

SECTION 501

PORTLAND CEMENT CONCRETE

~~04~~DESCRIPTION

501.01.01 GENERAL

- A. This work shall consist of Portland cement, fine aggregate, coarse aggregate, water and when specified, an air entraining admixture, proportioned, mixed, placed, and cured as herein specified. All concrete shall meet the most current requirements of American Concrete Institute (ACI) with the following additions and/or exceptions indicated in this specification.
- B. As used in this section, the term Portland Cement shall be considered synonymous with the term Hydraulic Cement.

501.01.02 ~~REFERENCE CODES AND STANDARDS~~ QUALITY CONTROL TESTING AND INSPECTION

- A. The testing and inspection of Portland cement concrete shall comply with ~~the IQAC Manual and~~ this specification. The inspection of the mixing plant shall comply with the ACI 311, Chapter 2, ~~and the IQAC Manual~~. In Clark County unincorporated areas and if required by other Contracting Agencies, ~~All field and laboratory sampling and testing for project control shall be performed by NAQTC or ACI certified technicians in an AASHTO or A2LA accredited laboratory. The concrete designs shall comply with Tables 1 and 2 and the IQAC website http://www.accessclarkcounty.com/depts/public_works/pages/iqac.aspx or comply with Contracting Agency requirements.~~
- ~~(a)Uniform Standard Specifications for Public Works' Construction Off-site Improvements, Clark County Area, Nevada that will henceforth be referred to as "USS" Specifications and Drawings~~
- ~~(b)Contract Special Provisions and Drawings~~
- ~~(c)NRS 338.176, NAC 625.550~~
- ~~(d)Most current ASTM, AASHTO, ACI, or NDOT test procedures~~
- ~~(e)Related Interagency Quality Assurance Committee (IQAC) procedures at www.accessclarkcounty.com/pubworks/iqac/IQAC.htm~~

~~02~~MATERIALS

501.02.01 GENERAL

- A. Materials shall meet the requirements of the following sections and subsections:

~~Table 1- Material Requirements~~

Materials	Section
Aggregate for Portland Cement Products	706
Concrete Curing Materials and Admixtures	702
Portland Cement	701
Water	722

501.02.02 GRADATION REQUIREMENTS

- A. Refer to ACI 304 Chapters 2.1 and 2.2, and comply with the gradation requirements specified in Section 706, "Aggregates for Portland Cement Products," and the following:
1. The gradation requirements represent the extreme limits in determining the suitability of material. The gradation from any one source shall maintain a uniformity such that variations in the fineness modulus will not exceed 0.2 from the ~~fineness modulus of samples of the material offered for use.~~ "Base Fineness Modulus."
 - a. The "Base Fineness Modulus" shall be the average of the most recent 10 fineness modulus values (or the average of all preceding values if less than 10 have been completed) from any one source.
 - b. Fine aggregate from any one source having a variation in fineness modulus ~~of more than exceeding~~ ± 0.2 as prescribed above ~~shall~~ will be rejected, or at the discretion of the Engineer, may be accepted subject to ~~such~~ approved changes.
 - c. The fineness modulus of fine aggregate shall be determined by adding the cumulative percentages, by weight, of material retained on each of U.S. Standard sieves No. 4, No. 8, No. 16, No. 30, No. 50, and No. 100, and dividing by ~~one hundred (100).~~
 2. Fine aggregates from different sources of supply shall not be mixed or stored in the same stockpile and shall not be used alternately in the same class of construction or job mix without written permission. Such permission will be contingent on amending the job mix and batch masses as necessary to protect the quality of the concrete produced.
 3. If the fine aggregate for a ~~job mix~~ job mix is to be a composite material from ~~two~~ 2 or more sources, material from respective sources shall be blended by methods ~~which that~~ which will maintain the degree of uniformity of gradation required by these specifications.
 4. Adequate supplies of aggregate shall be produced and stockpiled sufficiently in advance of construction operations to permit sampling and testing before use.
 5. Coarse aggregates ~~secured from sources~~ which vary ~~widely~~ in gradation shall be placed in separate stockpiles or bins and ~~re~~ recombined in approved proportions ~~approved by the Engineer~~. Different sizes of aggregates shall be stored in stockpiles sufficiently removed from each other to prevent ~~intermixing~~ the materials from becoming intermixed.
 6. If the Contractor changes the source of any size of aggregate, ~~opportunity~~ a new mix design shall be ~~given in advance of use~~ submitted to ~~permit~~ the Engineer ~~to determine the concrete-making properties as provided in Subsection 501.02.04, "Concrete Making Properties."~~ for approval.

501.02.03 ADMIXTURES

- A. Refer to ACI 212. Air-entraining admixtures and water reducers and retarders shall conform to the requirements of Subsection 702.03.03~~2~~, "Air-Entraining Admixtures," and Subsection 702.03.04~~3~~, ~~"Water Reducers and Retarders~~ Admixtures Other Than Air-Entraining."

- B. ~~No~~ ~~a~~ Admixtures that are not listed in the mix design shall not be used without written permission from the Engineer, except as otherwise provided in these specifications or in the Special Provisions.
- C. Admixtures used in Class EA Concrete, Modified shall be an approved chemical admixture for concrete, meeting the requirements of ASTM C494. Use Type "A" admixture when the anticipated high temperature for the day is 80 degrees F or below. Type "D" admixture shall be used when the anticipated high temperature is above 80 degrees F. The water-cement ratio shall not be adjusted once the chemical admixture has been incorporated into the mix.
- D. Admixtures shall not be used to replace cement. Admixtures containing chlorides as Cl⁻ in excess of ~~one (1)~~ percent by weight shall not be used in prestressed concrete. If admixtures are used to entrain air, to reduce the water-cement ratio, to retard or accelerate setting time, or to accelerate the development of strength, ~~they~~ admixtures shall be used at the dosage specified in the mix design, or in the contract documents, or as provided by the Engineer.
- E. When the use of an air-entraining agent is specified, it shall be added in a quantity conforming to Table ~~12 of~~ in Subsection 501.03.04, "Classifications and Proportions." It shall be measured into each batch by equipment and methods approved by the Engineer. Adjustments shall be made in the weights of the aggregates used per batch to compensate for increased yield due to air-entrainment so that the quantities of cement per cubic yard ~~(cubic meter)~~ of concrete remain constant. Such adjustments shall be made by decreasing the weight of fine aggregate without changing the weight of coarse aggregate unless otherwise approved by the Engineer.
- F. When a High Range Water Reducing admixture is used, the initial slump is waived and the slump of the concrete after the admixture is added shall not exceed 8 inches.
- G. Admixtures shall be measured accurately into each batch by methods approved by the Engineer.
- H. Except as otherwise provided for air-entraining agents, samples of admixtures proposed for use shall be submitted by the Contractor to the Engineer in advance of intended use to permit tests to be made to determine compliance with claimed properties.
- I. Any type of admixture shall be uniform ~~in properties~~ throughout its use in the work. Should it be found that the admixture as furnished is not uniform ~~in properties~~, its use shall be discontinued.
- J. Admixtures shall be dispensed in liquid form. Dispensers for admixtures shall have sufficient capacity to measure at one time the full quantity required for each batch. Unless admixtures are added to premeasured water for the batch, their discharge into the batch shall be arranged to flow uniformly into the stream of water. Dosages of admixtures shall not vary from the dosage indicated in the mix design or as approved by the Engineer by more than ~~five (5)~~ percent, with the exception of air entraining admixtures where the dosage is required to achieve the specified range. Equipment for measurement shall be designed for convenient confirmation of the accuracy of measurement. If more than one admixture is used, each shall be dispensed by separate equipment unless otherwise permitted in writing by the Engineer.
- K. When water-reducing agents or water-reducing retarders are used, the permitted dosage of the admixture shall not exceed that which will result in an increase in the drying shrinkage of the concrete of ~~twenty (20)~~ percent when used in precast, prestressed concrete; ~~ten (10)~~ percent when used in cast-in-place prestressed concrete; ~~ten (10)~~ percent when used in

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cast-in-place reinforced concrete; or ~~three (3)~~ percent when used in non-reinforced concrete pavements.

- L. Water reducers shall reduce the water demand of concrete for a given slump at least ~~seven (7)~~ percent when used at the maximum dosage recommended by the manufacturer. Set retarders shall not be used in greater dosages than those recommended by the manufacturer, nor more than that needed to obtain the desired retardation. The strength of the concrete containing the admixture in the amount approved by the Engineer, shall at the age of ~~forty-eight (48)~~ hours and longer, be not less than that of similar concrete without the admixture.
- M. When the Contractor proposes to use an air-entraining admixture which has been previously approved, ~~he~~ the Contractor shall submit a certification stating that the admixture is the same as that previously approved.
- N. If an admixture offered for use is essentially the same (with only minor differences in concentration) as another previously approved material, a certification will be required stating that the product is essentially the same as the approved admixture and that no other admixture or chemical agent is present.

~~**501.02.04 CONCRETE MAKING PROPERTIES:** Portland cement concrete shall be subject to the AASHTO related American Concrete Institute (ACI) standards:~~

- O. ~~Either b~~ Before or during construction, the Engineer may require that the admixture selected be further tested to determine its effect upon the strength of the concrete. The 7-day compressive strength of concrete containing the admixture under test shall not be less than 88 percent of the strength of concrete made with the same materials, the same cement content, and consistency, but without the admixtures.
- P. Subject to the following conditions, pozzolan conforming to Subsection 702.03.04, "Pozzolans (Fly Ash)," shall be used to a minimum of 20 percent and a maximum of 35 percent, by weight, of the required Portland cement in concrete, or as required by the Engineer.
 - 1. The replacement of cement with pozzolan shall be at a rate of 1 pound of pozzolan for each pound of Portland cement.
 - 2. Silica fume may be used to replace 3 percent to 7 percent, by weight, of the total cementitious material.
 - 3. Store pozzolan in separate weather-tight facilities.

501.02.04 CONCRETE MAKING PROPERTIES

- A. The mix design procedure shall comply with the method indicated ~~in the IQAC Manual on the IQAC website (see Subsection 501.01.02, "Quality Control Testing and Inspection").~~ The type of cement permitted, the minimum sacks of cement required, and the maximum water/cement ratio shall be as shown in Table 1.

<u>Type of Cement Permitted</u>	<u>Minimum Sacks of Cement Per Cubic Yard</u> ³⁴	<u>Maximum Water/Cement Ratio</u>
<u>Type II & Fly Ash</u>	<u>6.5</u> ^{2,3}	<u>0.45</u>
<u>Type MS & Fly Ash</u>	<u>6.5</u> ^{1,2}	<u>0.45</u>
<u>Type 1-P (MS)</u>	<u>6.5</u>	<u>0.45</u>
<u>Type V</u>	<u>6.5</u> ³	<u>0.45</u>
<u>Type HS</u>	<u>6.5</u> ²	<u>0.45</u>
<u>Type V & Fly Ash</u>	<u>6.0</u> ^{2,3}	<u>0.45</u>
<u>Type HS & Fly Ash</u>	<u>6.0</u> ^{1,3}	<u>0.45</u>

- B. The testing frequency shall comply with ~~IQAC Manual Section 4~~ the Contracting Agency requirements or the Special Provisions.
- C. Prior to mix design approval, the Contracting Agency reserves the right to verify the mix design test results, using the sources and proportions of materials as indicated by the mix design.
- D. The mix design submittal shall include the information indicated in the concrete design report form on the IQAC ~~Manual Section 2~~ website.

~~Trial batch test reports may be submitted for concrete at 56 days in lieu of 28 days to meet requirements. Acceptance testing will be based on time frames from the approved mix design.~~

501.02.05 ZERO SLUMP CONCRETE FOR THE MANUFACTURING OF PRECAST CONCRETE PRODUCTS

- A. Concrete products manufactured by the zero slump method shall comply with ~~material requirements contained in Subsection 701.01.01, "Materials Covered", Subsection 501.02.03, "Admixtures," and Subsection 501.02.04, "Concrete Making Properties," and Subsection 701.01.01, "Materials Covered."~~ Zero slump concrete shall also exhibit design, and performance requirements meeting IQAC ~~Manual Section 2~~ and relevant ASTM specifications. Air entrainment is not required in a dry cast manufacturing process.
- B. For zero slump concrete, all other parts of this Section 501, "Portland Cement Concrete," do not apply.

501.02.06 LOW SLUMP CONCRETE FOR THE MANUFACTURING OF EXTRUDED SLIP FORM CONCRETE

- A. Extruded slip form concrete shall comply with material requirements contained in ~~Subsection 701.01.01, "Materials Covered,"~~ Table 1, above, and with design and performance requirements meeting IQAC ~~Manual Section 2~~ and relevant ACI specifications. The plastic properties may be adjusted on-site with an appropriate type admixture to ensure compliance with Subsection 501.03.04, "Classification and Proportions," and to aid Contractor in placement and finishing of low slump slip form concrete.

¹ Maximum of 8 sacks.

² Sacks per cubic yard before replacement with fly ash.

³ 5.0 sacks per cubic yard for precast products, pipe and box, with zero slump mix design.

501.02.07 SELF-CONSOLIDATING CONCRETE

- A. The Contractor's use of self-consolidating concrete shall require the approval of the Engineer and shall be subject to the following requirements:
1. Substitutions. Class S concrete may be substituted for selected applications for classes A, D, Modified A, and Modified D; and Class SA concrete may be substituted for selected applications for classes AA, DA, PAA, Modified AA, and Modified DA, as approved by the Engineer.
 2. Trial Placement.
 - a. The Contractor shall submit details of a representative test section (mockup) for approval.
 - b. Produce a trial batch of Class S and SA concrete, conforming to the proposed mix design.
 - c. As part of the concrete placement demonstration, provide the labor, equipment, and materials to test the concrete. Evaluate the mixture for strength, air content, slump flow, visual stability index, J-ring value, and hardened visual stability index.
 - d. Place a test section when the atmospheric conditions approximate the conditions anticipated for placing the final work. Finish and cure the mockup according to this section.
 - e. If it is determined that the trial batch is not workable or not able to be properly placed or finished, modify the mix design or batching sequence. Submit the revised mix design and batching sequence to the Engineer, and place another test section. Repeat the submittal and trial pour process until a workable and finished trial batch is produced.
 - f. Do not place any Class S and SA concrete until the Engineer accepts the mockup pour.
 - g. A new mix design and a new trial pour will be required whenever there is a change in the source of any component material.
 - h. Segregated concrete, as determined by NV Test Method SCC-2, shall not be incorporated into any component of the anticipated concrete work.
 - i. When a truck mixer or agitator is used for transporting concrete, deliver the concrete to the site of the work and complete discharge within 60 minutes after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to the aggregates. In hot weather, or under conditions contributing to quick stiffening of the concrete, a mixing and delivery time of less than 60 minutes may be required. A mixing and delivery time exceeding 60 minutes may be approved by the Engineer if a trial pour is performed with satisfactory results.
 - j. Place each successive batch within a maximum time interval of 20 minutes. Place the concrete in continuous layers. When it is necessary by reason of emergency or other delay, to place less than a complete horizontal layer in one operation, terminate each layer by using a vertical bulkhead. Do not rod or vibrate the concrete to attempt restoring the fluidity to the mix. Plan and regulate the delivery of concrete so that minor interruptions due to form repair,

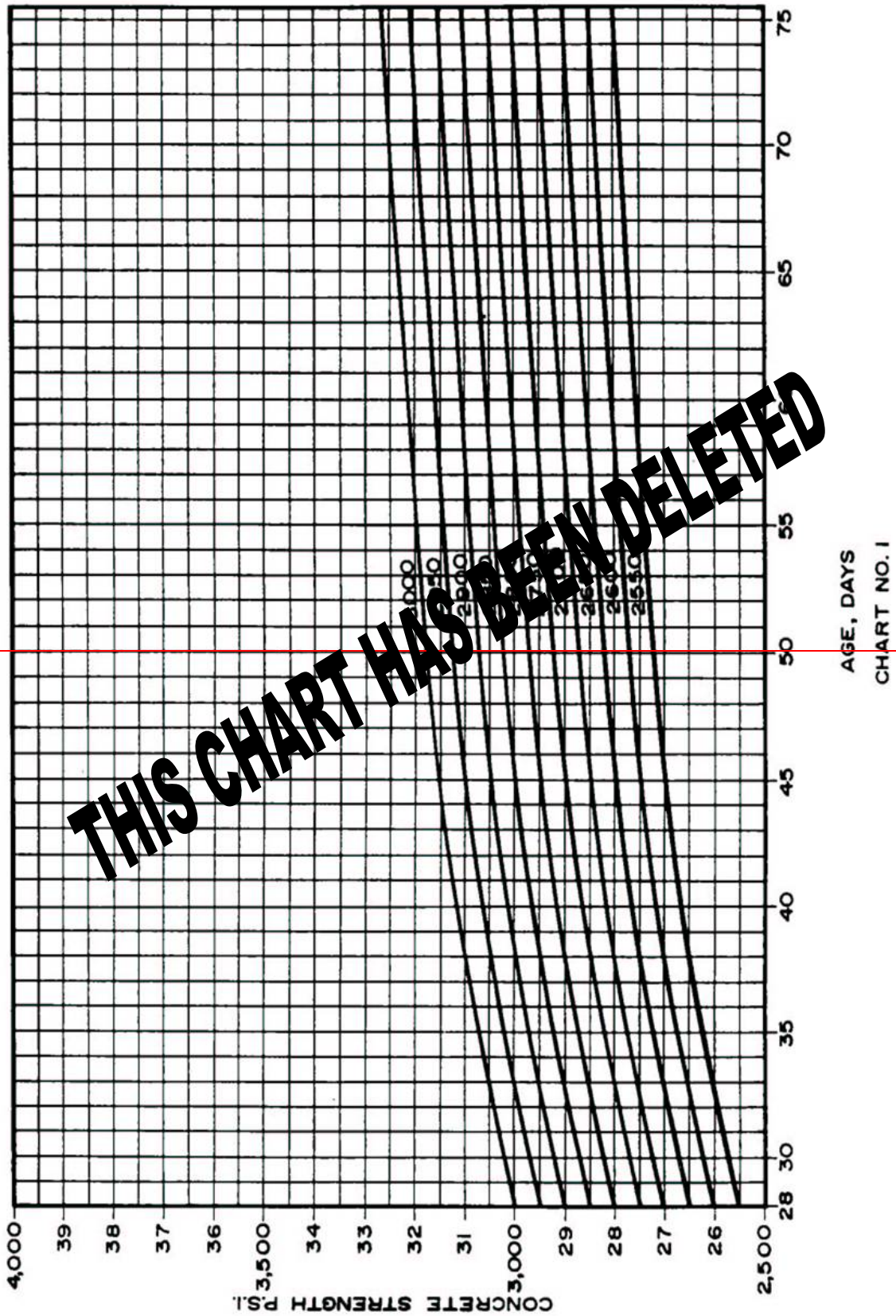
material testing, etc. will not impact the required 20-minute time interval between successive placements.

3. Concrete Slump Requirements. Except for concrete used in drilled shafts, the requirements of NV Test Method T438 will be performed at 2 -hours, 3 -hours, or for extended times depending on the concrete placement duration. ~~comply with NDOT Subsection 509.02.01, "General" of the NDOT Standard Specifications.~~
4. Drilled Shafts. Use Class -S or SA concrete for drilled shaft construction. Upper portions of drilled shafts (top of shaft down to bottom of embedded vertical column reinforcing) may be constructed using the column concrete mix.

03 CONSTRUCTION

501.03.01 EQUIPMENT

- A. With the exception of items indicated in Subsection 501.03.05, "Proportioning Methods," and Subsection 501.03.06, "Machine Mixing," the measurement of materials and batching shall comply to the ACI -304, Chapters -3 and 4 recommendations and those in this section or as approved by the Engineer.
 1. Certify concrete production facilities and delivery equipment by complying with National Ready-Mix Concrete Association certification requirements.
 2. Methods employed in performing the work, and all equipment, tools, and machinery used for handling materials and executing any part of the work, shall be subject to the approval of the Engineer.
 3. All equipment necessary shall be on hand and approved before concrete operations are begun by the Contractor. ~~Certify concrete production facilities and delivery equipment by complying with National Ready-Mix Concrete Association certification requirements.~~
- B. Provide adequate internal vibrating equipment, including power, to enable the Engineer to fabricate concrete cylinders for testing purposes.
- C. Furnish internal vibrators with rigid or flexible shafts, preferably powered by electric motors, capable of operating at a frequency of 7,000 vibrations per minute or greater.
 1. The outside diameter or the side dimensions of the vibrating element shall be at least 3/4 -inch and not greater than 1-1/2 -inches.
 2. The length of the shaft shall be at least 24 inches.
- D. The Contractor shall maintain the equipment in good condition and adjustment. Concrete mixers and other equipment which are not adequate or suitable for the work shall be removed and suitable equipment shall be provided by the Contractor.



501.03.02 PROTECTING AND SAMPLING CEMENT

- A. Suitable means of storing and protecting the cement against moisture or other injurious effects shall be provided by the Contractor. Sacked or bulk cement which, for any reason, has become partially set or which contains lumps of caked cement shall be rejected and shall be immediately removed from the worksite.
- B. Different brands of cement shall not be mixed during use or in storage, nor shall ~~they~~ different brands be used alternately in any one structure. The same brand and kind of cement shall be used in a given structure above the ground line. A change in brand of cement will require a new mix design.
- C. The sacked cement shall be so piled as to permit access for tally, inspection, and identification of each shipment.
- D. The Contractor shall obtain from the cement company from which the cement is purchased, a certificate stating that the cement delivered to the work complies with the specifications for the type of cement specified for use, with tests pertaining to the delivered lot. The certificate shall be dated, signed, and indicate the quantity of shipment. Two copies shall be delivered directly to the Engineer ~~in charge of the work.~~
- E. Upon receipt of the certificate of compliance, the Engineer may permit the use of the cement. When a certificate of compliance is not furnished ~~by to~~ the Engineer, the cement shall not be used in the work until a release ~~of for~~ its use has been received by ~~him the~~ Contractor from the ~~Contracting Agency's Materials and Research Division~~ Engineer.

~~When a certificate of compliance is not furnished, the Contracting Agency shall be afforded sufficient time to make a seven (7) day test on approved brands of cement in common use, and a twenty-eight (28) day test of new and unapproved brands of cement.~~

- F. Whenever it is determined by ~~subsequent a~~ subsequent a laboratory test of mill or field samples that the cement does not comply with the specifications, ~~subsequent the~~ subsequent the use of ~~that~~ that cement ~~from the same cement company~~ will be ~~delayed~~ suspended, ~~if required by the laboratory Engineer,~~ until tests by a third party paid for by the Contractor can be made ~~on each lot of cement delivered~~ and the test results are approved by the Engineer.
- G. All cement not conforming to the specifications and all cement damaged by exposure to moisture shall be removed immediately and permanently from the work.

501.03.03 STORAGE OF AGGREGATES

- A. Refer to ACI 304, Chapter 2.2.3. The handling and storage of aggregates shall be such as to prevent segregation or contamination by foreign materials.
- B. Maintain aggregate stockpiles in saturated surface dry condition ~~as directed.~~
- C. In placing materials in storage or in moving ~~them~~ materials from storage to the mixer, any method which may cause the segregation, degradation, or the combining of material of different gradings which will result in any stockpile or bunker material failing to meet specified requirements shall be discontinued and the materials shall be reprocessed or wasted.

501.03.04 CLASSIFICATION AND PROPORTIONS

- A. For non-commercial sources, ~~the~~ the Contractor shall notify the Engineer not less than ~~thirty-two (302)~~ calendar days in advance of use of the proposed sources of materials and shall make arrangements for the Engineer to obtain samples as required for testing purposes.

1. ~~The sources of materials to be used on a project shall not be changed during the job except with the written consent of the Engineer.~~o
 2. ~~If permission to change sources of material is granted, a new ~~job-mix~~job mix formula ~~will~~shall be required.~~
 3. ~~Samples shall not exceed 500 pounds for each separate grading.~~
- B. When requested by the Contractor, exceptions to the above requirement may be granted in writing by the Engineer under either of the following conditions:
1. ~~(a)The concrete structures on the project are minor in nature, such as culvert headwalls, manholes, small boxes, sidewalks, etc., generally, when less than ~~one hundred (100)~~ cubic yards (~~76 cubic meters~~) of concrete are called for on the project.~~
 2. ~~(b)When the aggregate source has been previously tested within the past ~~one (1)~~ year and accepted by the Contracting Agency.~~

~~Samples will not exceed five hundred (500) pounds (200 kilograms) for each separate grading.~~

~~Before beginning concrete work, the Contractor shall submit in writing to the Engineer the proposed concrete mix design giving the cement factor in sacks per cubic yard (cubic meter) indicating the proportions of cement, water, admixtures and the gradation of the primary aggregate nominal sizes which he proposes to furnish. When the primary coarse aggregate is separated into two sizes, the gradation shall consist of the gradation for each individual size, and the proposed proportions of each individual size, combined mathematically with the fine aggregate to indicate one proposed gradation. Such gradation shall meet the grading requirements shown in the following table. (Not applicable to light weight concrete). If the Contractor proposes to use an admixture other than an air-entraining agent, he shall state its complete brand name and the quantity proposed to be used per sack of cement.~~

~~If the mix design is not listed on the IQAC web page, a written concrete mix design shall be furnished giving the cement factor in pounds per cubic yard, the source and proportions of cement, water, and each size of aggregate by weight in a saturated surface dry condition, per cubic yard of concrete and the percentage of air in the concrete proposed for use in the work. The mix design shall also show the gradation for each individual primary aggregate nominal size and the mathematically combined gradation of the proposed proportions of each individual size. If proposing to use an admixture or additive, state its complete brand name and the quantity proposed to be used per cubic yard of concrete.~~

- C. ~~Portland cement concrete shall be proportioned by weight, such that the requirements in Table 3, Mortar Proportioning, in Subsection 501.03.12, "General," using the aggregates tested such that the compressive strength requirements in Table 1 of this subsection will~~shall ~~be satisfied.~~The Contractor shall give the Engineer advance notice in writing when any changes are to be made in the batch proportions. In the case of Class EA concrete, no changes will be allowed without new laboratory trial testing and subsequent approval.
- D. Batches of concrete shall not vary more than \pm ~~three (3)~~ pounds per cubic foot (\pm ~~48 kilograms per cubic meter~~) in unit weight from design mix. The cement factor of any individual batch placed in the work shall not be more than ~~0.15 sack~~14 pounds per cubic yard less, nor more than ~~0.25 sack~~23 pounds per cubic yard (~~8.4 kilograms per cubic meter less or 14.0 kilograms per cubic meter more~~) greater than the designated cement factor (~~sacks of cement per cubic yard~~) (~~kilograms of cement per cubic meter~~). Batch

aggregates and report by weight to the Engineer. The weights used may be varied as necessary to comply with the above tolerances in cement factor and unit weight.

- E. For Class EA Concrete, Modified, perform laboratory trial tests to determine strength and compatibility of all materials (as specified in Table 2 of this subsection and in Subsection 501.02.03, "Admixtures") to be used. Contractor shall have an approved laboratory perform the tests and furnish documentation of such tests. Laboratory trial batches may be observed by the Engineer.

<u>Class of Concrete</u>	<u>Cementitious Range lb/yd³</u>	<u>Max. Nom. Coarse Aggregate Size inches</u>	<u>Min. 28-Day Compressive Strength⁶ psi</u>	<u>Slump Range inches</u>	<u>Entrained Air Range %</u>	<u>Unit Weight Variation lb/ft³</u>	<u>Use</u>
<u>A</u>	<u>564-705</u>	<u>1-1/2</u>	<u>3000</u>	<u>1-4</u>	<u>4-7</u>	<u>± 3</u>	<u>General use and reinforced structures</u>
<u>AA</u>	<u>564-705</u>						
<u>B</u>	<u>517-705</u>	<u>2</u>	<u>3000</u>	<u>1-5</u>	<u>4-7</u>	<u>± 3</u>	<u>Massive or lightly reinforced sections</u>
<u>BA</u>				<u>1-4</u>			
<u>C</u>	<u>470-611</u>	<u>50</u>	<u>2500</u>	<u>1-5</u>	<u>4-7</u>	<u>± 3</u>	<u>Massive unreinforced and backfill</u>
<u>CA</u>	<u>517-658</u>						
<u>D</u>	<u>564-705</u>	<u>3/4</u>	<u>3000</u>	<u>1-4</u>	<u>4-7</u>	<u>± 3</u>	<u>Thin reinforced sections, hand rails, etc.</u>
<u>DA</u>	<u>564-752</u>						
<u>PA A</u>	<u>564-752</u>	<u>3/4</u>	<u>Specified on Plans</u>	<u>1-4</u>	<u>Specified on Plans</u>	<u>± 3</u>	<u>Prestressed members</u>
<u>Modified A and AA</u>	<u>564-752</u>	<u>1-1/2</u>	<u>Specified on Plans</u>	<u>1-4</u>	<u>4-7 (AA only)</u>	<u>± 3</u>	<u>Where specified on plans</u>
<u>Modified D and DA</u>	<u>564-752</u>	<u>3/4</u>	<u>Specified on Plans</u>	<u>1-4⁷</u>	<u>4-7 (DA only)</u>	<u>± 3</u>	<u>Where specified on plans</u>
<u>Modified EA⁸</u>	<u>564-752</u>	<u>3/4</u>	<u>Specified on Plans</u>	<u>1/2 -4</u>	<u>4-7</u>	<u>± 3</u>	<u>High Performance Concrete</u>
<u>S and SA</u>	<u>639-925⁹</u>	<u>3/4¹⁰</u>	<u>Specified on Plans</u>	<u>N/A</u>	<u>4-7 (SA only)¹¹</u>	<u>± 3</u>	<u>Self Consolidating Concrete</u>

⁴ Blend the coarse aggregate gradation from stockpiles conforming to the requirements of Subsection 706.03.01, "Coarse Aggregate." and the stated nominal maximum size. Submit test reports for trial batches showing each stockpile sieve size and the proportions used for blending. Adhere to Subsection 706.02.01, "General." for the combined gradation regardless of coarse aggregate gradation. If approved, coarse aggregate nominal maximum size of 1 inch may be used in lieu of 3/4 inch.

⁵ Air entrainment on mixes placed above 6000 feet elevation

⁶ Comply with Subsection 501.02.04, "Concrete Making Properties," of the NDOT Standard Specifications for the moving average method of evaluating concrete specified under Statistical Evaluation of Concrete Strength.

⁷ For extruding barrier or bridge rail, slump range is 0.5-4 inches.

⁸ Aggregates shall consist of a blend of coarse, intermediate, and fine aggregates in order to produce a dense grading. Consideration of the grading, workability factor, and coarseness factor, as outlined in ACI_302 ~~should~~ shall be utilized. The aggregate maximum nominal size shall consist of at least a nominal 3/4 inch stone size.

⁹ The maximum shrinkage requirement of 0.06% in 28 days air dry after 28-day wet cure, ASTM_C157, shall apply if the total cementitious material exceeds 752 pounds per cubic yard.

¹⁰ If approved, 1/2 inch or 3/8 inch may be used in lieu of 3/4 inch.

¹¹ Air content shall be as follows: For 1/2 inch max. aggregate size, 4.5% - 7.5%, and for 3/8 inch max. aggregate size, 5% - 8%.

501.03.05 PROPORTIONING METHODS

- A. Except as hereinafter noted, aggregate bins shall conform to either ~~(a1)~~ or ~~(b2)~~ as follows:
1. ~~(a)~~ Each specified size of aggregates shall be stored in a separate bin. Except as hereinafter specified, each bin shall be provided with an individual outlet gate, designed and constructed to prevent leakage when closed. The gates shall cut off quickly and completely.
 2. ~~(b)~~ Each size aggregate shall be weighed individually in a single bin, providing there is a satisfactory method employed to eliminate any excess material resulting from over-charging of the bin before the material reaches the surge hopper.
- B. Conformance to ~~(a1)~~ and ~~(b2)~~ above will not be required when batching for culvert headwalls, manholes, small boxes, sidewalks, etc., and the total quantity of concrete called for on the project does not exceed ~~three hundred (300_)~~ cubic yards ~~(229 cubic meters)~~.
- C. All aggregates for use in Portland cement concrete shall be proportioned by weight, with the exception that aggregates for culvert headwalls, short pieces of curb and gutter, or small sections of sidewalk and related minor work may be proportioned either by weight or volume as the Contractor may elect. Measuring boxes of known capacity shall be furnished and used to measure each size of aggregate proportioned by volume.
- D. Water shall be proportioned to maintain batching consistency with regard to stockpile moisture contents and varying absorption values for both coarse and fine aggregates. The Engineer may request the Contractor to submit a new mix design if either the coarse or fine aggregate absorption values vary from the approved mix design by more than 1 percent.
- ~~Batches requiring fractional sacks of cement will not be permitted, unless the Contractor elects to weigh the cement in each batch.~~
- E. Bulk cement shall be weighed separately when the batch is ~~one (1_)~~ cubic yard ~~(cubic meter)~~ or more.
1. ~~–~~The scale and weigh hopper for the cement shall be separate and cement hopper shall be interlocked against opening before the full amount of cement is in the hopper, against closing before the contents of the hopper are entirely discharged and the scales are back in balance, and against opening when the amount of cement in the hopper is underweight by more than ~~one (1_)~~ percent of the amount specified.
 2. ~~–~~An interlock system will not be required on projects having less than ~~three hundred (300_)~~ cubic yards ~~(229 cubic meters)~~ in the bid schedule.
- F. Scales utilized in the proportioning device may be of the springless dial type or of the multiple beam type.
- G. If of the dial type, the dial shall be of such size and so arranged that it may be read easily from the operating platform.
- H. If of the multiple beam type, the scales shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight.
1. ~~–~~The indicator shall be so designed that it will operate during the addition of the last ~~four hundred (400_)~~ pounds ~~(180 kilograms)~~ of any weighing.
 2. ~~–~~The over travel of the indicator hand shall be at least ~~one-third~~ 1/3 of the loading travel.

3. ~~The indicator shall be enclosed against moisture and dust.~~
- I. Weighing equipment shall be insulated against vibration or movement of other operating equipment in the plant. When the entire plant is running, the scale reading and cutoff shall not vary from the weight designated by more than ~~one (1.)~~ percent for cement and ~~one and one-half (1-1/2.)~~ percent for any size aggregate, nor ~~one and one-half (1-1/2.)~~ percent for the total aggregate in any batch.
- J. Scales shall be approved with a certificate of inspection as required by Subsection 109.01, "Measurement of Quantities."
- K. When the entire plant is running, the scale reading and cutoff weights shall not vary from the mix design by more than 1 percent for cement, fly ash, and silica fume, 1.5 percent for any individual size aggregate, and 1 percent for the total combined aggregate in any batch. The total water shall not exceed the maximum water specified in the mix design.
- L. Should separate supplies of aggregate and material of the same size group, but of different moisture content or specific gravity be available at the proportioning plant, withdrawals shall be made from one supply exclusively and the material therein completely exhausted before starting upon another.
- M. Stockpiled aggregates shall be in a saturated surface dry condition just prior to batching.
 1. ~~The moisture content of the aggregate shall be such that no visible separation of moisture and aggregate will take place during transportation from the proportioning plant to the point of mixing.~~
 2. ~~Aggregate containing excess moisture shall be stockpiled prior to use until sufficiently dried to meet the above requirements.~~
- N. Batches with cement in contact with damp aggregates shall be mixed within ~~thirty (30.)~~ minutes after being proportioned. Batch trucks hauling more than ~~one (1.)~~ batch of cement and aggregate shall be so constructed that materials do not flow from one compartment to another during haul or discharge.
- O. Coarse and fine aggregate shall be handled and measured separately. ~~Each bag of cement shall contain ninety-four (94) pounds (42.5 kilograms) net and~~ shall be emptied directly into the charging skip of the mixer. Water shall be measured either by volume or by weight.
- P. The equipment for measuring and supplying the water to the mixer shall be so constructed and arranged that the amount of water added to the mixture can be measured in one operation into the mixing drum without dribbling.
 1. ~~The equipment shall be so designed that water from the source of supply cannot enter the measuring tank while the water is being discharged from the measuring tank into the mixer.~~
 2. ~~Tanks or other equipment for measuring and discharging water into the mixer shall be sufficiently accurate that the amount of water delivered to the mixer for any batch shall not vary more than one (1.) percent from the required quantity of water for any position of the mixer with respect to a level plane.~~
 3. ~~The tanks or other equipment shall be so arranged as to permit the checking of the amount of water delivered by discharging into measured containers.~~

501.03.06 MACHINE MIXING

- A. Concrete manufactured by any procedure which results in any unmixed lumps of cement in the mixed product shall be rejected. The preparation of the mix shall be in accordance to ACI 318, Section 5.8, "Mixing," and this section. The Cement and Concrete terminology is defined in ACI 116.
- B. The Engineer shall be provided with a legible ticket with each load of concrete delivered to the ~~contract~~project site which shall contain the following information:
1. Name of Vendor.
 2. Name of Contractor.
 3. Number of Cubic Yards in the Load.
 4. Actual Weights of Cement and of each Size of Aggregate.
 5. Amount of Water Added at the Plant.
 6. Amount of Water in the Aggregate.
 7. Brand and Type of Cement.
 8. Brand and Amount of Admixture.
 9. Time and Date of Batching.

~~When mix proportions have been designated for a project and are identified by number, the Engineer may waive the foregoing and accept a legible ticket which shall contain the following information:~~

~~Name of Vendor
Name of Contractor
Number of Cubic Yards in the Load
Mix Designation Number
Amount of Water Added at the Plant (including Water in Aggregates)
Time and Date of Batching~~

- C. Space shall be provided on the ticket so the amount of water added on the job may be indicated.
- D. ~~(a)~~ **General.**—All concrete shall be mixed in mechanical mixers, except that when permitted by the Engineer, batches not exceeding ~~one-third (1/3)~~ cubic yard ~~(1/3 cubic meter)~~ may be mixed by hand methods in accordance with the provisions of Subsection 501.03.07, "Hand Mixing."
1. ~~—~~Mixers shall have legible permanently attached plates showing manufacturer's rated capacity, mixing speeds, and serial number.
 2. Mixers may be stationary mixers or truck mixers.
 - a. ~~—~~Agitators may be truck mixers operating at agitating speed or truck agitators.
 - b. ~~—~~Each mixer and agitator shall have attached thereto in a prominent place a metal plate or plates on which is plainly marked the various uses for which the equipment is designed, the manufacturer's guaranteed capacity of the drum or container in terms of the volume of mixed concrete, and the speed of rotation of the mixing drum or blades.

3. The Contractor, at ~~his expense~~ no additional cost to the Contracting Agency, shall furnish samples of the fresh concrete and provide safe and satisfactory facilities for obtaining the samples.
 4. Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer.
 5. The temperature of materials as charged into the mixer shall be such that the temperature of the mixed concrete at the time it is placed in final position is not less than ~~fifty (50_) degrees _F.~~ nor more than ~~ninety (90_) degrees _F. (10 degrees C. nor more than 32 degrees C.)~~ as specified in Subsection ~~501.03.10B,~~ "Weather Limitations,"(b), "Cold Weather -- General," and Subsection 501.0310C(e), "Low Temperature Protection." Aggregates and water used for mixing shall not exceed ~~one hundred fifty (150_) degrees _F. (66 degrees C.)~~
 6. Concrete for structures shall be mixed for a period of not less than ~~sixty (60_) seconds~~ nor more than ~~five (5_) minutes~~ after all materials, including water, are in the mixer.
 7. Cement shall be batched and charged into the mixer by means that will not result either in loss of cement due to the effect of wind, or an accumulation of cement on surfaces of conveyors or hoppers, or in other conditions which may vary the required quantity of cement in the concrete mixture.
 8. Stationary mixers having a capacity of ~~one (1_) cubic yard (1 cubic meter)~~ or more and all paving mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanisms shall be so interlocked that during normal operations no part of the batch will be discharged until the specified mixing time has elapsed.
 9. The total ~~elapsed~~ elapselapsed time between the intermingling of damp aggregates and cement and the start of mixing shall not exceed ~~thirty (30_) minutes.~~
 10. Mixers and agitators which have an accumulation of hard concrete or mortar or worn blades shall not be used.
 11. When central-mixed concrete is furnished and non-agitating hauling equipment is used for transporting concrete to the delivery point for Portland cement concrete pavement, discharge into the laydown machine shall be completed within ~~forty-five (45_) minutes~~ after the addition of the cement to the aggregates.
- ~~(b) **On-Site Mixed Concrete.** When mixing at the site of the work, the mixers used shall be of the paving or stationary type. The size of batch shall not exceed the rated capacity as determined by the standard requirements of the Associated General Contractors of America, except that in paving mixers when used for Portland cement concrete pavement, concrete slope protection and curbs and sidewalks, the size of the batch may exceed the rated capacity of the mixer as determined by the standard requirements of the Associated General Contractors of America to a total of 32.4 cubic feet (0.92 cubic meter) in 27 E mixers and 40.8 cubic feet (1.15 cubic meters) in 34 E mixers, provided that all parts of the mixer will hold the overcharge without spillage, that the uniformity and strength of the resulting concrete is not reduced, and provided further that when paving mixers are operating on grades in excess of six (6) percent, the size of batch shall not exceed 29.7 cubic feet (0.84 cubic meter) in 27 E mixers nor 37.4 cubic feet (1.06 cubic meters) in 34 E mixers.~~

E. ~~(e)~~ **Ready-Mixed Concrete.**

1. ~~Ready-mixed~~ concrete shall be central-mixed, shrink-mixed, or transit-mixed concrete. Shrink-mixed concrete is that which has been mixed partially in a stationary mixer and the mixing completed in a truck mixer.
2. The size of batch in truck mixers and truck agitators shall not exceed the rated capacity as determined by the current Standard Requirements of Truck Mixer Manufacturers Bureau. The size of batch in stationary mixers shall not exceed the rated capacity of the mixer as determined by the standard requirements of the Associated General Contractors of America. No batches requiring fractional sacks of cement will be permitted unless all of the cement is weighed when added to the batch.
3. If the use of ready-mixed concrete is approved, the producers shall use only that cement approved by the Contracting Agency for use on the project. Contracting Agency approved cement shall be stored at the concrete plant in such a manner that it can be identified and kept separate from other cement.
4. Ready-mixed concrete for structures shall be transported in truck mixers or truck agitators.
5. The mixer, when loaded to capacity, shall be capable of combining the ingredients of the concrete within the specified time, into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity. The agitator, when loaded to capacity, shall be capable of maintaining the mixed concrete in a thoroughly mixed uniform mass and of discharging the concrete with a satisfactory degree of uniformity.
6. Mixers and agitators shall be examined periodically for changes in condition due to accumulation of hardened concrete or mortar or to wear of the blades.
 - a. ~~When~~ any such change in condition is found, the concrete shall ~~not~~ be subjected to the slump tests.
 - b. ~~If~~ the tests indicate that the concrete is not being properly mixed, the faulty equipment shall be corrected before its further use is allowed.
7. Truck mixers shall be equipped with electrically or mechanically actuated revolution counters by which the number of revolutions of the drum or blades may be readily verified. The counters shall be of the continuous-registering, non-resettable type, which accurately register the number of revolutions, and shall be mounted on the truck mixer so that the Engineer may safely and conveniently inspect them from alongside the truck.
8. When a truck mixer is used, each batch of concrete shall be mixed for not less than ~~seventy (70)~~ and no more than ~~one hundred (100)~~ revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as mixing speed. If any additional mixing is done, it shall be at the speed designated by the manufacturer of the equipment as agitating speed.
9. When shrink-mixed concrete is furnished, concrete that has been partially mixed at a central plant shall be transferred to a truck mixer and all requirements for transit-mixed concrete shall apply. No credit in the number of revolutions at mixing speed shall be allowed for partial mixing in a central plant.

10. No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point, unless permitted by the Engineer. If the Engineer permits additional water to be incorporated into the concrete, the drum shall be revolved not less than ~~thirty (30)~~ revolutions at mixing speed after the water is added and before discharge is commenced.
11. The rate of discharge of mixed concrete from truck mixer-agitators shall be controlled by the speed of revolution of the drum in the discharge direction with the discharge gate fully open.
12. When truck mixer or truck agitator is used for transporting concrete that has been completely mixed in a stationary mixer, mixing during transportation shall be at the speed designated by the manufacturer of the equipment as agitating speed. Do not exceed a total of ~~320~~ 300 revolutions from the time of initial batching to complete discharge of delivered concrete.
13. When a truck mixer or agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within ~~ninety (90)~~ minutes after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to the aggregates. In hot weather, or under conditions contributing to quick stiffening of the concrete as determined by the Engineer, a delivery time of less than ~~ninety (90)~~ minutes may be required. When a truck mixer is used for the complete mixing of the concrete, the mixing operations shall begin within ~~thirty (30)~~ minutes after the cement has been intermingled with the aggregate.
14. If the mixing plant is such a distance from the site of the work that it is not practical to have the mixed concrete delivered and placed in forms within the time limit specified, cement and water shall not be added until such time as requirements can be complied with.
15. The organization supplying concrete shall have sufficient plant capacity and transporting apparatus to ~~insure~~ ensure continuous delivery at the rate required.
 - a. ~~The rate of delivery of concrete shall be used as to provide for the proper handling and placing of concrete.~~
 - b. ~~An interval of more than ~~forty-five (45)~~ minutes between any ~~two~~ 2 consecutive batches or loads, or a delivery and placing rate of less than ~~eight (8)~~ cubic yards (~~6 cubic meters~~) of concrete per hour shall constitute cause of shutting down work for the remainder of the day, and if so ordered by the Engineer, the Contractor shall make, at ~~his own expense~~ no additional cost to the Contracting Agency, a construction joint at the location and of the type directed by the Engineer in the concrete already mixed.~~
16. After mixing of ready-mixed concrete has been completed, it shall be agitated continuously at agitating speed until it has been discharged from the drum.
17. Wash water shall be completely discharged from the drum or mixing container before the succeeding batch is introduced. Cement balling (intermittent clumping) and mix foaming shall be prevented by controlling the batch sequence, mixing speed, and mixing time.
 - a. When intermittent clumping exceeds 1-2 clumps per yard or 10 clumps per truck, the entire load will be rejected.
 - b. The clumps shall not exceed 5 inches in diameter.

501.03.07 HAND MIXING

- A. Hand mixing shall not be permitted, except in case of an emergency or under written permission of the Engineer.
- B. ~~When permitted, #hand mixing shall be done only on watertight platforms.~~
1. ~~The sand shall be spread evenly over the platform and the cement spread upon it.~~
 2. ~~The sand and cement shall then be thoroughly mixed while dry by means of shovels until the mixture is of uniform color, after which it shall be formed into a "crater" and water added in the amount necessary to produce mortar of the proper consistency.~~
 3. ~~The material upon the outer portion of the "crater" ring shall then be shoveled to the center and the entire mass turned and sliced until a uniform consistency is produced.~~
 4. ~~The coarse aggregate shall then be thoroughly wetted and added to the mortar and the entire mass turned and returned at least ~~six (6)~~ times and until all of the stone particles are thoroughly covered with mortar and the mixture is of a uniform color and appearance.~~
- C. ~~Hand mixing will not be permitted for concrete to be placed under water.~~
- D. Preproportioned sack concrete may be used for grout caps or other nonstructural uses as approved by the Engineer.

501.03.08 RETEMPERING

- A. Concrete shall be mixed only in such quantities as are required for immediate use and shall be placed before initial set has taken place. Any concrete in which initial set has begun shall be wasted and not used in the work.
- B. ~~No retempering of concrete shall be allowed.~~

501.03.09 CURING

- A. Comply with ACI 308, Standard Specification for Curing Concrete, with the following exceptions or additions:
1. ~~(a) General.~~ All concrete shall be cured for the length of time hereinafter specified. If Type III cement is used, the curing time may be reduced as directed by the Engineer. In the event of low temperatures, the time will be increased according to the ~~produce~~procedures specified in Subsection 501.03.10B, ~~---"Weather Limitations,"(b), "Cold Weather -- General."~~
 - a. Cure all bridge decks and approach slabs according to Subsection 501.03.09A(6), (f) "Bridge Deck Curing."
 - b. Curing shall commence immediately upon completion of the finish. In the event that the application or placement of the curing medium is delayed, curing will be as described under ~~(b)2~~ below.
 2. ~~(b) Water Method.~~ The concrete shall be kept continuously wet by the application of water for a minimum period of ~~seven (7)~~ days after the concrete has been placed.

~~The entire surface of the concrete shall be kept damp by applying water in the form of a fine fog mist, until the surface of the concrete is covered with the curing medium. The~~

~~moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.~~

- a. Use fogging equipment capable of applying water through an atomizing nozzle in the form of a fine mist, not a spray. The equipment may use water pumped under adequate high pressure, or a combination of air and water pumped under high pressure. Use equipment sufficiently portable for use in the direction of any prevailing wind. Adapt equipment for intermittent use as directed to prevent excessive wetting of the concrete.
 - b. Cotton mats, rugs, carpets, or earth or sand blankets may be used as a curing medium to retain the moisture during the curing period. The cotton mats, rugs, or carpets shall be of such character that they will retain water.
3. ~~(c)~~ **Curing Compound Method.** The entire surface of the concrete shall be sprayed uniformly with a curing compound. It shall be applied when just a light film of water is present on the surface. If the surface is dry, water shall be added as specified in ~~2(b)~~ above before the curing compound is applied.
- a. On decks or slabs cured by this method, foot traffic ~~must~~ shall be held to a minimum and these surfaces shall not be used as a work area during the cure period. Should the film of the compound be damaged before the expiration of ~~seven (7)~~ days, the damaged portions shall be repaired immediately with additional compound.
 - b. Uniformly spray the entire surface of the concrete with a curing compound conforming to Subsection 702.03.01, "Curing Materials," except as hereinafter specified for concrete bridge decks that are to be the roadway surface. The curing compound shall be applied to the exposed surface at a uniform minimal rate of 1 gallon per 150 square feet of area.
 - c. Do not apply the curing compound until all patching and surface finishing, except grinding, have been completed. When ordered during periods of hot weather, continue fogging of the concrete with water after curing compound is applied until no longer required. Such fogging after the application of the curing compound will be paid for as extra work as provided in Subsection 104.03, "Extra Work."
 - d. The curing compound shall be delivered to the work in ready-mixed form. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. The compound shall not be diluted or altered in any manner, unless dilution is recommended by the manufacturer.
 - e. Provide curing compounds which remain sprayable at temperatures above 40 degrees F and do not hard settle in storage.
 - f. Curing compound that has become chilled to such an extent that it is too viscous for satisfactory application shall be warmed to a temperature not exceeding ~~one hundred (100)~~ degrees ~~F~~ F ~~(38 degrees C)~~.
 - g. Curing compound shall be packaged in clean 55-gallon steel barrels or round 5-gallon steel containers or supplied from a suitable storage tank located at the jobsite.

- 1) Each 55-gallon barrel shall be equipped with a built-in agitator having 2 sets of blades, one at the bottom and one midway between top and bottom, and with removable lids and airtight band fasteners.
 - 2) On-site storage tanks shall be kept clean and free of all contaminants. Each tank shall be provided with a permanent system designed to completely redisperse any settled material without introducing air or any other foreign substance.
 - 3) Barrels shall be filled in a manner that will prevent skinning.
 - 4) Ring seals and lug type crimp lids shall be used to seal 5-gallon containers well.
 - 5) Containers shall be provided with lining that will resist the solvent of the curing compound and will not permit skins to be loosened into the body of the curing compound.
 - 6) Each container shall be labeled with the manufacturer's name, batch number, type of compound, number of gallons, and date of manufacture. Each container shall also be labeled with an Interstate Commerce Commission Red Label warning concerning flammability. The label shall also warn that the curing compound shall be well stirred before use.
 - 7) When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall be supplied with each load containing the same information as that required herein for container labels.
- h. Curing compound may be sampled by the Engineer at the source of supply, at the job site, or at both locations.
- i. Curing compound not used within 6 months of the date of manufacture will require certification from the manufacturer that the curing compound still conforms to ASTM C309. Curing compound more than 1 year old or without a manufacture date on the container will not be allowed for use.

~~The curing compound shall be applied to the exposed surface at a uniform minimal rate of one (1) gallon per one hundred fifty (150) square feet (1 liter per 3.7 square meters) of area.~~

4. ~~(d)~~ Waterproof Membrane.

- a. Keep the exposed finished surfaces of concrete damp with water using an atomizing nozzle, as specified in ~~(b)~~ above Subsection 501.03.09.A.2, until the concrete has set.
- b. Place the curing membrane after the concrete has set.
 - 1) The membrane shall be formed into sheets of such width as to provide a complete cover of the entire concrete surface.
 - 2) All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint.
 - 3) Overlap of sheets shall have a minimum lap of ~~eighteen (18.)~~ inches ~~(46 centimeters)~~.
 - 4) The sheets shall be securely weighted down by placing a bank of earth on the edges of sheets or by other means satisfactory to the Engineer.

- 5) Sheeting material shall conform to Subsection 702.03.01, "Curing Materials."
 - c. The curing membrane shall remain in place for a period of not less than ~~seven (7.)~~ days.
 - d. Should any portion of the sheets be broken or damaged before the expiration of the curing period, the broken or damaged portion shall be immediately repaired with new sheets properly cemented into place, or water curing as described above shall commence immediately.
 - e. Sections of the membrane ~~shall not be used~~ which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing shall not be used.
5. ~~(e)~~ Form Method.
 - a. If forms are kept on the concrete surfaces, this will be considered adequate cure for these surfaces.
 - b. ~~–~~However, should the forms be removed within ~~seven (7.)~~ days after the concrete has been placed, one of the above methods ~~must~~shall be used on the exposed surfaces.

~~b.c.~~ Attention is directed to Comply with Subsection 502.03.11, "Removal of Falsework and Forms."
6. Bridge Deck Curing.
 - a. Submit a quality control plan for concrete placement and curing, for review and approval, a minimum of 30 days prior to the pre-pour conference for bridge decks and approach slabs. The plan shall include, but not be limited to, information on the procedures for when and how the concrete and the curing system is to be placed, frequency for monitoring, maintaining, and re-wetting the curing system chosen, and a list of personnel responsible for performing such work. Include in the plan, equipment to be used for placement of concrete and the curing system, methods of protecting the covers from displacement from wind or weather, and methods of preventing loss of heat and moisture.
 - b. Describe procedures to be followed in the event of equipment breakdown or inclement weather during concrete placement. In addition, describe the method to be used to protect pedestrian and vehicular traffic under the structure.
 - c. Use Figure 2.1.5 from ACI 305R, Hot Weather Concreting, to determine the evaporation rate. Additional protection measures shall be provided if the rate of evaporation exceeds 0.1 pound per square foot per hour.
 - 1) Accurate record of placement location, air temperature, relative humidity, concrete temperature, and wind velocity shall be provided.
 - 2) Readings shall be taken an hour prior to the concrete placement and at 1-hour increments during concrete placement, until the final curing blanket is placed.
 - 3) Required data shall be submitted to the Engineer.

- d. Concrete temperature shall be monitored during the entire curing period by utilizing recording thermocouples embedded at 1 inch below the concrete surface and 1 inch above the bottom concrete surface.
- 1) A minimum of 2 sets of thermocouple installations will be required per each day's placement.
 - 2) The thermocouple shall be capable of recording the concrete temperature as a function of time.
 - 3) Acceptable devices include thermocouples connected to electronic data loggers.
 - 4) The recording time intervals shall be a maximum of 30 minutes.
 - 5) The recording devices shall be accurate to within ± 1.8 degrees F. Concrete temperature between the top and bottom of the slabs and the supporting girders shall be maintained to a maximum differential temperature of 30 degrees F.
 - 6) If differential temperatures exceed the requirements, measures shall be taken to correct the curing process.
 - 7) Required data shall be submitted to the Engineer.
- e. Immediately after the concrete is placed, the moisture content shall be maintained by humidifying the air directly above the concrete surface until the curing covers are placed. Fogging equipment described in ~~“(b) Subsection 501.03.09.A.2, “Water Method,” of this subsection~~ shall be used, mounted on a finishing bridge that is separate from the concrete placing equipment.
- f. Begin placing pre-soaked burlap within 30 minutes after finishing has started. Wet curing of the surface shall be performed for 10 days, unless otherwise directed, with the following covering:
- 1) Burlap and Polyethylene Covering. Burlap conforming to Subsection 702.03.01, “Curing Materials,” and polyethylene (white or reflective) conforming to ASTM C171 shall be furnished. Soaker hose shall be placed or other approved method shall be used to provide continuous wetting of burlap between the burlap and polyethylene covering.
- g. Pre-wetted curing coverings shall be placed with a finishing bridge. Covers shall be placed directly behind the concrete fogging operation.
- h. The covering shall be maintained uniformly wet during the entire curing period. Provide 24-hour monitoring of the wet curing for the full length of the curing period. Water temperature shall not be more or less than 20 degrees F from the temperature of top of bridge deck.
- i. Covers shall be lapped a minimum of 18 inches. All lapped edges shall be sealed to prevent loss of heat and moisture.
- j. If the ambient temperature drops below 45 degrees F during the first 4 days of curing, additional protection shall be provided according to Subsection 501.03.10.C, ~~(e)~~, “Low Temperature Protection.”
- k. After completion of wet curing and removal of curing covering, immediately remove excess water and apply an application of curing compound according

~~to paragraph~~ Subsection 501.03.09.A.3, "Curing Compound Method." ~~of this subsection.~~

- I. All cracks on new bridge decks and approach slabs shall be repaired. Requested method of repair shall be submitted for approval.
7. Maturity Meter Method:
 - a. This method may be used if referred to in the Contract Special Provisions.
 - b. The method specified in ASTM C1074 may be used in order to reduce the cure time. This method requires training and certification of the Quality Assurance and Control personnel.
 - c. This method shall not be used for acceptance but for reducing the time ~~for~~ required for form removal. The Contractor shall have a plan of action approved by the Engineer and monitored by a third party engineer for meter placement and monitoring.

501.03.10 WEATHER LIMITATIONS

- A. ~~(a)~~ **General.** If impending inclement weather conditions exist, the Contractor shall decide whether or not to begin the ~~pour~~placement and ~~he~~ the Contractor shall have sole responsibility for ~~hi~~Contractor's decision.
 1. ~~–~~Before any concrete is placed, the Contractor shall have adequate provisions readily available as approved by the Engineer, to protect the concrete from any impending weather conditions.
 2. ~~–~~In case precipitation should occur after placing operations have started, the Contractor shall provide ample covering to protect the work.
 3. ~~–~~The placing of concrete shall be stopped before the quantity of precipitation is sufficient to cause a flow or to wash the surface.
- B. ~~(b)~~ **Cold Weather ~~---~~ General.** Comply with ACI 306, Cold Weather Concreting, with the following exceptions or additions:
 1. All concrete shall be maintained at a temperature of not less than ~~fifty (50)~~ degrees F. (10 degrees C.) for ~~three (3)~~ days or not less than ~~forty (40)~~ degrees F. (4.4 degrees C.) for ~~seven (7)~~ days. The count of time shall commence immediately upon completion of final placement and vibration. The ~~three (3) fifty (50)~~ degree F. (10 degree C.) days need not be consecutive.
 2. One ~~twenty-four (24)~~ hour period shall constitute ~~one (1)~~ day.
 3. The temperature of the concrete shall be determined by placement of thermometers on the concrete surfaces and properly insulating ~~said~~these devices to record the surface temperature of the concrete.
 - a. ~~–~~Temperature shall be monitored continuously throughout the total protection time required by this subsection.
 - b. ~~–~~In case the surface temperature of the concrete falls below ~~forty (40)~~ degrees F. (4.4 degrees C.) for a duration of ~~three (3)~~ hours or more in any ~~twenty-four (24)~~ hour period during the time of temperature protection, the time shall be increased ~~one (1)~~ day for each day this occurs.

- c. ~~An absolute minimum temperature of thirty-five (35) degrees F. (1.7 degrees C.) must~~shall be maintained for the total time of protection specified in this subsection.
 - d. ~~Should the temperature of the concrete fall below thirty-five (35) degrees F. (1.7 degrees C.) at any time, damage may occur.~~
 - e. ~~The assessment of damage will be determined by the Contracting Agency a~~professional engineer registered in Nevada and paid for by the Contractor and concrete so damaged may require repair or replacement at the option of the Engineer.
4. The concrete shall have a temperature of at least ~~fifty (50) degrees F. (10 degrees C.)~~ and not more than ~~ninety (90) degrees F. (32 degrees C.)~~ at the time of placing. (Also, see comply with temperature constraints specified in Subsection 501.03.06, "Machine Mixing.")
- a. ~~Heating equipment or methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used.~~
 - b. ~~The equipment shall be capable of heating the materials uniformly.~~
 - c. ~~Aggregates and water used for mixing shall not be heated to a temperature exceeding one hundred fifty (150) degrees F. (66 degrees C.)~~
 - d. ~~Concrete containing frost or lumps at the time of placing shall not be used.~~
5. Stockpiled aggregates may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire.
6. Reinforcing steel shall be free of ice, snow, ~~or~~and frost during placement of concrete. Concrete shall not be placed on frozen ground.
- C. ~~(c)~~Low Temperature Protection. Refer to guidelines in ACI 306, Cold Weather Concreting, with the following exceptions or additions:
- 1. ~~(1)~~General. After the concrete has been placed, means shall be taken to protect the concrete from any impending low temperatures.
 - a. Methods and materials not hereinafter prescribed may be used if approved by the Engineer and the following requirements adhered to:
 - 1) ~~(a)~~—Materials shall be fire resistant
 - 2) ~~(b)~~—Materials shall be waterproof
 - 3) ~~(c)~~—Materials shall not adhere, abrade or damage the surface of the concrete.
 - b. Approval of the Engineer shall not relieve the Contractor from obtaining specification results.
 - 2. ~~(2)~~Insulating Blankets.
 - a. ~~Insulating blankets used to protect concrete from low temperatures shall be fire resistant and waterproof.~~
 - b. ~~The blankets must~~shall be secured and overlapped along the edges and joints to ~~ensure~~ensure that no opening will exist in the protection during high winds or other adverse conditions.

- c. -Provisions shall be made to allow the reading of ~~any~~ thermometers placed inside of the protection.
 - d. -When depositing concrete against previously cast concrete, the blanket insulation shall extend at least ~~fourteen (14) inches (36 centimeters)~~ onto the existing concrete and shall be securely held in place.
3. ~~(3)~~ **Low Temperatures Protection -- Heating and Housing.**
- a. -In order to meet the provisions of ~~Articles paragraphs (a) and (b) of this~~ ~~s~~ Subsection 501.03.09, paragraphs A and B, the concrete may be protected by applying artificial heat within an enclosure.
 - b. -The enclosure ~~wi~~shall be constructed with fire resistant material, unless otherwise directed by the Engineer, and shall be subject to ~~his~~ Engineer's approval.
 - c. -The heating system shall be so arranged as to provide uniform heating, ~~i~~ensuring that the concrete farthest from the source of heat is receiving adequate protection without drying the concrete near the source of heat so as to cause shrinkage cracks.
4. The temperature of the concrete will be determined by placement of thermometers on the concrete surfaces and properly insulating these devices to record the surface temperature of the concrete according to NV Test Method ~~No. Nev. T440.~~
- a. Temperature will be monitored continuously throughout the total projection time required by this subsection.
 - b. If the surface temperature of the concrete falls below 50 degrees F during the first 3 days and 40 degrees F during the next 4 days of the temperature protection for a duration of 3 hours, the curing time will be increased 1 day for each day this occurs.
 - c. Should the temperature of the concrete fall below 35 degrees F at any time during the 7 days of temperature protection or if the surface temperature of the concrete falls below 40 degrees F during the first 24 hours of temperature protection period, the assessment of damage will be determined by a Nevada registered professional engineer paid for by the Contractor and damaged concrete shall be repaired or replaced at the option of the Engineer.
 - d. Contractor shall be responsible for all costs associated with damage assessment and repair.
- D. ~~(d)~~ **Hot Weather.** Comply with guidelines in ACI 305, Hot Weather Concreting, with the following exceptions or additions:
- 1. The maximum temperature of cast-in-place concrete shall not exceed ~~ninety (90)~~ degrees ~~F. (32 degrees C.)~~ immediately before placement.
 - 2. For continuous placement of concrete on the deck with reinforcing steel units, retard the initial set of the concrete sufficiently to ensure that concrete remains plastic for subsequent placement.
 - 3. For both simple and continuous spans, submit a retardation schedule for approval.
 - 4. The consistency of the concrete as placed ~~should~~ shall allow the completion of initial finishing operations without the addition of water to the surface. When conditions are such that additional moisture is needed for initial finishing, the required water

shall be applied to the surface fog spray only, and shall be held to a minimum amount. Apply fog spray for this purpose as specified in Subsection 501.03.09.A.2 (b), "Water Method." Fog spray for this purpose may be applied with hand-operated fog equipment, as approved by the Engineer.

5. From the time of initial strike-off until final finish is complete, the unformed surfaces of slab concrete shall be protected from rapid evaporation of mixing water from the concrete due to wind, high temperature, low humidity, or combination thereof.
6. Equipment for fogging, type of evaporation retarder, and method of application shall be approved by the Engineer. Equipment shall be portable, adapted for intermittent use, and operable in the direction of any prevailing wind.
7. Use fogging equipment capable of providing a fog mist, as necessary, to the area between the finishing machine and the tining machine. The fogging equipment shall meet the requirements of Subsection 501.03.09.A.2-(b), "Water Method." If at any time it becomes apparent that the combination of fogging and curing application are not, or will not be effective in preventing plastic shrinkage cracking, stop the concrete placement until environmental conditions improve substantially, or until other preventative measures are approved in writing by the Engineer.
8. After all finishing operations are complete a final curing membrane shall be applied.

501.03.11 TRIAL SLAB AND PROCESS CONTROL TESTING

- A. If silica fume is used in bridge deck concrete, construct a trial slab at least 30 days prior to placement of concrete on a bridge deck. Submit a written plan for the casting of decks. Include in this plan, at a minimum, the location of slab, the equipment and personnel used for construction, and disposal of slab. Prior to placement of the trial slab, conduct a ~~pre-pour conference~~Pre-Activity Meeting.
- B. Use approved mix designs. Place concrete at a location other than the bridge deck, but under similar conditions to those that exist during bridge deck concrete placement.
 1. The trial slab shall have a minimum length and width of 50 feet and a depth of 8 inches.
 2. Reinforce slab with a top and bottom mat of No. 5 bars spaced 6 inches longitudinally and transversely.
 3. Place top mat at a depth of 2-1/2 inches from the top of the slab.
 4. Place bottom mat at a depth 1-1/2 inches from the bottom of slab.
 5. The trial slab shall be wet-cured in accordance with the specifications.
 6. Use personnel such as superintendent, key operators, and finishers that are the same personnel who will be involved in the final construction of the bridge deck.
 7. Demonstrate the use of equipment, proficiency of personnel, and techniques for mixing, transporting, placing, and curing of the concrete during the trial.
 8. Fifteen days after the placement of the trial slabs, conduct a post construction critique of the trial slab placement in writing.
- C. Do not commence placement of bridge deck concrete until after any issues from the post construction critique of trial slab construction have been resolved to satisfaction of the Engineer.
- D. Upon notification, remove and dispose of trial slabs according to Subsection 107.14, "Disposal of Material Outside Project Right-of-Way."

MORTAR**501.04.01501.03.12 GENERAL MORTAR**

- A. Cement mortar shall consist of a mixture of Portland cement, sand, and water. Cement and sand shall first be combined in the proper proportions, and then thoroughly mixed with the required amount of water.
1. ~~(a)~~ Cement mortar shall be designated by class and proportioned by loose volume as follows:

Designation	Proportions
Class "A" Mortar	1 Part Cement to 1 Part Sand
Class "B" Mortar	1 Part Cement to 1-1/2 Parts Sand
Class "C" Mortar	1 Part Cement to 2 Parts Sand
Class "D" Mortar	1 Part Cement to 2-1/2 Parts Sand
Class "E" Mortar	1 Part Cement to 3 Parts Sand
Class "F" Mortar	1 Part Cement to 3-1/2 Parts Sand

2. The quantity of water to be used in the preparation of mortar shall be only that required to produce a mixture sufficiently workable for the purpose intended.
 3. Mortar shall be used as soon as possible after mixing and shall show no visible signs of setting prior to use. Re-tempering of mortar will not be permitted.
- B. ~~(b)~~ **Cement.** Cement shall conform to the requirements of Section ~~701~~, "Hydraulic Portland Cement."
- C. ~~(c)~~ **Sand.** Sand shall conform to the requirements of Subsection ~~706.03.04~~, "Grout and Mortar Sand." In proportioning the sand it shall be measured loose (without shaking or compacting) in measuring boxes or other suitable containers of known capacity.
- D. ~~(d)~~ **Admixtures.** No admixture shall be used in mortar unless otherwise specified or approved by the Engineer.

METHOD OF MEASUREMENT**501.04.01 MEASUREMENT**

- A. Portland cement concrete will be measured for payment in accordance with the provisions specified in the various sections of these specifications covering construction requiring concrete.

~~05~~ BASIS OF PAYMENT**501.04.01501.05.01 PAYMENT**

- A. Portland cement concrete shall be ~~measured and~~ paid for in accordance with the provisions specified in the various sections of these specifications covering construction requiring concrete.

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501.05.02 TRIAL SLAB PAYMENT

- A. Full compensation for construction and removal of trial slabs and trial pours shall be considered as included in the contract unit price paid for other appropriate items and no separate payment will be made therefor.