet the above requirements.

If the placement is expected to last more than two hours, the evaporation rate shall be checked and recorded on form BMT-171 at two-hour intervals or less. To prevent plastic shrinkage cracking, the expected evaporation rate shall not exceed 0.2 pounds per square foot per hour {1.0 kg/m^2/hour}. When the evaporation rate exceeds this amount, the Contractor shall be required to effectively reduce the rate to within the allowable limits by taking one or more of the following actions:

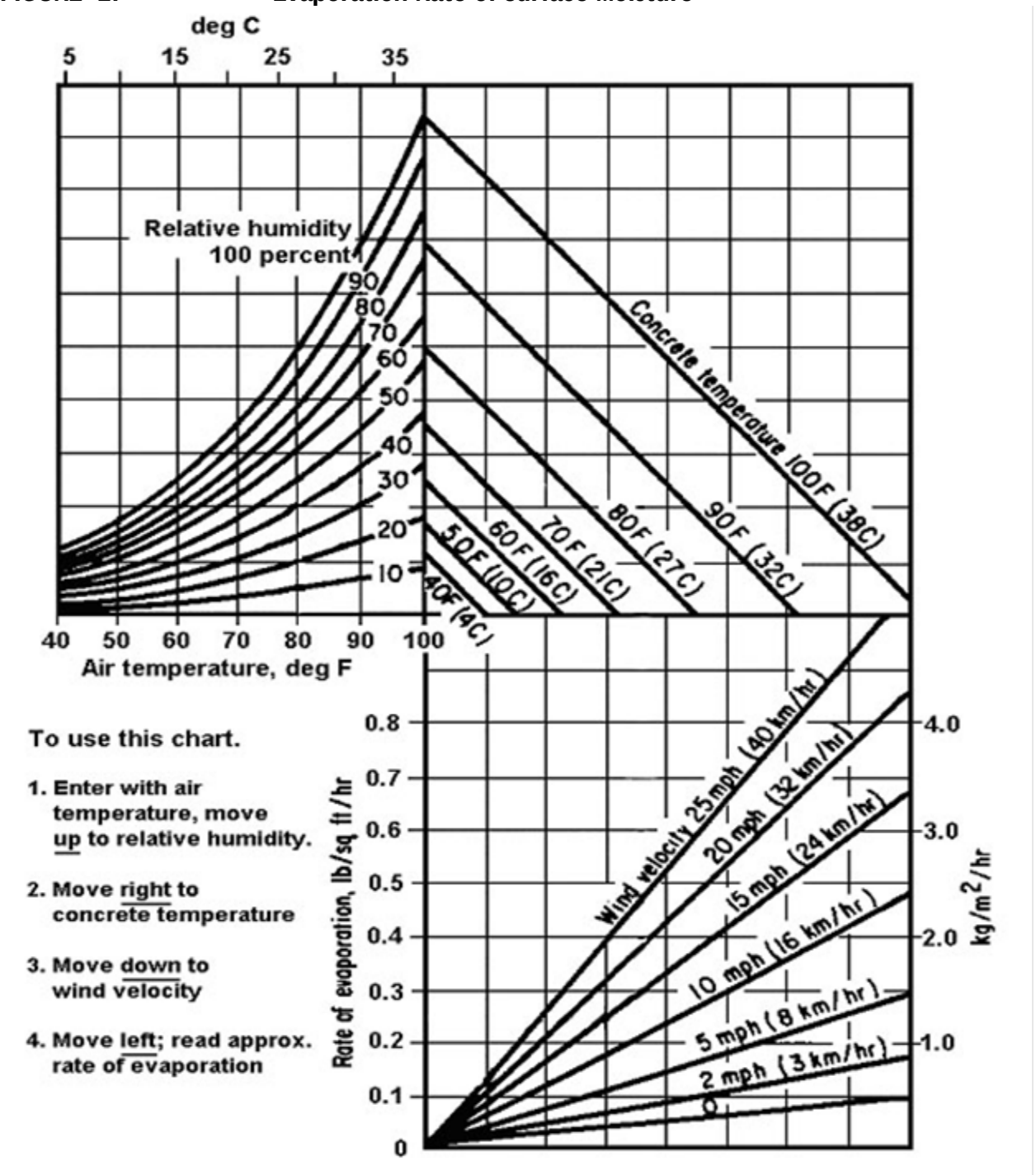
(1) Construct windbreaks or enclosures to effectively reduce the wind velocity throughout the area of placement.

(2) Use fog sprayers or sprinklers upwind of the placement operation to effectively increase the relative humidity.

(3) Reduce the temperature of the concrete.

The Department will evaluate plastic shrinkage cracks that occur. Remedial measures shall be performed as directed by the Engineer. Plastic shrinkage cracks shall never be troweled over or filled with slurry.

FIGURE 1. Evaporation Rate of Surface Moisture



b. Evaporation Control After Screeding.

Continuous fogging or an evaporation barrier (monomolecular) material shall be used for all bridge deck curing beginning immediately after the screeding operations have been completed for sections of the deck not to exceed five feet from the starting location.

If fogging is to be used, a continuous fog or mist spray shall be maintained until the moist curing procedures described elsewhere in this Section begin. Intermittent fogging is not acceptable if there is drying of the concrete surface. If water begins to pond on the deck, the Contractor shall adjust the rate of fogging to minimize the ponding of water.

If an evaporation barrier material is to be used, it shall be applied immediately behind the screeding operation and in accordance with the manufacturer's recommendations. The entire top portion of the concrete slab shall be covered with the barrier material applied under pressure at a rate of one gallon {liter} to not more than 200 square feet {5 m^2} of fresh concrete. Application shall be done with an industrial type sprayer in such a manner as to cover the surface being treated with a uniform film.

c. Moist Curing After Finishing.

Immediately after the finishing operation, concrete bridge decks shall be moist cured for seven days by maintaining a moist condition for the entire curing period. This may be accomplished by one of the following methods:

(1) Fog spraying or sprinkling with nozzles or sprinklers. When using this method, the Contractor shall maintain a complete and continuous moist condition of the concrete surface. Intermittent sprinkling is not acceptable. Care shall be taken that erosion of the surface does not occur.

(2) Saturated burlap, saturated plastic coated burlap, or cotton mats. These curing materials shall be clean and free from any injurious substances that can cause deleterious effects to the concrete or cause discoloration. The burlap or cotton shall be completely saturated before being placed on the concrete and shall be maintained in that condition for the entire curing period. Should tears or holes appear in the mat sheets, they shall be repaired immediately. All edges of burlaps and mats shall extend at least 18 inches {450 mm} beyond the concrete surface. Where two individual sheets join, their edges shall overlap at least 12 inches {300 mm}. All edges and overlaps shall be secured to ensure that the concrete surface is completely covered during the entire curing period. These curing materials shall be kept in contact with the concrete surface at all times. Alternate cycles of wetting and drying shall be avoided because this may result in pattern cracking.

Prior to the start of the curing operation, the contractor shall have an approved curing system that ensures continuous moist curing of the concrete for 24 hours per day.

If water or the chosen curing material stains or discolors concrete surfaces, which are permanently exposed, the contractor shall be responsible for cleaning the surfaces. When wooden forms are left in place during curing, they shall be kept wet at all times. If steel forms are used in hot weather, non-supporting vertical forms shall be broken loose from the concrete and curing water continually applied in this void. If the forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces.

3. Protection of Concrete during Curing.

Green concrete shall be protected against jarring or other movement that might cause damage. No traffic or other superimposed load will be permitted over bridges or culverts until the following criteria have been met:

(1) Bridges - The concrete shall have reached a minimum 4000 psi {28 MPa} compressive strength as determined from test cylinders.

(2) Culverts - The culvert concrete shall have reached a minimum of 4000 psi {28 MPa} compressive strength as determined from test cylinders or 28 days have passed since the last concrete was placed exclusive of days when for 4 hours or more the temperature is below 40 °F {5 °C}.

(k) Finishing Concrete.

1. General.

The details set forth hereinafter in this Subarticle cover the requirements for the several classes of surface finishes which shall be applied to the various parts of concrete structures.

These various classes of surface finishing will be used in accordance with the following:

Class 1 - required on all concrete surfaces except wearing surfaces and surfaces placed in direct contact with natural ground or embankment.

Class 2 - required on all exposed concrete surfaces within the requirements noted elsewhere in this Section unless another class is specified.

Class 3 - may be used on designated bridge structures when specified by plan details.

Wearing surface finish for bridge deck travelway shall be as specified in Subitem 510.03(c)6.c. and for sidewalks as specified in Item 510.03(c)7.

Exposed surfaces or sidewalks, driveways, curbs, and gutters shall have a textured finish obtained by the use of a burlap or cotton drag, brush, or broom so that a uniform gritty texture is obtained. Exposed surfaces of concrete flumes and slope paving shall have a float finish.

2. Class 1 Finish (Ordinary Surface Finish).

This class finish will require the concrete surface to be free from objectionable projections, swells, fins, ridges, depressions, waves, holes, and other defects. This will require that immediately after the forms are removed, metal ties shall be removed for a minimum depth of 1 inch {25 mm} from the face of the concrete. All cavities or depressions resulting from this removal, or from other causes, shall be carefully filled and pointed with a mortar of sand and cement, and the surface left smooth and even. The proportion of cement to sand, measured by volume, shall be one to two unless otherwise specified. The surface film of all pointed areas shall be carefully removed before setting occurs. Any fins, ridges, or projections shall be struck off smooth with the surface of the concrete. Particular care shall be taken throughout the progress of this operation to use one of the curing methods covered elsewhere in this Section.

If a Coated Surface Finish is to be applied in a later finishing operation, the coating material may be used in lieu of mortar to fill small air holes in the concrete surface; however, this must be given time to take a set prior to applying the Coated Surface Finish.

3. Class 2 Surface Finish.

a. General.

This class surface finish requires that, in addition to a Class 1 finish, the exposed surfaces of bridges, culverts, headwalls, inlets, etc. as defined in the Subitem d. below, receive an additional surface finish in accordance with the following:

If only one brand and type of cement from the same mill is used in a structure or unit (substructure or superstructure), the Contractor may elect to either apply a Rubbed Surface Finish or apply an approved coated Surface Finish.

If more than one brand of cement is used in a structure, the Contractor shall apply a Coated Surface Finish.

The same type of surface finish shall be used throughout the entire structure unless otherwise authorized in writing by the Engineer.

b. Rubbed Surface Finish.

As soon as the Class 1 surface finish has been completed and the pointing has set sufficiently to permit it, the entire surface except chamfers shall be wetted with a brush and rubbed with a No. 16 carborundum stone or an abrasive of equal quality, bringing the surface to a paste. The rubbing shall be continued sufficiently to remove all form marks and projections, producing a smooth dense surface without pits or irregularities. The material, which in the above process has been ground to a paste, shall then be carefully spread or brushed uniformly over the entire surface and allowed to take a reset. Curing shall continue on this surface as noted to be required elsewhere in this Section.

The final finish shall be obtained by a complete rubbing with a No. 30 carborundum stone or an abrasive of equal quality. This rubbing shall continue until the entire surface is of a smooth texture and uniform in color.

c. Coated Surface Finish.

Only Departmental approved coated finishing materials may be used. The coating material shall be one of the coating materials shown on List III-3, "Surface Coatings for Portland Cement Concrete". This list is given in the Department's Manual, "Materials, Sources, and Devices with Special Acceptance Requirements".

The application of the coating shall be in an approved manner (normally in accordance with the manufacturer's recommendations) by competent and experienced personnel. The overall coated finish shall be uniform in coverage, texture, and color after the coating material has taken set and cured. Failure to obtain uniformity of coverage, texture, and color shall be cause for the Engineer to require such remedial action as deemed necessary to obtain the desired results.

The following actions shall be taken before the application of any coated finish:

A Class 1 surface finish shall be applied and all pointing completely set.

Surface shall be cleaned and free from foreign matter.

If membrane curing compound was used to cure the concrete, the curing compound shall have weathered for a minimum time period of six weeks. Special care shall be taken to ensure that areas not to be treated are protected to prevent treatment from overlapping onto these designated areas.

d. Exposed Surfaces.

Exposed surfaces for this class finish is defined as all surfaces, including bottom chamfers and fillets except (1) the wearing surface of roadway slabs and sidewalks, (2) those surfaces having immediate contact with embankment or excavation, (3) those surfaces below low water level and/or below newly established ground line after backfilling excavation or excavated channels, (4) underside and interior faces of girders, beams, and slabs, and underside of sidewalks where the edge beam extends 3 inches {75 mm} or more below the bottom of the sidewalks, (5) top and bottom surfaces of all type caps, and (6) those parts of minor structures, box culverts, and bridge culverts that are not readily visible from a travelway.

4. Class 3 Surface Finish.

This class surface finish requires that, in addition to the Class 1 surface finish, only the designated exposed surfaces of a bridge structure noted below be given an additional finish of either a rubbed or coated finish in accordance with the requirements given elsewhere in this Section.

Exposed surfaces shall be defined as the inside, top, and outside surfaces of barrier rail to bottom of slab overhang, and all portions of the bridge abutments outside the edge of the exterior girders that are not in immediate contact with embankment or excavation. All other structure surfaces, exposed and unexposed, shall receive a Class 1 finish immediately after the forms are removed.

(l) Concrete for Precast Non-Prestressed and Prestressed Members.

Concrete for precasting shall meet the requirements given in this Section unless amended by concrete requirements given in other Sections.

Additional requirements are given in Section 512 and ALDOT-367 for the concrete required for precast non-prestressed concrete bridge members. Additional requirements are given in Section 513 and ALDOT-367 for the concrete required for precast prestressed concrete bridge members.

501.04 Inspection.

(a) General.

The Contractor shall give the Engineer sufficient advance notice before starting to place concrete in any section of a structure to permit the inspection of forms, placing of steel reinforcements, and of preparation for placing. Any defective falsework or forming shall be

corrected, or removed and replaced as necessary to the satisfaction of the Engineer, all at the expense of the Contractor.

Authorization of the Engineer shall be secured before concrete is placed in any portion of a structure. Any concrete placed in violation of this provision, or in the absence of the Inspector, shall be removed and replaced at no additional cost to the State.

(b) Removable Forms.

After the forms have been removed, any defective work discovered shall be removed and replaced in a satisfactory manner. If the surface of the concrete is bulged, sagged, uneven, or honeycombed to such an extent that it cannot be satisfactorily repaired, the entire section shall be removed and replaced, at no additional cost to the State.

(c) Stay In Place Steel Forms.

After the deck concrete has been in place for a minimum period of two days, the concrete, if deemed necessary by the Engineer, shall be tested for soundness and bonding of the forms by sounding with a hammer as directed by the Engineer. The number and locations of the forms to be tested shall be as selected by the Engineer. If areas of doubtful soundness are disclosed by this procedure, the Contractor will be required to remove the forms from such areas for visual inspection after the concrete has attained a minimum compressive strength of 2400 psi {17 MPa}. Care shall be exercised to distinguish the sound of broken bond from the sound of defective concrete.

At locations where sections of the forms are removed, the Contractor will not be required to replace the forms, but the adjacent metal forms and supports shall be repaired to present a neat appearance and assure their satisfactory retention. As soon as the forms are removed, the concrete surfaces will be examined for cavities, honeycombing, and other defects. If irregularities are found, and in the opinion of the Engineer these irregularities do not justify rejection of the work, the concrete shall be repaired as the Engineer may direct. If the concrete where the forms are removed is unsatisfactory, additional forms, as necessary, shall be removed to inspect and repair the slab, and the Contractor's methods of construction shall be modified as required to obtain satisfactory concrete in the slabs. All unsatisfactory concrete shall be removed or repaired as directed by the Engineer.

The Contractor shall provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedures. No additional compensation will be allowed the Contractor for compliance with the above inspection procedures.

501.05 Acceptance of Concrete.

(a) General.

Certified Concrete Technicians, as required by the Department, shall perform all concrete inspections and testing. Procedures for technician certifications and laboratory qualifications are described in ALDOT-405, "Certification and Qualification Program for Concrete Technicians and Concrete Laboratories".

Fresh concrete will be accepted on the basis of slump, total air content, and temperature meeting the requirements specified for the Class of concrete.

Hardened concrete shall be accepted on the basis of compressive strength meeting the requirements specified in Item 501.02(c)2 for that Class of concrete.

Compressive strength from concrete cylinders will be accepted when the average of two consecutive cylinder test results, obtained at the same age, equals or exceeds the specified 28-day compressive strength, and neither cylinder test result is below 95% of the specified 28-day compressive strength.

(b) Substandard Concrete.

1. General.

The Department will investigate any concrete not meeting the acceptance requirements outlined in Subarticle 501.05(a). Concrete investigations will be used to determine the suitability of potentially substandard concrete. This investigation may include any or all of the procedures outlined in ALDOT-457.

The combined results of the Department’s investigations will be used to assess the acceptability or rejection of potentially substandard concrete.

If the investigation results show that the concrete fails to meet the contract requirements, the Contractor shall be responsible for the cost of the investigation to include, but not limited, to per-diem, travel expenses, and sampling and testing.

In instances where the Department determines it is impractical or unfeasible to core the in-place concrete represented by substandard cylinder breaks, the concrete will be accepted with a price adjustment equivalent to the cylinders' percentage of the specified 28-day compressive strength. If the average 28-day compressive strength of the cylinders is less than 70% of the specified 28-day compressive strength, the concrete will be rejected.

The price adjustment will be applied to the applicable pay item for the number of cubic yards represented by the low breaks.

2. In-Place Compressive Strength.

If the Department deems it necessary, a core investigation, as described in ALDOT-457, will be performed to determine the average equivalent 28-day compressive strength of the in-place substandard concrete.

If the average equivalent 28-day compressive strength of the cores is equal to or greater than 90% of the specified 28-day compressive strength, the concrete will be accepted with no price adjustment.

If the average equivalent 28-day compressive strength of the cores is 85% or greater but less than 90% of the specified 28-day compressive strength, the concrete will be accepted with an 85% price adjustment. The price adjustment will be applied to the applicable pay item for the number of cubic yards represented by the low breaks.

If the average equivalent 28-day compressive strength of the cores is 75% or greater but less than 85% of the specified 28-day compressive strength, and the Engineer deems the concrete to be structurally acceptable, the concrete will be accepted with a 50% price adjustment. The price adjustment will be applied to the applicable pay item for the number of cubic yards represented by the low breaks.

If the average equivalent 28-day compressive strength of the cores is less than 75% of the specified 28-day compressive strength, the concrete will be rejected.