SECTION 1006 PORTLAND CEMENT CONCRETE: of the Standard Specifications is revised to read:

1006-1 General Requirements:

Portland cement concrete shall consist of a mixture of hydraulic cement, fine aggregate, coarse aggregate, and water. It may also contain chemical admixtures, additives, and supplementary cementitious materials meeting the requirements herein.

The contractor shall determine the mix proportions and shall furnish concrete which conforms to the requirements of the specifications. All concrete shall be sufficiently workable, at the slump proposed by the contractor within the specified range, to allow proper placement of the concrete without segregation, bleeding, or incomplete consolidation. It shall be the responsibility of the contractor to proportion, mix, place, finish, and cure the concrete properly in accordance with the requirements of the specifications.

1006-2 Materials:

1006-2.01 Cementitious Material:

(A) General:

Cementitious material is defined as an inorganic material or a mixture of inorganic materials that sets and develops strength by chemical reaction with water by formation of hydrates and is capable of doing so under water. In this specification, cementitious materials are defined as hydraulic cement (Portland cement or Portland-pozzolan cement) and supplementary cementitious materials (fly ash, natural pozzolan, or silica fume).

(B) Hydraulic Cement:

Hydraulic cement shall consist of either Portland cement or Portland-pozzolan cement.

Portland cement shall conform to the requirements of ASTM C150 for Type II, III, or V, and shall not contain more than 0.60 percent total equivalent alkalies.

Portland-pozzolan cement shall conform to the requirements of ASTM C595 for blended hydraulic cement with moderate sulfate resistance, Type IP (MS).

Cement of different types or brands shall not be intermingled or used in the same batch. The contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which has become partially set or which contains caked lumps shall not be used.

The use of either sacked cement or bulk cement is permissible. The use of fractional bags of sacked cement will not be permitted unless the contractor elects to weigh the cement into each batch.

(C) Supplementary Cementitious Materials:

(1) General:

Supplementary cementitious materials may be used in addition to hydraulic cement. Supplementary cementitious materials shall be approved prior to their use. When either moderate or high sulfate resistant concrete is specified in the Special Provisions, the proposed hydraulic cement/supplementary cementitious material blend shall be tested for sulfate expansion in accordance with ASTM C1012. When moderate sulfate resistance is specified, the maximum expansion shall be 0.10 percent at six months. When high sulfate resistance is specified, the maximum expansion shall be 0.05 percent at six months or 0.10 percent at one year.

(2) Fly Ash and Natural Pozzolan:

Fly ash and natural pozzolan shall conform to the requirements of ASTM C618 for Class C, F, or N, except that the loss on ignition for Class F and Class C shall not exceed 3 percent.

(3) Silica Fume:

Silica fume shall conform to the requirements of ASTM C1240. Certification of silica fume will be based on a Certificate of Compliance conforming to the requirements of Subsection 106.05 submitted for each lot of silica fume.

(D) Acceptance of Cementitious Materials:

The certification and acceptance of cementitious materials will be on the basis of the materials originating from an Approved Materials Source. Approved Materials Sources Lists for cementitious materials are maintained by the Materials Group, Structural Materials Testing Section.

Source approval of hydraulic cement, fly ash, and natural pozzolan producers/suppliers will be based on monthly submittals to the Materials Group, Structural Materials Testing Engineer, at cert@azdot.gov. The following documentation shall be submitted:

(1) A Certificate of Compliance which lists the lots produced during that month.

(2) A separate Certificate of Analysis for each lot shown on the corresponding Certificate of Compliance for that month.

1006-2.02 Water:

Water shall meet the requirements of ASTM C1602, except that it shall contain no more than 1,000 parts per million of chlorides as Cl and no more than 1,000 parts per million of sulfates as SO_4. The water used shall be free of injurious amounts of oil, acid, alkali, clay, vegetable matter, silt, or other harmful matter. Potable water obtained from public utility distribution lines will be acceptable.

1006-2.03 Aggregates:

(A) General Requirements:

When concrete is to be placed at elevations above 4,500 feet, the fine aggregate and the coarse aggregate shall be subjected to five cycles of the sodium sulfate soundness test, and the weighted percentage loss determined separately for each, in accordance with the requirements of ASTM C88. The weighted percentage loss determined for each shall not exceed 10 percent. Tests for soundness may be waived when aggregates from the same source have been approved and the approved test results apply to the current production from that source.

Mill tailings or material from mine dumps shall not be used in the production of fine or coarse aggregate.

The following test methods may be used to evaluate the quality of aggregates for concrete:

TABLE 1006-1
Test Methods for Quality of Aggregates

Sampling	Arizona Test Method 105
Reducing field samples to testing size	AASHTO R 76
Potential for Alkali Silica Reaction (ASR)	ASTM C1260, C1567, or ASTM C1293
Clay lumps and friable particles	AASHTO T 112
Lightweight particles (Specific gravity less than 2.0)	AASHTO T 113 (See Note)
Organic impurities	AASHTO T 21
Aggregate gradation	Arizona Test Method 201
Soundness (Sodium Sulfate)	ASTM C88
Mortar Strength	AASHTO T 71 (See Note)
Sand equivalent	AASHTO T 176
L.A. abrasion	AASHTO T 96
Fractured Coarse Aggregate Particles	Arizona Test Method 212
Note: AASHTO T 113 and T 71 are modified as specified in Subsections 1006-2.03 (B) and (C).	

(B) Fine Aggregate:

Fine aggregate shall be a natural or manufactured sand, or other approved inert material with similar characteristics, composed of clean, hard, strong, durable, uncoated particles. The aggregate shall be washed and shall conform to the requirements of AASHTO M 6, with the following exceptions:

The amount of deleterious substances in the washed fine aggregate shall not exceed the following limits by dry weight, when tested in accordance with the following test methods:

TABLE 1006-2 Deleterious Substances in Fine Aggregate		
Clay lumps and friable particles	AASHTO T 112	0.5%
Lightweight particles (Specific gravity less than 2.0)	AASHTO T 113 (Except that the percent of lightweight particles shall be reported to the nearest 0.01%.)	1.25% (0.25% Max. Coal and Lignite*)
* Only material that is brownish-black, or black, shall be considered coal or lignite.		

Fine Aggregate shall meet the following gradation requirements when tested in accordance with Arizona Test Method 201.

TABLE 1006-3 Gradation of Fine Aggregate	
Sieve Size	**Percent Passing**
3/8 in.	100
No. 4	95 - 100
No. 16	45 - 80
No. 50	0 - 30
No. 100	0 - 10
No. 200	0 - 4.0

Fine aggregate shall have a sand equivalent value of not less than 75. Fine aggregates shall be subjected to testing under AASHTO T 21 for organic impurities. Fine aggregate producing a color darker than the standard color shall be rejected unless the material passes the mortar strength requirements specified in the following paragraph:

Fine aggregate not meeting the requirements for organic impurities shall be made into mortar and subjected to testing in accordance with AASHTO T 71, except that the mortar shall develop a compressive strength at seven and 28 days of not less than 90 percent of that developed by a mortar prepared in the same manner with the same Type II cement and graded sand conforming to the requirements of ASTM C778.

(C) Coarse Aggregate:

Coarse aggregate shall consist of crushed stone, gravel, crushed gravel, or other approved inert material of similar characteristics, including cinders when specified, having hard, strong and durable pieces free of clay and other deleterious substances. The aggregate shall be washed. The aggregate gradation, when tested in accordance with Arizona Test Method 201, shall conform to the appropriate size designation of AASHTO M 43.

The amount of deleterious substances in the washed coarse aggregate shall not exceed the following limits by dry weight, when tested in accordance with the following test methods, except as noted:

TABLE 1006-4 Deleterious Substances in Coarse Aggregate		
Clay lumps and friable particles	AASHTO T 112	0.3%
Lightweight particles (Specific gravity less than 2.0)	AASHTO T 113 (Except that the percent of lightweight particles shall be reported to the nearest 0.01%.)	1.25% (0.25% Max. Coal and Lignite*)
Material passing No. 200 sieve	Arizona Test Method 201	1.0%
* Only material that is brownish-black, or black, shall be considered coal or lignite.		

The percent of wear of coarse aggregate at 500 revolutions, when tested in accordance with the requirements of AASHTO T 96, shall not exceed 40. The percent of one face fractured coarse aggregate particles shall be at least 30 when tested in accordance with the requirements of Arizona Test Method 212.

1006-2.04 Admixtures and Additives:

(A) General Requirements:

A list of approved admixtures and additives is maintained on the Department's Approved Products List (APL). Copies of the most recent version of the APL are available on the internet from the ADOT Research Center through its Product Evaluation Program. Admixtures and additives other than those listed on the APL may be considered for use as specified in Subsection 106.14.

Certificates of Compliance shall be submitted which clearly state the time period in which the production of the product meets the appropriate ASTM standard and that formulation of the product has not changed during the stated time period. The time period shall be limited to 12 months prior to the date of signature on the certificate. The certificate shall be submitted to the Materials Group, Structural Materials Testing Section, and retained for record.

Concrete admixtures and additives shall be uniform throughout their use in the work. All concrete admixtures and additives shall be stored in suitable containers in accordance with the manufacturer's recommendations. All liquid admixtures shall be protected from freezing. Liquid admixtures that have frozen shall not be used. If more than one admixture is used, the admixtures shall be compatible with each other so that the desired effects of all admixtures used are realized.

Admixtures and additives having a chloride concentration of 10,000 parts per million (1 percent by weight of the admixture) or less, as determined in accordance with Arizona Test Method 738 or Test Method BS EN 480-10:2009, are acceptable unless otherwise specified. Calcium chloride as a separate admixture shall not be used. At no time shall materials with chlorides be incorporated into any precast bridge members, precast concrete product, or concrete pipe product.

(B) Chemical Admixtures:

Air-entraining admixtures shall conform to the requirements of ASTM C260.

Water reducing, retarding, hydration stabilizing, and accelerating admixtures shall conform to the requirements of ASTM C494 for the appropriate type.

Specific performance admixtures for precast items, patching materials, or other products shall also conform to the requirements of ASTM C494, including data to substantiate the specific performance characteristics.

(C) Additives:

Pigments incorporated into the approved concrete mix design for integrally colored concrete shall meet the requirements of ASTM C979.

Fibers incorporated into the approved concrete mix shall meet the requirements of ASTM C1116. The specific type, size, and quantity of fiber shall be determined by the mix designer.

Micro fiber additive may be used for plastic shrinkage control, subject to approval by the Engineer.

1006-3 Design of Mixtures:

1006-3.01 Design Criteria:

Portland cement concrete shall conform to the requirements specified in Table 1006-5 for each of the classes listed therein. Unless otherwise specified, the cementitious material content shall be as shown.

TABLE 1006-5 Design Criteria				
Class of Concrete	**Minimum 28-Day Compressive Strength Required: psi (ASTM C39)**	**Cementitious Material Content: Lbs. per Cu Yd. Minimum - Maximum**	**Maximum Water-Cementitious Material Ratio (w/cm): Lb./Lb.**	**Slump Range: Inches**
B	2,500	470 - 658	None	Chosen by Contractor
S	2,500	520 - 752	0.55	
	3,000			
	3,500			
	4,000			
	4,500	564 - 752	0.50	
	Greater than 4,500	564 - 800	0.45	
P	4,000	564 - 658	None	0 - 4.5
H	High performance concrete as specified in project special provisions.			

(A) Supplementary Cementitious Material Limitations and Requirements:

Supplementary cementitious materials (fly ash, natural pozzolan, or silica fume) conforming to the requirements of Subsection 1006-2.01 may be used, as specified in the paragraphs below.

(1) When Portland cement is used, a maximum of 25 percent, by weight of the cementitious material, may be an approved fly ash or natural pozzolan, except as specified in paragraphs (4), (5), and (6) below.

(2) When Portland pozzolan cement [Type lP (MS)] is used, fly ash or natural pozzolan is not allowed, except as specified in paragraphs (4), (5), and (6) below.

(3) When silica fume is used, a maximum of 10 percent, by weight of the cementitious materials, may be used.

(4) When a compressive strength greater than 4,500 psi is required, supplementary cementitious materials may be added in excess of the maximum cementitious material content. Fly ash or natural pozzolan may exceed 25 percent and silica fume may exceed 10 percent, by weight of the cementitious material, if approved by the Engineer.

(5) When increased sulfate resistance is specified, the required amount of fly ash or natural pozzolan shall be incorporated into the concrete and may exceed 25 percent, by weight of the cementitious material.

(6) For Class S concrete used in bridge decks, a minimum of 20 percent, by weight of the cementitious material, shall be an approved Class F fly ash or natural pozzolan, unless otherwise approved by the Engineer.

(B) Alkali-Silica Reactivity Limitations and Requirements:

For any concrete mix, other than for precast or prestressed bridge members, with a Portland cement content greater than 545 pounds per cubic yard, one of the options specified in the paragraphs below for the mitigation of a potential alkali silica reaction (ASR) shall be used:

(1) A minimum of 20 percent Class F fly ash or natural pozzolan, by weight of the cementitious material, shall be used.

(2) Instead of using Portland cement, Type IP (MS) Portland-pozzolan cement with a Class F fly ash or natural pozzolan content of at least 20 percent, by weight of the cementitious material, shall be used.

(3) Limit the total equivalent alkalies to a maximum of 3.00 pounds per cubic yard of concrete, when calculated as follows:

$$\begin{bmatrix}\text{Pounds of total}\\ \text{alkali per cubic}\\ \text{yard of concrete}\end{bmatrix} = \frac{\begin{pmatrix}\text{Pounds of Portland}\\ \text{cement per cubic}\\ \text{yard of concrete}\end{pmatrix} \text{ x } \begin{pmatrix}\text{Equivalent alkalies (\%)}\\ \text{in Portand cement}\end{pmatrix}}{100}$$

(4) Introduce a lithium nitrate admixture, which has been approved by the Engineer, at a minimum dosage of 0.55 gallons of 30 percent lithium nitrate solution per pound of total equivalent alkalies per cubic yard of concrete. The required amount of lithium nitrate is calculated as follows:

$$\begin{bmatrix}\text{Required gallons}\\ \text{of 30 percent}\\ \text{lithium nitrate}\\ \text{solution}\end{bmatrix} = \frac{\begin{pmatrix}\text{Pounds of}\\ \text{Portland cement}\\ \text{per cubic yard}\\ \text{of concrete}\end{pmatrix} \text{ x } \begin{pmatrix}\text{Equivalent alkalies (\%)}\\ \text{in Portand cement}\end{pmatrix}}{100} \text{ x } (0.55)$$

(5) The coarse aggregate and the fine aggregate shall be tested separately in accordance with ASTM C1260 to determine the potential for alkali silica reaction (ASR). When aggregates show the potential for ASR, as indicated by expansions of 0.10 percent or greater at 16 days after casting, sufficient mitigation for the expansion shall be determined in accordance with ASTM C 1567. The use of fly ash or natural pozzolan

may exceed 25 percent, by weight of the cementitious material when used to mitigate the potential for ASR.

(C) Class B and Class S Concrete Slump Limitations and Requirements:

The proposed slump for Class B and Class S concrete shall be chosen by the contractor. The permissible variation for the proposed slump shall be as specified in Subsection 1006-7.03. Concrete at the proposed slump shall be sufficiently workable to allow proper placement without harmful segregation, bleeding, or incomplete consolidation.

(D) High Performance Concrete Limitations and Requirements:

For Class H concrete, if the maximum cementitious material content is exceeded in order to achieve high early strength requirements, and if required by the Engineer, the mix design shall be accompanied by shrinkage testing demonstrating that shrinkage is less than 0.04 percent when tested in accordance with ASTM C157. However, the conditioning period shall be modified to consist of an initial seven day wet curing period followed by a 21 day dry curing period.

(E) Air Entrainment Requirements:

Air-entraining admixtures are required for all classes of concrete placed at an elevation of 3000 feet or above and may be used in other situations at the contractor's discretion. For air-entrained concrete placed at an elevation of 3000 feet or above, a specific air content target shall be established in the mix design with a value within the range of the appropriate criteria from Table 1006-10 in Subsection 1006-7.03 (A).

No air-entrainment will be required for minor precast structures, precast pipe, and precast, prestressed structural members supporting a concrete deck slab or impervious overlay. Also, no air-entrainment is required for any precast items constructed using the dry pack or no-slump method.

(F) Water-Reducing Admixtures:

Unless specifically required, water-reducing admixtures may be used at the option of the contractor.

(G) Coarse Aggregate Size Determination:

The coarse aggregate size designation for Class S or Class B concrete shall be chosen by the contractor and approved by the Engineer and shall conform to the size designation and grading requirements of AASHTO M 43. In choosing the size designation, the maximum size of coarse aggregate shall not be larger than 1/5 of the narrowest dimension between the sides of adjacent forms, or 2/3 of the minimum clear spacing between reinforcing bars, or 2/3 of the minimum clear spacing between reinforcing bars and the sides of adjacent forms, or 1/3 of the depth of the slab, whichever is least. If two or more stockpiles are utilized to manufacture an AASHTO M 43 size designation, at the time of proportioning for mixing, the aggregate from each stockpile shall be measured by weight and proportioned so

that the resulting mixture of coarse aggregate meets the requirements for the chosen size designation.

Coarse aggregate for Class P concrete used to construct Portland cement concrete pavement without load transfer dowels shall be separated into two or more stockpiles. At the time of proportioning for mixing, the aggregate from each stockpile shall be measured by weight and proportioned so that the resulting mixture of coarse aggregate meets the requirements for size designation No. 467, as specified in AASHTO M 43. Coarse aggregate for Class P concrete placed in pavement ramp tapers not exceeding a width of 10 feet and in pavement gore areas may be size designation No. 57, as specified in AASHTO M 43. The use of size designation No. 57 coarse aggregate may be used in concrete placed in other inaccessible pavement areas when approved in writing by the Engineer.

Coarse aggregate for Class P concrete used to construct Portland cement concrete pavement with load transfer dowels and adjacent shoulders shall meet the requirements for size designation No. 57, as specified in AASHTO M 43.

1006-3.02 Mix Design Submittal Procedures:

At least two weeks prior to the appropriate concreting operation, the contractor shall submit concrete mix designs to the Engineer for review and approval. More than one mix design for each class of concrete and each strength of Class S concrete may be submitted for approval provided specific items and locations of intended uses accompany each mix design. For mix designs without historical data in ADOT files, the contractor shall substantiate the mix design(s) by furnishing sufficient mix history or trial batch testing data as specified in Subsection 1006-3.03 and providing all details of the mixtures proposed for use. The contractor shall submit all mix designs with a separate cover sheet(s) which includes the following information:

(A) Cover Sheet:

(1) Project name
(2) Project number
(3) ADOT project number
(4) Contractor
(5) Subcontractor (if applicable)
(6) Material supplier
(7) A list of the submitted mix designs identified by product code, design strength, batch plant, class, and intended use(s)

If supplied by a commercial ready-mix supplier, the batch plant number and address shall be provided on the cover sheet as well as the date of the most recent batch plant certification and the name of the inspecting and certifying organization or agency.

(B) Mix Designer:

Mix designs shall be prepared by or under the direct supervision of, and signed by a person having both experience in the development of mix designs, including the respective type of concrete, and satisfying one of the following criteria:

(1) Registered Professional Engineer
(2) Certified National Institute for Certification in Engineering Technologies (NICET) Level III Technician or higher
(3) Certified National Ready Mix Association (NRMCA) Level 3 Concrete Technologist
(4) Certified American Concrete Institute (ACI) Concrete Laboratory Testing Technician Level 2 or Grade II

Mix designs for precast or prestressed concrete shall be prepared by or under the direct supervision of, and signed by, a Registered Professional Engineer or a PCI Quality Control Technician/Inspector Level II or higher.

(C) Mix Design Submittal Requirements:

Concrete mix designs shall be proportioned on the basis of a cubic yard of concrete. The complete solid volume mix design(s) submitted for approval shall be provided to the Engineer by the contractor and shall include all of the following:

(1) Product Code
(2) ADOT project number
(3) Plant Identification and Location
(4) Class of Concrete
(5) Design strength and age
(6) Design air content and range (+/-)
(7) Design slump range for Class P (as specified in Table 1006-5) or design slump and permissible variation (as specified in Subsection 1006-7.03) for Class S and Class B concrete
(8) Design spread and permissible variation for self-consolidating concrete (SCC) (as specified in Subsection 1006-4.05(E)).
(9) Design water-cementitious materials ratio
(10) Design unit weight in pounds per cubic foot
(11) Name and type of each material including admixtures and additives
(12) Supplier of each material including admixtures and additives
(13) Source of cementitious materials, water, and aggregates including the associated commercial materials (CM) source number(s)
(14) Weight of each material measured to the nearest pound
(15) Specific gravity of each material (determined within last 12 months) to the nearest thousandth
(16) Volume of each material measured to the nearest hundredth of a cubic yard
(17) Dosage rate of each chemical admixture or additive or manufacturer-recommended dosage range when applicable.
(18) Total volume measured to the nearest hundredth of a cubic yard
(19) Total weight per cubic yard measured to the nearest pound

(20) Printed name and signature of the individual responsible for development of the mix design

A single mix design product code may include multiple sources of cement, fly ash, natural pozzolan, and silica fume. When multiple sources of material are used under one product code, documentation shall be provided which shows similar performance using materials from each source. Multiple sources of material shall be listed on the mix design as alternative sources.

1006-3.03 Approval of Concrete Mix Designs:

All mix designs shall be approved by the Engineer prior to use. All mix designs for precast or prestressed concrete shall be approved by the Materials Structural Testing Section prior to use. Mix designs meeting the criteria herein and identified as one of the following will be considered for approval:

A mix design that has been previously approved or used successfully on an ADOT project within the past 24 months and is on file with the Department.

A mix design similar to that specified that has been used successfully on a non-ADOT project and sufficient mix history no older than 24 months shall be included with the mix design submittal. The mix history shall include dates placed, compressive strength test records, and other pertinent data.

A new mix design that does not meet the criteria for a previously used mix design requires a trial batch from either the field batch plant or an ADOT approved testing laboratory.

In no case shall the approval of a mix design relieve the contractor of the responsibility for the results obtained by the use of such approved mix design.

(A) Previously Used Mix Design Approval:

(1) Previously Used on ADOT Projects:

Mixtures having been ADOT approved or used previously with satisfactory compressive strength history within the past 24 months may be acceptable provided all of the following apply:

(a) The mix code, design slump, and air content have not changed, and the water-cementitious materials ratio has not increased.

(b) The coarse aggregate size designation(s) and source remain unchanged and the total coarse aggregate quantity has not changed by more than 5 percent

(c) The fine aggregate source remains unchanged and the quantity has not changed by more than 5 percent

(d) The source and type of each cementitious material remains unchanged and the quantity of each has not changed by more than 2 percent

(e) The quantity of water has not changed by more than 2 percent

(f) Coarse and fine aggregate specific gravities have been measured and updated within the last 12 months

(g) The dosage of chemical admixtures remain within manufacturer's recommended ranges

(2) Previously Used on Non-ADOT Projects:

When submitting a concrete mix used successfully on a non-ADOT project, mix history shall be required for consideration and approval of the mix. Using strength test records from an ADOT approved laboratory, which are not more than 24 months old, a sample standard deviation (s_s) may be used to establish the required over-design. Test records shall comply with the following criteria:

(a) Representative of materials, quality control procedures, and conditions similar to those expected on the project.

(b) Representative of concrete produced to meet a compressive strength, or strengths, within 1000 psi below or 1000 psi above the specified design compressive strength.

(c) Shall include the date, compressive strength, slump, air content (when applicable), and calculated results from Table 1006-6 and Table 1006-7.

(d) Consist of at least 15 consecutive compressive strength tests that span a period of not less than 45 days. If the test record consists of at least 30 consecutive tests, the sample standard deviation (s_s) of those tests is used. If the test record consists of 15 to 29 consecutive tests, the standard deviation of those tests shall be modified in accordance with Table 1006-6.

TABLE 1006-6 Standard Deviation Modification Factor	
No. of tests *	Modification factor for sample standard deviation (k)
< 15	Minimum 20% over-design
15	1.16
20	1.08
25	1.03
30 or more	1.00
* For 15 to 29 tests, interpolate for intermediate number of tests. k = Modification factor (multiplier) by which s_s shall be multiplied to be used to determine the required minimum over-design compressive strength, f'_{cr}, in Table 1006-7.	

The required minimum over-design compressive strength shall be determined by the equations shown in Table 1006-7.

Table 1006-7 Over-Design Compressive Strength Equations	
Specified design compressive	Required minimum over design compressive
$f'_c \leq 5000$	Use the larger value computed from these two equations: $f'_{cr} = f'_c + 1.34k \times s_s$
$f'_c > 5000$	Use the larger value computed from these two equations: $f'_{cr} = f'_c + 1.34k \times s_s$
f'_c = Specified design compressive strength. f'_{cr} = Required minimum over-design compressive strength s_s = Sample standard deviation k = Modification factor from Table 1006-6 if applicable	

To be considered for approval by the Engineer, the average strength of the provided test data shall be greater than f'cr, and the mix history shall be from a mix deemed to be sufficiently representative of the materials and proportions proposed for use in the submitted mix design.

(B) New Mix Design Approval:

The over-design requirement for new mix designs shall be a minimum of 20 percent of the specified design compressive strength and shall be substantiated by trial batches. Trial batch results may be from laboratory trial batches or full-scale trial batches.

(1) Laboratory trial batches are defined as "proportionally reduced quantities of the materials that are to be used in production, mixed in a portable or laboratory concrete mixer at an ADOT Approved Laboratory". Such trial batches shall be overseen and verified by a Professional Engineer with experience in concrete mix designs.

(2) Full-scale trial batches are defined as "utilizing the materials, mixing equipment, and procedures that are the same as those to be used in production." Full-scale trial batches shall consist of at least 4 cubic yards of concrete and shall be overseen and verified by a Professional Engineer with experience in concrete mix designs. The Engineer reserves the right to witness the full-scale trial batch activities.

(3) All trial batches for precast or prestressed concrete will be observed, tested, and documented by the ADOT Materials Structural Testing Section and approved by the Engineer.

Trial batches shall have slump results within the range specified for the proposed work. When air-entrained concrete is specified, the air content shall be in compliance with the specified requirements. Compressive strength testing samples shall be cured and tested by an ADOT Approved Laboratory.

Trial batch test results, prior to the specified compressive strength acceptance age, may be used for early approval if the compressive strength test results meet the minimum over-design requirement for the specified acceptance age.

When approved by the Engineer, concrete from trial batches may be used in the work at locations where concrete of a lower strength is required and such concrete shall meet the requirements of the class of concrete at that location.

1006-4 Concrete Production:

1006-4.01 General Requirements:

The contractor may obtain concrete for each class of concrete and for each strength of Class S concrete from a source approved by the Engineer in lieu of establishing a batch plant at the project site.

1006-4.02 Measuring Materials:

(A) Cementitious Material:

Cementitious material shall be measured by weight. When supplementary cementitious materials are used in the concrete mixtures, the cumulative weight is permitted to be measured with hydraulic cement, and on a scale which is separate and distinct from those used for other materials. The weight of the hydraulic cement shall be measured before supplementary cementitious materials. When the quantity of cementitious material exceeds 30 percent of the full capacity of the scale, the measured quantity of the hydraulic cement shall be within 1 percent of the required weight, and the cumulative measured quantity of hydraulic cement plus supplementary cementitious materials shall also be within 1 percent of the required cumulative weight at each intermediate weighing. For smaller batches of less than 30 percent of the full capacity of the scale, the measured quantity of the hydraulic cement and the measured cumulative quantity of hydraulic cement plus supplementary cementitious materials used shall not be less than the required amount or more than 4 percent in excess of the required amount. In specific cases, cementitious materials in bags may be used with prior approval of the Engineer.

(B) Water:

Mixing water is defined as the total amount of water in a batch less the water absorbed by the aggregates and is used to calculate the water-cementitious materials ratio (w/cm). Mixing water shall consist of batch water (water weighed or metered at the plant), ice, free moisture on the aggregates, wash water retained in the mixer before batching, and water added at the jobsite in accordance with Subsection 1006-7.03. The batch water shall be measured by mass or volume to an accuracy of ± 1.5 percent of the target batch water. If the quantity of water introduced from admixtures increases the water-cementitious materials ratio by more than 0.01, it shall also be included in the total amount of mixing water. In the case of truck mixers, any wash water retained in the drum for use in the next batch of concrete shall be measured; if this proves impractical the wash water shall be discharged before loading the next batch of concrete. The total quantity of mixing water shall not exceed the mix design target quantity by more than 3 percent.

(C) Aggregates:

Aggregate shall be measured by weight. The quantity of aggregate weighed shall be the required dry weight plus the total moisture content (absorbed and surface) of the aggregate.

When aggregates are measured in an individual or cumulative weigh batcher and the required weight of aggregate is equal to or greater than 30 percent of the scale capacity, the total quantity of aggregate shall be within 2 percent of the required weight. In addition, if a cumulative weigh batcher is used, the quantity of aggregate at each successive weighing shall be within 2 percent of the required weight.

When aggregates are measured in individual or cumulative weigh batchers, and the required intermediate or final weight is less than 30 percent of the scale capacity, the aggregate weight shall be within 3 percent of the required weight.

(D) Admixtures and Additives:

Chemical admixtures in powdered form or other additives in solid form (such as fibers or color) shall be measured by weight. Liquid chemical admixtures shall be batched by weight or volume. Admixtures measured by either weight or volume, shall be batched with an accuracy of ± 3 percent of the total required amount. For liquid chemical admixtures, dispensers of a mechanical type capable of adjustment for variation of dosage, and of simple calibration, are required, unless approved by the Engineer.

1006-4.03 Batching of Concrete:

(A) General Requirements:

Concrete may be batched in a standard batch plant or a central mixing plant. The plant may be situated at the project site, or it may be located off-site or at a commercial supplier. All materials utilized in the batching of concrete shall be from an approved source or supplier.

(B) Concrete Plant Requirements:

(1) All Concrete Plants:

The handling and storage of concrete aggregate shall be such as to maintain them at or above a saturated-surface-dry (SSD) moisture condition and to minimize segregation or the intermixing and contamination with foreign materials. The Engineer may require that aggregate be stored separately. Different sizes of aggregate shall be separated by bulkheads or stored in separate stockpiles sufficiently removed from each other to prevent the materials from becoming intermixed. When aggregates are stored on the ground, the sites for the stockpiles shall be level and clear of all vegetation. The bottom one foot layer of aggregate shall not be disturbed or used.

All concrete batch plants and batching operations shall have been inspected and satisfy applicable criteria before being used to produce concrete. As an alternative to an ADOT inspection of the concrete batch plants and batching operations, the supplier may submit certification of their concrete production facilities from NRMCA or Arizona Rock Products Association (ARPA) to the Engineer. Concrete batch plants shall be inspected a minimum of once every two years. ADOT may inspect concrete batch plants at any time.

Each batch plant shall be equipped to control the time when the water enters the mixer during the mixing cycle. Batch and mixing time shall be calculated from the time cementitious material is first combined with water or aggregates.

(2) Project Specific Plants for Class P Concrete:

The handling and storage of concrete aggregate for Class P concrete at the job site or a project specific plant site shall be such as to minimize segregation. Stockpiles shall be neat and regular in form and shall occupy as small an area as possible.

Contamination of concrete aggregate for Class P concrete by contact with the ground at the job site shall be prevented. The contractor shall take the necessary measures to prevent such contamination. Such preventive measures include placing aggregate on hardened surfaces consisting of Portland cement concrete, asphaltic concrete, or cement treated material.

The contractor shall maintain at least two full days' worth of production of fine and coarse aggregate stockpiled at the batch plant for Class P concrete prior to starting and throughout the duration of Portland cement concrete paving operations. This requirement is waived for the last two days of production.

(C) Concrete Plant Operation and Documentation:

Concrete batch plants shall be operated in accordance with the manufacturer's guidelines and recommendations. The amount of material measured for each batch of concrete shall not exceed the plant's rated capacity. A record of certification current to within the last six months for all scales, balances, load cells, or water measuring systems used in the production of concrete shall be maintained at the batch plant and shall be made available to the Engineer upon request.

When requested by the Engineer, the contractor shall supply a separate record for each batch of concrete which shows the batch weight or quantity of each individual ingredient. The amount of water introduced into the batch including that contained on the aggregate shall be verifiable.

(D) Concrete Ticketing Systems:

For each class of concrete and each strength of Class S concrete, except for Class P concrete produced in a batch plant at the project site and used exclusively for Class P work, the contractor shall furnish a delivery ticket for each batch of concrete, including any trial batches. The minimum information to be shown on each delivery ticket shall be:

(1) Date
(2) Time batched
(3) Truck identification number
(4) Name or identification of batch plant
(5) Name of contractor
(6) Name and location of project
(7) Quantity of concrete,
(8) Mix design product code
(9) Amount of permissible additional water to meet the design water-cementitious material ratio

Any manually added additives or admixtures previously approved by the Engineer to be added to an existing mix design, which cannot go through the plant or batching system, shall be recorded and shown on the delivery ticket.

In addition, the number of revolutions that the concrete has been mixed at mixing speed in a truck mixer shall be noted on the delivery ticket.

An authorized representative of the contractor shall be responsible for each delivery ticket and shall sign each delivery ticket accepting the contractor's responsibility for the concrete. The representative shall furnish a copy of the delivery ticket to the Engineer after discharge of the concrete is complete.

1006-4.04 Mixing and Transport of Concrete:

(A) General Requirements:

All concrete shall be homogeneous and thoroughly mixed, and there shall be no lumps or evidence of un-dispersed cement. Equipment having components made of aluminum or magnesium alloys, which would have contact with plastic concrete during mixing and transporting, shall not be used.

(B) Mixing in a Stationary Mixer (Central Mix Plant or Drum Mix Plant):

The volume of concrete mixed per batch shall not exceed the capacity of the mixer as shown on the manufacturer's plate or documentation. No spillage of concrete is allowed during the process of mixing.

While mixing, the mixer shall be operated at the speed shown on the manufacturer's plate as the mixing speed.

The mixing time shall not be less than 60 seconds per batch for Class P concrete and the mixing time shall be increased if directed by the Engineer. The mixing time shall be not less than 60 seconds for 1 cubic yard and shall be increased 15 seconds for each additional cubic yard or fraction thereof for Class S or Class B concrete.

The mixer shall have an automatic timing device which locks the discharge equipment until the required mixing time has been completed. The mixer shall be operating at mixing speed at the time that all ingredients enter the mixer to ensure the immediate beginning of the mixing cycle. Mixing time shall end when the discharge chute opens. The contents of the mixer shall be completely discharged before the succeeding batch is placed in the mixer.

Any concrete discharged before the mixing time is completed shall be disposed of by the contractor at no additional cost to the Department.

Central mixers shall be equipped with automatic batch meters for counting the batches for Class P concrete. The contractor shall furnish the batch count daily to the Engineer.

In the case of mixing in a central mixer, when fibers are incorporated into the concrete, mixing time and revolution rate is performed the same way as plain concrete because there is sufficient shear provided to uniformly disperse the fibers. A test or trial mixing is always recommended to ensure that the mixture supports the fiber type and dosage and that there are no problems with the batching sequence.

Mixed concrete shall be transported in truck mixers, truck agitators or in non-agitating trucks.

When truck mixers or truck agitators are used, the concrete shall be continuously agitated from the time of loading until the time of discharge. Agitation shall be by rotation of the drum at the speed shown on the manufacturer's plate as agitating speed. The truck mixer or truck agitator shall be loaded and operated within a capacity not to exceed 80 percent of the gross volume of the drum. The rate of discharge shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully opened.

Bodies of non-agitating trucks shall be smooth, mortar-tight, metal containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation. If discharge of concrete is accomplished by tilting the body, the surface of the load shall be retarded by a suitable baffle. Covers shall be provided when needed for protection.

Discharge from non-agitating trucks shall be completed within 45 minutes from the time concrete is batched.

Concrete hauled in open-top vehicles shall be protected against rain. When the ambient temperature exceeds 85 degrees F the concrete shall be covered if it could be exposed to the sun for more than 30 minutes.

(C) Mixing in Truck Mixers:

All concrete truck mixers shall be inspected and satisfy applicable criteria before being used to mix and deliver concrete. As an alternative to the annual ADOT inspection of truck mixers, the trucks may be inspected in accordance with the requirements of the NRMCA and/or ARPA inspection programs. Such inspections shall be performed in accordance with NRMCA's "*Section 5 of Quality Control Manual, Section 3, Inspection & Certification of Delivery Vehicles"* or ARPA's *"Certification of Ready Mixed Delivery Fleet"* checklist and guideline. Upon satisfactory completion of inspection, an inspection sticker shall be applied in a clearly visible location to the inside of the driver's side door of the truck, or an NRMCA card shall be readily available. Truck mixers that do not have a valid NRMCA card, or ADOT or ARPA sticker indicating the date of inspection are not allowed to supply concrete to ADOT projects. Truck mixers shall be inspected annually at a minimum and may be inspected at any time.

Each mixer shall meet the specified requirements for type and size and shall have attached in a prominent place a manufacturer's plate showing the gross volume of the mixer and the recommended speeds of the mixer for mixing and for agitating. Truck mixers shall be operated within a capacity not to exceed 63 percent of the gross volume of the drum and at speeds shown on the manufacturer's plate as mixing and agitating speeds.

Truck mixers shall be equipped with an electrically or mechanically activated revolution counter by which the number of drum revolutions may be verified. The counter shall accurately register the number of revolutions. It shall be mounted on the truck mixer or

inside the truck cab, so that it may be safely and conveniently read. The revolution counter shall be reset to zero after all materials have been loaded into the drum at the plant.

Truck-mixed concrete shall be mixed entirely in the truck mixer. Mixing shall begin after the cement has been combined with either the aggregate or water. Each batch of concrete shall be mixed for not less than 70 nor more than 100 revolutions of the drum, at mixing speed, after all materials have been loaded into the drum at the plant, except that when approved by the Engineer, the maximum of 100 revolutions may be increased. Any revolving of the drum beyond the maximum number of revolutions shall be at the agitating speed.

When fibers are incorporated into the concrete, it is recommended to add the fibers in a continuous manner. A mixing speed of 10 to 12 rpm is typically used for the rate of addition in trucks. A minimum of 40 revolutions (four to five minutes) after all the fibers are added is recommended for proper mixing and dispersion of fibers in trucks.

Mixers shall be cleaned at suitable intervals. Water used for cleaning the mixer shall be discharged prior to further batching.

(D) Mixing in Volumetric Mixers:

Concrete mixing in volumetric mixers for Class S or Class B concrete shall be performed in accordance with the requirements of ASTM C685.

1006-4.05 Manufacturing Precast Items:

(A) General:

Manufacturers proposed by the contractor to manufacture precast items shall be on the "Approved Precast Concrete Products Manufacturers List" or the "Approved Precast/Prestressed Bridge Members Manufacturers List" on the Structural Materials Testing Section website. Only the manufacturers on the approved list(s) shall manufacture precast concrete products or precast bridge members for ADOT construction projects.

(B) Scheduling:

Shop drawings shall be submitted and approved as required in Subsection 105.03. The reviewer shall notate their full first and last name and contact phone number on the approved shop drawings. The contractor shall submit a copy of the approved shop drawings to the Structural Materials Testing Section at least five working days in advance of the start of production of the precast items. Any changes to shop drawings must be approved by the Engineer. These updated and approved shop drawings shall be sent to the Structural Materials Testing Section at least 24 hours in advance of the start of production.

(C) Plant and Personnel Certifications:

All precast bridge members shall be manufactured in a plant certified by the Precast/Prestress Concrete Institute (PCI). The manufacturer shall be, at a minimum, certified for Product Group "B"- Bridge Products, Category B4. Erection of precast/prestress

bridge members shall be performed by a contractor, manufacturing plant, or erector which has an individual on staff who has attended and received a “Certification of Completion” from the PCI “Industry Erection Standards School” or is certified by PCI as a “Certified Field Auditor”.

All precast concrete products, other than concrete pipe, shall be manufactured in a plant certified by the National Precast Concrete Association (NPCA) or PCI.

All precast concrete pipe products and precast concrete box culverts shall be manufactured in a plant certified by the American Concrete Pipe Association (ACPA) or NPCA.

All plant certifications shall be maintained throughout the production of all precast concrete items. Production for projects shall stop immediately if at any time the manufacturer’s certification is revoked, regardless of the status of completion of contracted work. Production shall not proceed until certification has been re-established.

Each plant requesting to be added to the “Approved Precast Concrete Products Manufacturers List” or the “Approved Precast/Prestressed Bridge Members Manufacturers List” shall do so in writing to the Structural Materials Testing Section. The request shall include a copy of the compliance certificate issued by the ACPA, NPCA, or PCI, a copy of the most recent audit conducted in accordance with the ACPA, NPCA, or PCI certification programs, a copy of the response to deficiencies of the audit upon request, a copy of the Quality System Manual (QSM), and the designated Quality Control (QC) Manager for the plant.

The contractor shall provide documentation to the Structural Materials Testing Section for any changes to the manufacturer’s QSM, certified personnel, or plant certifications within 10 days of the respective change.

The QSM shall contain, at a minimum, the methods of production and quality control policies and procedures used by the plant. The QSM shall be in accordance with ACPA, NPCA, or PCI Plant Certification requirements and their respective programs.

Each manufacturer on the “Approved Precast Concrete Products Manufacturers List” or the “Approved Precast/Prestressed Bridge Members Manufacturers List” is required to submit to the Structural Materials Testing Section, a copy of the annual audit and the response to deficiencies of the audit, if applicable, to verify compliance with the ACPA, NPCA, or PCI certification programs.

If an audit is not completed or audit documents are not submitted within a period of 16 months of the last audit date, the plant will be removed from the approved list for a minimum of two months. After the two months, the manufacturer can apply to have the plant reinstated to the approved list. Reinstatement is subject to review and compliance with the Structural Materials Testing Section.

In the event of a change in ownership of an approved manufacturer, the manufacturer shall notify Structural Materials Testing Section of the change in ownership a minimum of 30 days prior to the date at which the change of ownership takes effect. Approval will expire if the

Department is not notified of the change in ownership. The new ownership may avoid expiration by submitting a statement to the Structural Materials Testing Section indicating recognition of the details of the approval requirements, any changes to personnel and certifications, and verification that the plant is in accordance with the ACPA, NPCA or PCI certification program requirements.

The Engineer may conduct annual audits on a random basis of each approved precast manufacturer.

For precast concrete products, the manufacturer shall have either a Registered Professional Engineer or a QC Manager who has at least one of the following certifications:

(1) PCI QC Level II,
(2) NPCA Production & Quality School (PQS) Level II QA/QC and Production, or
(3) ACPA Q-school.

For precast bridge members, the manufacturer shall have a Registered Professional Engineer or QC Manager who is certified by PCI as QC Level II or higher. In addition, the QC Manager shall be certified, or have a technician(s) performing QC testing, as an ACI Concrete Field Testing Technician Grade I and ACI Concrete Strength Testing Technician Grade I.

In the event of a change in QC Manager or certified QC Technician, the manufacturer shall notify the Structural Materials Testing Section of the change within 30 days. Failure to notify the Department of the change will result in the expiration of the approval. Expiration may be avoided by notifying the Structural Materials Testing Section of any changes to personnel and include their certifications, and verification that the plant is in accordance with the ACPA, NPCA or PCI certification program requirements.

(D) Plant Quality Control:

The contractor shall submit the concrete mix design(s) along with shop drawings to the Structural Materials Testing Section for approval.

The shop drawings shall contain at the minimum:

(1) Concrete strength requirements
(2) Method of concrete placement
(3) Method of concrete vibration
(4) Method of curing
(5) Tensioning method and calculations, including stressing jacks and pumps, gauge pressure values and theoretical elongations
(6) Detensioning method
(7) Concrete finishing requirements and method of finishing.
(8) Storage method

When Requests for Information (RFI) are submitted to the Engineer, a copy of the RFI shall also be submitted to the Structural Materials Testing Section.

The manufacturer shall fabricate concrete test cylinders for each product, strength requirement, and mix design per each day of production. When “dry cast” or “zero slump” concrete is used, the concrete test cylinders will be fabricated per ASTM C497. For “wet cast” concrete, the concrete test cylinders will be fabricated per AASHTO T 23. When “Self Consolidating Concrete” (SCC) is used, the concrete test cylinders shall be fabricated, and unit weight and air content tests shall be performed as described in Subsection 1006-4.05 (E).

Release strength shall be met prior to detensioning. At the discretion of the Engineer, release strength testing may be performed at the plant under the observation of the Engineer, if not performed by the Engineer.

Concrete test results shall be made available upon request.

(E) Precast Concrete Operations:

When requested, the precast manufacturer shall supply a monthly concrete compressive strength report, which contains the following information:

Daily average concrete compressive strength

Monthly average concrete compressive strengths, with the high test result, the low test result, and the standard deviation of concrete compressive strength results

Weekly aggregate gradation and sand equivalent test results

For SCC, results of “Column Segregation Test”, when requested by the Engineer.

(1) Precast Bridge Members Concrete Operations:

Concrete mix designs shall be submitted and comply with the requirements of Subsection 1006-3.01 of these specifications, and the requirements listed herein. Calibration reports for batch plants scales and measuring devices shall be supplied to the Engineer upon request.

All concrete used in the production of precast bridge members at the manufacturer’s plant or purchased from a Ready Mix supplier shall be batched with load cell indicating devices providing a digital readout and printed weights. Printed copies shall be available upon request by the Engineer.

The rate of concrete placement and consolidation shall be such that the formation of cold joints within monolithic sections of any bridge member shall not occur, but at no time shall concrete placement be less than 25 cubic yards per hour.

When consolidating concrete that includes epoxy coated reinforcement which requires vibration during placement, methods of vibration shall be equipped with neoprene or rubber boots or like material that protects the epoxy coatings from damage and/or abrasion.

When concrete placement is interrupted by rain, the forms shall be covered with tarps or plastic. If it is determined that concrete placement can proceed during rain, tarps or plastic shall be used to cover the forms ahead of and behind the concrete placement.

(2) Precast Concrete Products Concrete Operations:

Calibration reports for batch plant scales and measuring devices shall be supplied to the Structural Materials Testing Section when requested. Each precast plant shall submit a "Hot Weather" and/or a "Cold Weather" concrete batching and placement plan which addresses the steps that will be taken to ensure concrete temperature and curing meets the specifications. The plan shall specify procedures detailing how the concrete temperature will be monitored throughout each day's production. The Structural Materials Testing Section may test concrete temperature at any time. Concrete failing to meet the specification will be rejected along with any precast products produced that day.

The precast manufacturer shall supply annual test results for aggregate as required per ASTM C33, and also an annual absorption test on manufactured products.

All concrete batched at the manufacturer's plant, or purchased from a ready mix supplier, shall be batched with load cell indicating devices providing a digital readout and printed weights. Copies shall be available when requested by the Structural Materials Testing Section.

The rate of concrete placement and consolidation shall be such that the formation of cold joints within monolithic sections will not occur.

When consolidating concrete that includes epoxy coated reinforcement which requires vibration during placement, methods of vibration shall be equipped with neoprene or rubber boots or like material that protects the epoxy coatings from damage and/or abrasion.

When a stripping strength is specified, the manufacturer may determine the concrete strength using Arizona Test Method 318, "Estimating the Development of Concrete Strength by Maturity Method."

When concrete placement is interrupted by rain, the forms shall be covered with tarps or plastic. If it is determined that concrete placement can proceed during rain, tarps or plastic shall be used to cover the forms ahead of and behind the concrete placement.

(3) Self Consolidating Concrete (SCC):

SCC shall be flowable under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, while maintaining homogeneity. Placement is to be accomplished in one lift, with the placement equipment within 25 feet of the rolling edge that the SCC creates.

Trial mixes shall be observed by an ADOT representative. Trial mixes may include an inverted slump spread test in accordance with ASTM C1611, L-box, J-box, J-ring, Column

Segregation Test, or other tests as deemed necessary by the Engineer for the concrete mix approval. In addition, the following is required:

(a) The visual stability index (VSI), performed in accordance with ASTM C1611, shall be determined for each precast concrete product being produced.
(b) Any viscosity modifying agents (VMA) shall be identified for the mixture
(c) The spread shall be within ± 3 inches of the design spread defined in the mix design.

Concrete strength test cylinders shall be fabricated in accordance with ASTM C31, but filling the molds shall be done in accordance with ASTM C1758.

Concrete unit weight and air content tests shall be performed in accordance with ASTM C138 and ASTM C231, respectively, but filling the cylinder molds shall be done in accordance with ASTM C1758.

1006-5 Weather and Placement Limitations:

1006-5.01 General Requirements:

Concrete shall not be placed during adverse conditions, which may include but are not limited to rain, snow, freezing weather, unstable site conditions, excessively high ambient temperature, and high winds, unless approved by the Engineer.

Under rainy conditions, placing of concrete shall be stopped before the quantity of surface water is sufficient to cause a flow or wash of the concrete surface or have a detrimental effect on the finished concrete and acceptance parameters.

Placing of concrete shall immediately cease if the hauling vehicles or any equipment or pedestrian traffic tracks mud on the prepared base or changes the allowable subgrade dimensional tolerances for Class P concrete and slabs placed on subgrade for Class S or Class B concrete.

1006-5.02 Hot Weather Concreting:

Forms, subgrade, and reinforcing steel shall be lightly sprinkled with cool water just prior to the placement of concrete.

Chilled mix water or well crushed ice (substituted as a part of the mix water on a pound for pound basis) may be used to control the concrete temperature.

Aggregate may be cooled by systematic sprinkling of aggregate stockpiles for evaporative cooling or by the use of liquid nitrogen systems.

If required by the Engineer, windscreens shall be used to reduce the evaporation rate when curing methods alone are not sufficient to maintain the evaporation rate within acceptable limits. On bridge decks, windscreens shall project at least 6 feet above the prepared bridge

deck surface. Windscreens may be made of any construction material that provides sufficient strength to resist the force of the wind.

If during finishing an unexpected environmental change or delay occurs, a monomolecular film product that aids in retarding the evaporation may be used prior to finishing with the Engineer's approval. The monomolecular film shall be applied in accordance with the manufacturer's recommendations. The evaporation retarder shall be applied in a fine mist using suitable sprayers; it shall not impact the plastic concrete surfaces in a stream.

Concrete surfaces to which an evaporative retardant has been applied shall not be subjected to finishing which mixes the retardant into the plastic concrete. Application of an evaporation retardant shall not delay the placement of curing compound as described in Subsection 1006-6.01(C).

1006-5.03 Cold Weather Concreting:

Concrete shall not be placed on or against ice-coated forms, reinforcing steel, structural steel, conduits, or construction joints; nor on or against snow, ice, or frozen earth materials. Immediately prior to placing concrete, the temperature of forms, reinforcing steel, earthen material, or any other material that will come in contact with the freshly placed concrete shall be a minimum temperature of 40 degrees F. If artificial heat is used to adjust the temperature of the items that will come in contact with the freshly mixed concrete, the temperature of these items shall not exceed 10 degrees F greater than that of the concrete being placed.

Concrete operations shall be discontinued when a descending ambient temperature in the shade and away from artificial heat falls below 40 degrees F. Concrete operations shall not be resumed until an ascending ambient temperature in the shade and away from artificial heat exceeds 35 degrees F unless otherwise approved by the Engineer.

Mixing and placing concrete shall continue no later than that time of day which allows sufficient time to place and protect the concrete already poured before the ambient temperature drops to 35 degrees F.

Concrete shall be protected in a manner to maintain all concrete surface temperatures at not less than 50 degrees F for a period of 72 hours after placement and at not less than 40 degrees F for an additional 96 hours.

The contractor may use equipment to heat the aggregates or water, or both, prior to mixing. If aggregates are heated, the minimum temperature of the heated aggregate shall be 60 degrees F and the aggregates shall have no chunks of ice or frozen aggregate present. Equipment used to heat the aggregates shall be such that consistent temperatures are obtained throughout the aggregate within each batch and from one batch to another. Water shall not be heated in excess of 150 degrees F unless the water is mixed with the aggregate prior to the addition of cement to the batch. During the heating or mixing process, cement shall not be added to water and aggregate combinations which exceed 100 degrees F.

When weather forecasts indicate a probability that ambient temperatures are to fall below 35 degrees F during the placement or curing periods, the contractor shall submit a cold weather concreting plan to the Engineer for approval prior to concrete placement. The cold weather concreting plan shall detail methods and equipment which are to be used to ensure that the required concrete temperatures are maintained. The contractor shall provide adequate cold weather protection in the form of insulation and/or heated enclosures to protect the concrete after placement. For bridge decks and suspended structures, the cold weather concreting plan shall include protection measures for both the top and bottom surfaces of the concrete. This protection shall maintain concrete surface temperatures as specified above at all locations in the structure. When artificial heating is required, the heating units shall not locally heat or dry the surface of the concrete.

When a cold weather concreting plan is required, the Engineer may require concrete temperatures to be measured and continuously recorded by the use of temperature sensing devices during the entire curing period. The contractor shall provide the temperature sensing devices, including its manufacturer's certification which shall be in accordance with ASTM C1074, and recording instruments. The contractor shall install temperature sensing devices near the surface of the concrete at locations and depths designated by the Engineer. When concrete is placed on a bridge deck or suspended structure, both the bottom surface and the top surface shall be monitored with temperature sensing devices. Temperature sensing devices and recording instruments shall be approved by the Engineer. The contractor shall continuously monitor the concrete temperature and provide the recorded data to the Engineer upon request.

If the surface concrete temperature at any location in the structure falls below 35 degrees F during the curing period, the Engineer may direct the contractor to core the areas in question at the locations indicated by the Engineer. The contractor shall submit the cores to a petrographer for examination in accordance with ASTM C856. Concrete damaged by frost, as determined by the petrographer, shall be removed and replaced at no additional cost to the Department. All costs associated with coring, transmittal of cores, and petrographic examination shall be at no additional cost to the Department regardless of the outcome of the petrographic examination.

The placing of concrete will not be permitted until the Engineer is satisfied that all the necessary protection equipment and materials are on hand at the site and in satisfactory working condition.

Concrete requiring cold weather protection shall have such protection removed at the end of the required curing period in such a manner that will permit a gradual drop in the concrete temperatures.

1006-6 Curing Concrete:

1006-6.01 Curing Cast-in-Place Concrete:

(A) General Requirements:

All cast-in-place concrete shall be cured by one, or by a combination of more than one, of the methods specified herein and curing shall begin immediately after completion of machine or hand finishing of the fresh concrete.

Curing shall be continued for a period of at least seven days after placing if either Type II Portland cement or Portland pozzolan cement has been used, or for at least three days if Type III Portland cement has been used.

Surfaces requiring a Class II finish shall not be cured by the Liquid-Membrane Forming Compound Method until after the finishing operations are completed.

No traffic, hauling, storing of material or other work shall be allowed on any concrete surface during the required curing periods.

(B) Water Curing Method:

All surfaces not covered by reasonably waterproof forms shall be kept damp by applying water with a nozzle that so atomizes the flow of the water that a fog mist and not a spray is formed until the surface of the concrete is covered with a curing medium or sprinkling of the surface is permitted. 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.

If a curing medium is used, the concrete shall be kept continuously wet by sprinkling with water for the entire curing period. Burlap, rugs, carpets, or earth or sand blankets may be used as a curing medium to retain the moisture during the curing period. Application of the curing medium shall not begin until such time that placement can be made without marring the surfaces of the concrete. Application of a non-atomized spray of water, water by brushes, or any other non-approved method will not be permitted.

Fogging equipment shall consist of a mechanically operated pressurized system using incrementally spaced triple headed nozzles or equivalents. The nozzles shall be pointing horizontally, parallel to the surface of the concrete and at a distance not to exceed 36 inches above the concrete surface.

The fogging equipment shall be mounted such that it is stationary. Each nozzle shall be equipped with an easily accessible control capable of varying the volume of water flow and immediately shutting off the water when in the off position. Hand-held fogging equipment will not be allowed.

If a curing medium is not used, the entire surface of the concrete shall be kept damp by the application of water with an atomizing nozzle as specified above until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for the entire curing period.

In no case shall curing be interrupted by more than one hour during the curing period.

(C) Liquid-Membrane Forming Compound Method:

Liquid membrane forming compound shall conform to the requirements of ASTM C309 and also meet the criteria in Table 1006-8. Approval of curing compound will be based on a Certificate of Analysis conforming to the requirements of Subsection 106.05 submitted for each lot. Curing compound shall not be used on a project prior to approval.

Any curing compounds not previously approved for use on a current or past ADOT project shall be tested for pre-approval by the Structural Materials Testing Section prior to the submittal of the Certificate of Analysis. The pre-approval testing shall be determined by the Engineer and in accordance with the requirements in Table 1006-8.

TABLE 1006-8
Testing Criteria for Liquid Membrane Forming Compound

Procedure	Criteria	
Color	Clear (Type 1-D)	White (Type 2)
Deleterious Reaction w/ Concrete	No Reaction	No Reaction
Drying Time Test	Less than 4 hours	Less than 4 hours
Moisture Loss (72 hours)	Less than 0.55 kg/m²	Less than 0.55 kg/m²
Reflectance Test	N/A	60% or greater
Three-Day Settlement Test (MNDOT Procedure)	Less than 2 ml after 3 days	Less than 2 ml after 3 days
Non-volatile Content Test (D2369 Method A)	Minimum 25%	Minimum 25%

The approval of Type 2 (white pigmented) curing compounds shall be effective for a maximum of six months from the production date. The approval of Type 1-D (clear or translucent with fugitive dye) curing compounds shall be effective for a maximum of 12 months from the production date.

The Engineer shall reserve the right to sample curing compound at the source to perform tests specified in ASTM C309 for verification purposes. Sampling frequency will be at the discretion of the Engineer. Curing compound with failing verification test results shall not be used.

All surfaces not covered by waterproof forms shall be cured by the liquid-membrane forming compound method. The curing compound shall be applied to the concrete immediately following the surface finishing operation in one or more applications totaling a rate of at least 1 gallon per 100 square feet. The contractor shall not exceed the coverage rate specified in ASTM C309.

The curing compound shall form a continuous unbroken surface.

Type 2 compound with either a Class A or Class B vehicle shall be used for concrete pavement, bridge decks, and approach slabs. Type 1-D compound with either a Class A or Class B vehicle shall be used for other concrete items.

If the membrane film is broken during the curing period, the broken area shall be given a new application of compound at a rate sufficient to ensure uniform coverage.

In no case shall curing be interrupted by more than one hour during the curing period.

(D) Forms in Place Method:

Formed surfaces of concrete may be cured by retaining the forms in place. The forms shall remain in place for the entire curing period.

All joints in the forms and the joints between the end of forms and concrete shall be kept moisture-tight during the curing period.

Cracks in the forms and cracks between the forms and the concrete shall be resealed by methods approved by the Engineer.

(E) Curing Bridge Decks, Approach Slabs, and Anchor Slabs:

The top surface of bridge decks, approach slabs, and anchor slabs shall be cured by the liquid-membrane forming compound method and by the water curing method. The curing compound shall be applied progressively immediately following the surface finishing operation.

Water curing shall be applied not later than four hours after the completion of the surface finishing operations and shall be applied as specified herein.

The top surface of bridge decks, approach slabs, and anchor slabs that will be covered with a special riding surface or waterproofing membrane shall be cured by the water curing method only. Water curing shall be applied progressively immediately following the surface finishing operation as specified herein.

1006-6.02 Curing Precast Concrete:

(A) General Requirements:

The contractor may cure precast concrete in accordance with the requirements specified above for curing cast-in-place concrete or the curing of precast concrete may be performed by external heating. This may be accomplished by the use of low-pressure steam or radiant heat with moisture.

If curing of the concrete is accomplished by low-pressure steam or radiant heat with moisture, curing will be considered completed after termination of steam or radiant heat curing. Rapid temperature changes in the concrete shall be avoided during the cooling period.

If curing of the concrete is accomplished by the water curing method, the liquid-membrane forming compound method, or the forms-in-place method, such curing shall be continued for

a period of at least seven days after placement of the concrete. The curing time may be reduced to a minimum of three days when a Type III Portland cement has been used.

For precast items, when a concrete mix contains silica fume, a curing plan acceptable to the Engineer shall be submitted for approval.

Concrete test cylinders shall be initially cured with, and in the same manner as the precast concrete products. Final curing will be per AASHTO T 23/ASTM C31.

(B) Low-Pressure Steam Curing:

After placement of the concrete, precast items shall be held for a minimum two-hour presteaming period. If the ambient air temperature is below 50 degrees F, steam shall be applied during the presteaming period to hold the air surrounding the precast item at a temperature between 50 and 90 degrees F. When the ambient temperature falls below 50 degrees F, steam or radiant heat may be used to keep the enclosure at a temperature of not more than 90 degrees F until the accelerated curing period begins.

Accelerated curing shall not commence until one hour after initial set or three hours after placement of concrete, whichever is longer. Initial set will be determined in accordance with ASTM C403 and the results submitted with each mix design.

To prevent moisture loss on exposed surfaces during the presteaming period, precast items shall be covered as soon as possible after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture.

Steam at the jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders or forms. During application of the steam, the ambient air temperature rise within the enclosure shall not exceed 40 degrees F per hour. The average curing temperature throughout the enclosure shall not exceed 160 degrees F and shall be maintained at a constant level for a sufficient length of time so as to ensure the development of the required compressive strength by the age of 28 days in concrete items which are not be prestressed. The concrete temperature during accelerated curing shall not exceed 170 degrees F. The manufacturer shall have a temperature measuring device(s) that allows the Department to monitor the concrete curing temperature at all times. For items which are to be prestressed, the constant temperature shall be maintained for sufficient time necessary to develop the concrete compressive strength required for prestressing. The ambient curing temperature shall not exceed 175 degrees F at any point. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

Temperature recording devices that will provide an accurate continuous permanent record of the ambient curing temperature shall be provided. A minimum of two temperature recording devices or one for every 200 feet of continuous bed length are required for checking temperature. The location of each temperature measuring device will be chosen by the Engineer. The enclosure around each precast concrete item shall be adequate to ensure a consistent concrete curing temperature. Once the curing enclosure procedure is established, the concrete curing temperature shall be monitored at one location for each precast item. A temperature measuring device shall be placed in each precast bridge member. The difference in the concrete curing temperature at the ends of each precast bridge member shall not exceed 20 degrees F. Forms shall not be considered a component of the enclosure during accelerated curing. A temperature measuring device shall be placed in at least two precast concrete products. The difference in the concrete curing temperature at any location within the enclosure for a precast concrete product shall not exceed 20 degrees F. When box girders or voided slab lengths are less than 60 feet, the concrete curing temperature shall be measured on every other bridge member. The manufacturer shall supply a report of the concrete curing temperatures for each concrete casting.

In the event the side forms are removed before the precast unit has attained the required release compressive strength, the curing method shall be continuous in maintaining the temperature and moisture level as described above, within the enclosure, as nearly as practical. There shall not be a delay in re-covering the girder or prestress member.

(C) Radiant Heat with Moisture:

Radiant heat shall be applied by means of pipes circulating steam, hot oil or hot water, or by heating elements or electric blankets on the forms. Pipes, blankets or elements shall not be in contact with the concrete surfaces.

Moisture shall be applied in such a manner as to keep the top surface of the precast unit continuously moist during the curing period by fogging or spraying. Moisture shall be maintained by a cover of burlap or cotton matting and further covered by a waterproof tarpaulin with an insulating cover.

Temperature limits and the use of recording thermometers shall be the same as curing with low-pressure steam. Application of the heat cycle may be accelerated to meet climatic conditions upon the approval of the Engineer. A temperature sensing device shall be placed 2 ± 1/2 inches from the heated form.

1006-7 Acceptance Sampling and Testing

1006-7.01 General:

Sampling and testing of concrete will occur to determine the acceptability of the concrete in accordance with the test methods and criteria identified below. Concrete satisfying the criteria shown in the following sections is acceptable for use in the work. Rejection of concrete delivered to the site may occur due to failure to satisfy or achieve the specified criteria including, but not limited to: improper temperature, slump, air content, or batch

quantities that excessively deviate from the mix design. The Engineer may allow deficient concrete mixtures already placed to remain in place subject to final acceptance by the 28 day compressive strength testing provided there is confirmation that the placement had adequate consolidation throughout the pour. Deficient concrete mixtures due to insufficient air content, or improper slump which exhibit the appearance of segregation or lack of adequate consolidation, will not be accepted and shall be removed at no additional cost to the Department.

For the mixture delivered to the site, the weights and volumes shall be within the tolerances described in Subsection 1006-4.02 for each component.

Acceptance and penalties for placed concrete which meets the specified mixture requirements or is allowed to remain in place shall be determined by the results of the 28-day compressive strength as specified in Subsection 1006-7.03, and additionally in the case of Class P concrete, on the measured thickness of concrete pavement in place as specified in Section 401. Sampling and testing for compressive strength will be performed on all classes of concrete furnished, including each strength specified on the project plans for Class S concrete.

1006-7.02 Field Sampling and Testing:

(A) General:

A sample of concrete for determination of temperature, slump, unit weight (when required), and air content (when required) as well as for fabrication of test cylinders for compressive strength determination at 28 days will be taken at random at the specified sampling frequency for each type of concrete.

When “Self Consolidating Concrete” (SCC) is used, the concrete test cylinders shall be fabricated, and unit weight and air content tests shall be performed as described in Subsection 1006-4.05 (E).

All sampling and testing shall be done by a certified technician meeting the requirements of the ACI Concrete Field Testing Technician, Grade I or equivalent.

Required testing of concrete will be performed in accordance with the methods shown in Table 1006-9.

TABLE 1006-9
Sampling and Testing Test Procedures

Temperature	ASTM C1064
Slump	ASTM C143
Air Content	ASTM C231 or C173
Sampling	ASTM C172
Making and Curing Cylinders	ASTM C31
Compressive Strength	ASTM C39
Unit Weight and Yield	ASTM C138

Concrete shall be sampled in accordance with ASTM C172 for acceptance testing of temperature, slump, unit weight and yield (when required) and air content (when required) as well as for fabrication of test cylinders for compressive strength determination at 28 days except that the concrete shall be sampled once during discharge at the middle portion of the batch. Sufficient care shall be taken to obtain a representative sample by diverting the entire stream of the concrete to prevent segregation. Samples shall be of sufficient size to perform all the required tests and fabricate the necessary test cylinders but in no case less than 1 cubic foot.

If the properties of the concrete do not appear to be within the specification mix design limits for slump, or air content, a preliminary sample may be obtained after discharge of 1/4 cubic yards for initial check testing. If the preliminary measurement falls outside the specified limits, concrete placement shall be discontinued and addressed as follows:

(1) When the measured slump or air content, or both is greater than the specified mix design upper limit, another check test shall be made immediately on a new test sample. In the event the second check test fails, the concrete shall be considered to have failed the requirements of 1006-7.03 (A) and shall be rejected.

(2) When the measured slump is below the mix design specified lower limit, additional water may be added in accordance with the requirements of 1006-7.03 (A). In place of the addition of water to adjust the slump, an approved water reducing admixture may be added to increase workability. After any additions, the drum shall be turned at least 30 revolutions at mixing speed and a check test shall be made on a new sample of the adjusted concrete to verify compliance with 1006-7.03 (A).

(3) When the measured air content falls below the mix design specified limit, an approved air entrainment admixture may be added to increase the air content by an authorized representative of the ready mix supplier that has been approved by the Engineer. After any additions, the drum shall be turned at least 30 revolutions at mixing speed and a check test shall be made on a new sample of the adjusted concrete to verify compliance with the mix 1006-7.03 (A).

Preliminary samples for check testing do not take the place of acceptance samples. Once any additions, adjustments, and associated mixing are complete, another sample from the middle portion of the batch shall be taken for acceptance testing.

All compressive strength test specimens shall be made, cured, handled, protected, and transported in accordance with the requirements of ASTM C31. A safe storage location(s)/facilities shall be secured for the use of the testing laboratory(ies)/technician(s) to ensure proper curing of concrete test cylinders on the project site, including sufficient access on weekends and holidays to allow the timely pick-up of cylinders specimens. Upon arrival at the testing laboratory, all compressive test specimens shall be handled, cured, and tested in accordance with the requirements of ASTM C39. Any and all deviations from the standard procedure of any test method shall be promptly identified and corrected. Any deviations shall be clearly noted by the testing technician on reports. Should an individual cylinder show evidence of improper sampling, molding, curing, or testing, the results shall

be discarded and the compressive strength shall be the result of the average of the remaining cylinder(s).Testing results obtained from non-standard testing procedures shall be considered invalid and discarded by the Engineer.

If approved by the Engineer, and unless otherwise specified, Arizona Test Method 318 may be used to estimate concrete strength by the maturity method. The maturity method shall not substitute for compressive strength acceptance testing (28-day cylinders). The contractor shall submit a written request to the Engineer prior to using the maturity method. If its use is approved by the Engineer, the contractor shall develop a strength-maturity relationship and shall also provide the maturity meter(s) and digital data loggers necessary, as well as performing all required testing, all at no additional cost to the Department.

(B) Class S and Class B Concrete:

Concrete pumped to facilitate placement shall be sampled for acceptance at the final point of placement. Samples shall be taken during continuous discharge of concrete without interruption at the normal production rate. In accordance with Subsection 601-3.03 (C), where freeze-thaw durability is of concern (such as in bridge decks, overlays, approach slabs, and barrier walls), the concrete shall also be sampled at the truck to determine air loss through the pump. If the loss of air as measured between the supply truck and the point of placement exceeds 2 percent, the contractor shall employ measures acceptable to the Engineer to reduce the loss of air to less than 2 percent. If sampling at the point of placement is not practical, as determined by the Engineer, or creates a safety concern, the concrete shall be sampled for acceptance at the truck. When acceptance sampling can only be performed at the truck, the acceptable range of air content of the supplied mix will be adjusted to not less than 5 percent but no more than 8 percent in accordance with Table 1006-10.

For Class S concrete with a compressive strength requirement less than 4000 psi, or Class B concrete, a strength test will consist of the average strength of two test cylinders. However, if the compressive strengths of the two test cylinders differ by more than 10 percent from the average of the two, the strength test result shall be the cylinder with the highest compressive strength.

For Class S concrete with a compressive strength requirement equal to or greater than 4000 psi, or Class P concrete, the compressive strength of each sample shall be determined by averaging the results of the three test cylinders. However, if the compressive strength of any one of the three test cylinders differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cylinders. Should the individual compressive strength of any two of the three remaining cylinders differ by more than 10 percent from the average of the three, the results will be discarded and the compressive strength shall be the strength of the remaining cylinder.

(C) Class P Concrete

Samples of concrete shall be taken in accordance with the requirements of ASTM C172, except concrete for Class P shall be sampled immediately before going into the paver or forms, or as otherwise directed by the Engineer.

(D) Precast Concrete

(1) Major Precast Concrete Structures

The concrete will be field sampled and compressive strength tested by the Engineer in accordance with the requirements in 1006-7.02 for Class S with the addition of the following:

Fabrication of test cylinders for compressive strength determination shall be done for one day (for release breaks), seven days, and 28 days. The acceptance samples shall represent one member, one day's production, or as determined by the Engineer.

(2) Minor Precast Concrete Structures

A strength test on each precast unit produced will consist of the average rebound number as determined from readings taken on the precast unit with a rebound hammer. The average rebound number will be determined in accordance with the requirements of ASTM C805.

The compressive strength of the concrete will be determined from the average rebound number and the calibration chart established for the specific rebound hammer being used. The calibration chart will be established from rebound readings taken on concrete test cylinders fabricated at the precast plant and the actual compressive strength of the cylinders.

1006-7.03 Acceptance Criteria:

Concrete acceptance test results and verifications shall be evaluated for acceptance using the criteria established in this section.

(A) Plastic Concrete

Plastic concrete is concrete which has been delivered to the project, is still in a workable state, and has not yet achieved initial set. The criteria used for accepting plastic concrete are as follows:

(1) Elapsed Time

The batch time is defined as the time at which cementitious material is combined with water or aggregate. Discharge from the truck mixer or truck agitator shall be completed within 90 minutes from batching. The Engineer may allow concrete placement to continue in excess of the 90 minutes if the concrete is of such slump, workability, and/or temperature that it can be placed without the addition of water to the batch. Additional discharge time shall also be allowed provided a hydration stabilizing admixture is shown on the approved mix design and has been included in the batch, subject to the following:

(a) The concrete remains of sufficient slump and workability to facilitate adequate consolidation during placement, and;

(b) The hydration stabilizing admixture conforms to the requirements of subsection 1006-2.04 and retards hydration by a hydration stabilizing mechanism, and;

(c) The dosage rate is identified in the approved mix design, and the additional amount of batch to discharge time exceeding the 90 minute limit has been requested by the contractor for approval by the Engineer and acknowledged on the mix design by the Engineer, or;

(d) If during placement, the dosage range is identified in the approved mix design and the application-specific dosage and additional time has been requested by the contractor and approved by the Engineer.

(2) Temperature:

The temperature of the concrete mixture immediately before placement shall not be less than 50 degrees F nor greater than 90 degrees F. The Engineer may allow concrete placement to continue in excess of the maximum temperature if the concrete is of such slump or workability that it can be placed without the addition of water to the batch. The Engineer may also approve concrete mixtures with a temperature less than 50 degrees F or greater than 90 degrees F if otherwise specified or pre-approved by a mix design that accounts for the temperature deviation. Otherwise, concrete that fails to conform to this temperature requirement will be rejected prior to placement.

(3) Consistency:

The contractor shall furnish Class P Concrete having a slump within the range specified in Table 1006-5.

The contractor shall furnish Class S and Class B concrete having the slump shown on the approved mix design, with a permissible variation of ± 1 inch when the slump shown on the approved mix design is 4 inches or less, and a permissible variation of ±1½ inches when the slump shown on the approved mix design is greater than 4 inches. However, when an approved high range water reducing chemical admixture (ASTM C494, Type F or Type G) conforming to the requirements of Subsection 1006-2.04 is used, the permissible variation will be ± 2 inches, unless otherwise required by the Special Provisions. Concrete that fails to conform to the consistency requirements will be rejected.

When concrete is pumped, samples for consistency will be taken both as the concrete leaves the mixer and at the pump hose discharge. If the Engineer determines that there is a favorable correlation between the results of consistency tests on samples obtained from the mixer and from the pump hose, the Engineer may discontinue sampling from one of the

sources. If a favorable correlation is not maintained, the contractor shall employ corrective measures acceptable to the Engineer and sampling will continue from both sources to verify the correlation of test results.

If the workability of the concrete needs to be adjusted (or if additional mixing water is required to maintain the mix design water-cementitious material ratio), additional mixing water may be added as long as it does not exceed the amount of permissible water to meet the approved mix design maximum water tolerance, as noted on the delivery ticket. The concrete shall be mixed by a minimum of 30 revolutions of the drum at mixing speed after the water has been added, prior to discharge of any concrete for placement. The contractor shall ensure that any additional mixing water and required mixing revolutions shall be recorded on the delivery ticket as specified in Subsection 1006-4.03 (D). This additional mixing may be in excess of the maximum revolutions at mixing speed previously specified.

(4) Air Content:

Where air-entrainment is utilized as identified in Section 1006-3.01 (E), the air content of the concrete mixture at the point of placement shall meet the requirements in the following table:

TABLE 1006-10
Air Entrainment Requirements

Elevation	Freeze-Thaw & Air Loss Concern	Air Entrainment Required	Required Air Content by Volume (%)
3000 feet or above	No	Yes	4 to 7
3000 feet or above	Yes	Yes	5 to 8*
Below 3000 feet	N/A	Contractor's Option	≤ 7
*In accordance with Subsection 1006-7.02 (A), when the concrete is pumped and acceptable sampling can only be performed at the truck.			

Concrete that falls below the minimum may be adjusted with the addition of an approved air entrainment admixture in accordance with 1006-7.02 (A). Concrete that fails to conform to the maximum air content requirements listed above for the respective elevation as determined by the Engineer, shall be rejected prior to placement.

(B) Hardened Concrete:

(1) Class P Concrete:

Class P concrete will be accepted for compressive strength in accordance with the provisions of Section 401. All concrete failing to meet the compressive strength requirement or otherwise rejected in accordance with Section 401 or Subsection 1006-7.01, shall be replaced with concrete meeting the requirements of these specifications.

If the contractor chooses to contest the compressive strength results of any sample for purposes of acceptability or improving a negative pay factor, the contractor may elect to rely on the results of compressive strengths of cores. Three cores shall be obtained at no additional cost to the Department, at the approximate location where the contested test cylinders were obtained. Such cores shall be obtained and tested in accordance with the requirements of ASTM C42. Cores must be obtained under the observation of an ADOT representative and delivered to the Engineer in time to allow complete testing within 48 days of placement. Testing shall be performed by the Department. The contractor may elect to have a representative present during testing. Compressive strength shall be the average of the results of the three cores. However, if the compressive strength of any one of the three cores differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cores. Should the individual compressive strength of any two of the three cores differ by more than 10 percent from the average of the three, the results of both shall be discarded and the compressive strength shall be the result of the remaining core. Results of the core testing will be binding on both the contractor and the Department, and will replace the results of the test cylinders for that sample.

(2) Class S and Class B Concrete:

Class S and Class B concrete will be accepted for compressive strength and paid for in accordance with the following table. Concrete will be paid for by the linear foot or by the cubic yard, complete in place, except that an adjustment in the contract unit price, to the nearest cent, will be made for the quantity of concrete represented by 28-day compressive strength test results less than the specified requirement.

Adjustment in Contract Unit Price For Compressive Strength of Class S and Class B Concrete					
3000 psi and Below		**3500 psi**		**4000 psi and Above**	
Percent of Specified 28-Day Compressive Strength Attained, to the Nearest One Percent	Percent Reduction in Contract Unit Price (See Note 1)	Percent of Specified 28-Day Compressive Strength Attained, to the Nearest One Percent	Percent Reduction in Contract Unit Price (See Note 1)	Percent of Specified 28-Day Compressive Strength Attained, to the Nearest One Percent	Percent Reduction in Contract Unit Price (See Note 1)
100 or More	0	100 or More	0	100 or More	0
97 – 99	3	98 – 99	2	99	1
94 – 96	6	96 – 97	4	98	2
91 – 93	9	94 – 95	6	97	3
88 – 90	12	92 – 93	8	96	4
85 – 87	15	90 – 91	10	95	5
Less than 85	30 (See Note 2)	Less than 90	30 (See Note 2)	Less than 95	30 (See Note 2)
Note 1: For items measured and paid for by the cubic yard, the reduction shall not exceed $150.00 per cubic yard. Note 2: If allowed to remain in place.					

Concrete failing to meet at least 85 percent of the 28-day compressive strength for specified strengths of 3,000 pounds per square inch and below, 90 percent for a specified strength of 3,500 pounds per square inch, or 95 percent for specified strengths of 4,000 pounds per square inch and above, or any concrete failing to meet the other requirements of Subsection 1006-7.01, will be rejected and removed at no additional cost to the Department and replaced with concrete which meets the specified requirements, unless the contractor can submit evidence that will indicate to the Engineer that the strength and quality of the concrete is such that the concrete should be considered acceptable and be allowed to remain in place.

If such evidence consists of cores, the contractor shall obtain three cores from the concrete represented by the failing cylinder strength test. The cores shall be obtained at no additional cost to the Department, under the observation of an ADOT representative, and delivered to the Engineer in time to allow complete testing of such cores within 48 days after the placement of the concrete. All cores shall be obtained and tested in accordance with the requirements of ASTM C42. Testing shall be performed by the Department. The contractor may elect to have a representative present during testing. The concrete represented by the cores will be considered for acceptance, in accordance with the requirements of the table above. If the average compressive strength does not meet the

specified requirement, all concrete so represented shall be removed at no additional cost to the Department unless permitted to remain in place by the Engineer. Results of the core testing will be binding on both the contractor and the Department, and will replace the results of the test cylinders for that sample.

1006-7.04 Sampling Frequency for Cast-In-place Concrete:

(A) Class S and Class B Concrete:

For Class S concrete with a compressive strength requirement less than 4000 psi, a sample of concrete for the required tests, as specified in Subsection 1006-7.02, will be taken on a daily basis for each 100 cubic yards, or fraction thereof, of continuously placed concrete from each batch plant. For Class S concrete with a compressive strength requirement equal to or greater than 4000 psi, a sample of concrete for the required tests, as specified in Subsection 1006-7.02, will be taken on a daily basis for each 50 cubic yards, or fraction thereof, of continuously placed concrete from each batch plant. For Class B concrete, a sample of concrete for the required tests, as specified in Subsection 1006-7.02, will be taken for each 100 cubic yards placed from each batch plant. For Class S or Class B concrete placed at elevations of 3,000 feet or above, air content testing shall be performed for each 50 cubic yards placed, regardless of the compressive strength requirement. An additional sample or samples for any of the required tests may be taken at an interval of less than the sampling frequency specified above, at the discretion of the Engineer, on any batch or load of concrete. A sample for the required tests on daily placements of 10 cubic yards or less may be taken at the discretion of the Engineer.

(B) Class P Concrete:

Class P concrete shall be sampled and tested for compressive strength by the lot. A lot shall be considered to be one shift's production; however, a new lot shall begin when the mix design is changed. For partial shifts due to weather or other reasons, more than one day's production may be included in a lot. When such partial shifts occur, the contractor and the Engineer will jointly determine the lot limits. Five samples shall be obtained from each lot at random locations as directed by the Engineer. The Engineer may exclude certain locations from random sampling if the Engineer determines that the location of the work precludes normal construction operations. Three test cylinders shall be fabricated from each sample and tested for 28-day compressive strength in accordance with Subsection 1006-7.02.

Class P concrete shall be sampled and tested for temperature, slump, and air content (if applicable) a minimum of five times per lot. The frequency may be reduced for partial shifts with the approval of the Engineer. Additional samples for any of the required tests may be taken at the discretion of the Engineer.

(C) Precast Concrete:

A sample of concrete for the required tests as specified in Subsection 1006-7.02 will be taken for either each precast concrete member or for each day's production at the discretion of the Engineer.

An additional sample or samples for any of the required tests may be taken at the discretion of the Engineer. The Engineer will determine the quantity of concrete represented by each sample of concrete for any test performed.

When a sample of concrete for the required compressive strength test is taken to represent a single day's production and not each precast member, the degree of acceptance for all precast concrete members in that day's production will be established by the results of such compressive strength test.