Supplemental Specification
2017 Standard Specification Book

SECTION 03055

PORTLAND CEMENT CONCRETE

Delete Section 03055 in its entirety and replace with the following:

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Portland Cement Concrete.

1.2 RELATED SECTIONS

A. Section 03390: Concrete Curing

1.3 REFERENCES

A. AASHTO M 6: Fine Aggregate for Hydraulic Cement Concrete

B. AASHTO M 80: Coarse Aggregate for Hydraulic Cement Concrete

C. AASHTO M 85: Portland Cement

D. AASHTO M 154: Air-Entraining Admixtures for Concrete

E. AASHTO M 157: Ready-Mixed Concrete

F. AASHTO M 194: Chemical Admixtures for Concrete

G. AASHTO M 295: Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

H. AASHTO M 307: Silica Fume Used in Cementitious Mixtures

I. AASHTO T 160: Length Change of Hardened Hydraulic Cement Mortar and Concrete

J. AASHTO T 325: Estimating the Strength of Concrete in Transportation Construction by Maturity Tests

K. AASHTO T 358: Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

L ASTM C 150: Portland Cement

M. ASTM C 595: Blended Hydraulic Cements

N. ASTM C 1157: Hydraulic Cement

O. ASTM C 1567: Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)

P. ASTM C 1602: Mixing Water Used in the Production of Hydraulic Cement Concrete

Q. American Concrete Institute (ACI) Manual of Concrete Practice

R. UDOT Materials Manual of Instruction

S. UDOT Minimum Sampling and Testing Requirements

T. UDOT Quality Management Plan

U. AASHTO T 121: Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

V. ASTM C 1116: Fiber-Reinforced Concrete

W. ASTM C 1609: Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)

X. ICC Evaluation Service (ICC-ES) AC32: Concrete with Synthetic Fibers

1.4 DEFINITIONS

A. Cold Weather Protection Period: The required time during which the concrete is maintained at or above a specific temperature to prevent freezing of the concrete and to provide the necessary strength development for structural safety.

B. Fibrillated Microfiber – Fibrillated synthetic fibers with diameters or equivalent diameters less than 0.012 inch.

C. Macrosynthetic Fiber – Synthetic fibers with diameters or equivalent diameters greater than 0.012 inch.

1.5 SUBMITTALS

A. Mix design for all AAA, AA, and A concrete classes to be used for approval.
   1. The Department approves concrete mix designs based on trial batch test results or on Department project history.
   2. Include at least the following:
      a. The proposed mix design.
      b. Target slump value.
      c. Trial batch test results.
      d. Test results verifying that coarse and fine aggregates meet this Section, Article 2.2, paragraph B.
      e. Test results for the proposed mix design for potential reactivity of coarse and fine aggregates according to UDOT Quality Management Plan 506: Ready-Mix Concrete.
      f. Test results demonstrating the ability of the combinations of cementitious materials and aggregates to control the reactivity when using potentially reactive aggregates in a mix design.
      g. Written plan for admixtures. Refer to this Section, Article 2.2, paragraph D.
      h. Well-graded combined aggregate gradation for the mix design when used.
         1) Provide targets for each required sieve (listed in Tables 5 and 6) for control and acceptance.
         2) Submit the coarseness factor, 0.45 power chart, percentage retained (8-18 gradation chart) or a combination of methodologies.
         3) Identify the aggregate size and number of component stockpiles.
         4) Provide gradations for each component stockpile and the target percentages of each stockpile used to achieve the total combined gradation.
      i. Test results establishing a density (unit weight) target of freshly mixed concrete according to AASHTO T 121 when using Class AA(LSF) and AA(ES) concrete.

B. Mix design, manufacturer's product data, or manufacturer's labeling for Class B concrete for approval.

C. Cold Weather Concreting Plan and Hot Weather Concreting Plan for review.

1. Include the following:
    a. Detailed procedures for the placement, protection, curing, and temperature monitoring of concrete during cold and hot weather.
    b. Procedures to be implemented upon abrupt changes in weather conditions or equipment failures.
    c. Refer to this Section, Article 3.1, paragraph D for cold weather concreting requirements and Article 3.1, paragraph E for hot weather concreting requirements.
2. Allow the Engineer 10 calendar days to review the plans.
    a. The Engineer may grant an increase in contract time when this review and approval time is exceeded.
    b. This review period applies each time the plans are submitted.
3. Do not begin cold weather concreting before the Cold Weather Concreting Plan is approved.
4. Do not begin hot weather concreting before the Hot Weather Concreting Plan is approved.
5. Not required for precast concrete members provided by prequalified suppliers. Refer to this Section, Article 3.1, subparagraph D1 for cold weather. Refer to this Section, Article 3.1 paragraph E3 for hot weather.

1.6 ACCEPTANCE

A. Acceptance for strength, air entrainment, and slump is according to UDOT Minimum Sampling and Testing Requirements.
    1. The following exceptions apply when using Class AA(LSF) and AA(ES) concrete mixes:
        a. Slump tests are suspended.
        b. Test fresh concrete density (unit weight) according to AASHTO T 121 at the same frequency as Air Content and Concrete Temperature.
            1) Batch fails if the unit weight of the fresh concrete in the field varies more than ± 5 lb/ft^3 from the target density for fresh concrete established by the mix design.
        c. Reject batch if water/cementitious ratio exceeds the water/cementitious ratio established in the trial batch.

B. The Department may accept the item at a reduced price when concrete is below specified strength and does not have a separate strength pay factor.
    1. The pay factor will be applied to the quantity of the pay item that is represented by the strength tests that fall below a specified strength.

2. Department will calculate the pay factor using Table 1 based on 28 day compressive strength.

Table 1

Price Reduction for 28 Day Compressive Strength		
AAA(AE), AA(LSF), AA(LS), AA(ES), AA(P) Concrete Classes		AA(AE), A(AE) Concrete Classes
PSI below Specified Strength	Pay Factor	Pay Factor
1-100	0.95	1.0
101-200	0.90	0.95
201-300	0.85	0.85
301-400	0.80	0.80
More than 400	Reject	Reject

3. The Engineer may accept a “reject” lot based on an engineering analysis. The Department applies a 0.50 pay factor if a reject lot is allowed to remain in-place.

PART 2 PRODUCTS

2.1 CONCRETE CLASSES AND MIX REQUIREMENTS

A. Use only concrete mixes that have a Department approved mix design.
1. Refer to the requirements in Table 2.

Table 2

Concrete Classes and Mix Requirements							
Class	**Coarse Aggregate Size**	**Maximum Water / Cementi-tious Ratio**	**Maximum Percent Shrinkage at 28 days AASHTO T 160**	**Chloride Ion Penetration AASHTO T 358 Table 1**	**Air Content Percent (%) ***	**Mix Design Compressive Strength *f* 'cr (psi)**	**28 Day Minimum Compressive Strength *f* 'c (psi) ****
AAA(AE)	1" to No. 4 ¾" to No. 4	0.40	N/A	N/A	5.0 - 7.5	6,200 or f'c +1200	5,000 or as shown
AA(LSF)	1" to No. 4 ¾" to No. 4	0.42	0.035	Low to Negligible	5.0 - 7.5	5,200	4,000
AA(LS)	1" to No. 4 ¾" to No. 4	0.40	0.035	Low to Negligible	5.0 - 7.5	5,200	4,000
AA(P)	2" to No. 4 1½" to No. 4 1" to No. 4	0.44	0.042	N/A	4.0 - 7.0 4.5 - 7.5 5.0 - 7.5	5,200	4,000
AA(ES)***	1½" to No. 4 1" to No. 4 ¾" to No. 4	0.42	0.035	Low to Negligible	4.5 - 7.5 5.0 - 7.5 5.0 - 7.5	5,200	4,000
AA(AE)	2" to No. 4 1½" to No. 4 1" to No. 4 ¾" to No. 4	0.44	N/A	N/A	4.0 - 7.0 4.5 - 7.5 5.0 - 7.5 5.0 - 7.5	5,200	4,000
A	1½" to No. 4 1" to No. 4 ¾" to No. 4	0.53 0.53 0.48	N/A	N/A	N/A	3,900	3,000
A(AE)	1½" to No. 4 1" to No. 4 ¾" to No. 4	0.53 0.53 0.48	N/A	N/A	4.5 - 7.5	3,900	3,000
B or B(AE)		0.62	N/A	N/A	N/A 3.0 - 6.0	3,250	2,500

Table 2 Notes:

* Values listed represent in-place air content. Make necessary adjustments for impacts to air content due to placement.

** For *f* 'c over 4,000 psi, design and proportion mixes according to ACI Manual of Concrete Practice 301: Specifications for Concrete and project specific criteria. Use air content percent in Table 2 for these mixes according to the class specified and the coarse aggregate size.

*** For Class AA(ES), achieve at least 3,000 psi at 24 hr.

Acronym Definitions:

AE = air-entrained
LSF = low shrinkage with fiber
LS = low shrinkage
P = pavement
ES = early strength

B. Maximum nominal size of coarse aggregate:
   1. Not larger than 1/5 the narrowest dimension between sides of forms.
   2. Not larger than ⅓ the depth of slabs.
   3. Not larger than ¾ the minimum clear distance between reinforcing bars or between bars and forms, whichever is less.

C. Do not exceed water/cementitious ratio.
   1. Calculate the water/cementitious ratio (w/c) by weight according to the following formula:

$$\frac{w}{c} = \frac{Water}{Cement + Pozzolan}$$

D. Do not exceed 30 percent total pozzolan in any mix unless approved or otherwise specified.

E. Use 94 lb additional cementitious material per cubic yard to the amounts determined in the mix design for concrete deposited in water.

F. Slump tolerance
   1. Establish the target slump by mix design trial batch.
   2. The target slump tolerance is the acceptable variation from the maximum target slump.
   3. Do not exceed a 9 inch slump.

Table 3

Target Slump Tolerance (inch)		
	Target Slump	
	3 inch or less	More than 3 inch
Plus tolerance	0	0
Minus tolerance	1 ½ inch	2 ½ inch

G. Class AA(LSF) and AA(ES) concrete mixes require the following in addition to the requirements in Table 2:
   1. Synthetic Fiber Reinforcement according to this Section, paragraph 2.2F.
      a. Provide fibrillated microfibers and macrosynthetic fibers
   2. A well-graded combined aggregate gradation according to this Section, paragraph 2.2 B3.

2.2 MATERIALS

A. Cement
   1. Use Type II Portland Cement or equivalent according to Table 4 unless otherwise specified. Type III Portland Cement or equivalent may be used for precast items.
   2. Blended Hydraulic Cement
      a. Blended hydraulic cement substituted for Portland Cement:
         1) Use ASTM C 1567 to verify that expansion is less than 0.1 percent 14 days after the zero reading.
         2) Refer to the equivalent cements listed in Table 4.
      b. Do not exceed 30 percent total pozzolan limit when adding fly ash to a blended hydraulic cement.
         1) Submit documentation of the total pozzolan content with the mix design.

Table 4

Portland Cement/Blended Hydraulic Cement Equivalencies		
AASHTO M 85 Equivalent Alkalies 0.80 max percent	**ASTM C 595**	**ASTM C 1157**
*Type I	IP, IL, IT	GU
Type II	IP(MS), IT(MS)	MS
Type III	-	HE
*Type V	IP(HS), IT(HS)	HS

*Use only when specified

   3. Do not mix cements originating from different sources.
   4. Do not use air-entrained cement.

B. Aggregate
   1. Coarse Aggregate
      a. Use coarse aggregate that meets AASHTO M 80 physical properties. Use one of the gradations in Table 5.
      b. Do not exceed percentages of deleterious substances as specified in AASHTO M 80, Table 2, for Class A aggregates.

Table 5

Coarse Aggregate Gradations - Percent Passing (by weight)									
Aggregate Size (inches or sieve size)	**2½**	**2**	**1½**	**1**	**¾**	**½**	**⅜**	**No. 4**	**No. 200**
2 to No. 4	100	95-100		35-70		10-30		0-5	0-1
1½ to No. 4		100	95-100		35-70		10-30	0-5	0-1
1 to No. 4			100	95-100		25-60		0-10	0-1
¾ to No. 4				100	90-100		20-55	0-10	0-1

2. Fine Aggregate
   a. Use fine aggregate that meets AASHTO M 6 physical properties. Use the gradation in Table 6.

   b. Do not exceed percentages of deleterious substances as specified in AASHTO M 6, Table 2, for class A aggregates, using option “b” for material finer than the No. 200 sieve.

Table 6

Fine Aggregate Gradation	
Sieve Size	**Percent Passing (by weight)**
⅜ inch	100
No. 4	95 to 100
No. 16	45 to 80
No. 50	10 to 30
No. 100	2 to 10
No. 200	0 to 3.0

3. A well-graded combined aggregate gradation may replace the gradation requirements in Tables 5 and 6.
   a. Proportion combined aggregates using any combination of the 0.45 power chart, the 8-18 percent-retained and the Coarseness Factor charts in the UDOT Materials Manual of Instruction, Section 975: Guidelines for Well-Graded Combined Aggregate Gradations.
      1) Determine a combined gradation for the mix design. Provide targets for each sieve size (3/4”, ½”, 3/8”, #4, #8, #16, #30, #50, #100)
      2) Provide a combined gradation within the tolerances of Table 7 and with less than 3 percent passing the #200 sieve.
      3) Maintain gradations within zone II of the coarseness factor chart.

Table 7

Tolerances for a Well Graded Combined Aggregate Gradation	
Sieve Size	**Percent Passing Allowable Tolerance**
¾ “, ½”, 3/8”	± 10%
#4, #8	± 5%
#16, #30, #50	± 4%
#100	± 3%

C. Water
   1. Use potable water or water that meets ASTM C 1602, including Table 2.

D. Admixtures
   1. Do not use calcium chloride.
   2. Air Entrainment according to AASHTO M 154, including Section 5.
   3. Water Reducing Agents
      a. Refer to AASHTO M 194.
      b. High Range Water Reducer (HRWR) – Submit a written plan for approval with the trial batch that details ingredients, production methods, handling, and placing.
   4. Accelerators – Refer to AASHTO M 194.
   5. Set Retarding and Hydration Stabilizing Admixtures – Refer to AASHTO M 194.
      a. Establish and inform the Engineer of the effective life of the set-retarding or stabilizing admixture by trial batch if admixtures are required due to haul times exceeding the time limitations in this Section, Article 3.1, paragraph A.
      b. Do not exceed manufacturer’s recommendations for the use of the set retarding admixture.
      c. Do not re-dose the concrete with additional set retarding admixture.
      d. Add admixture at the batch plant at the time of initial batching operations.
      e. Show on batch tickets the amount of admixture used.
      f. Time of placement is established by the trial batch and supersedes the requirements in this Section, Article 3.1, paragraph A.
   6. Site-added air-entrainment – Refer to AASHTO M 154.
      a. Limit the use of site-added air-entraining agents to one addition per load, regardless of quantity.
      b. Use pre-measured admixtures.
      c. Record amount used on batch ticket.

d. Rotate the drum at least 30 revolutions at the mixing speed recommended by the manufacturer.

E. Pozzolan
1. Fly Ash
a. Class F according to AASHTO M 295 except Table 2.
1) Loss on Ignition (LOI) Not to exceed 3 percent.
2) Allowable CaO content Not to exceed 15 percent.
3) Label the storage silo for fly ash to distinguish it from cement.
4) Use different size unloading hoses and fittings for cement and fly ash.
2. Natural Pozzolan (Class N)
a. Refer to AASHTO M 295.
b. May use instead of fly ash provided that the expansion does not exceed 0.1 percent. Refer to ASTM C 1567.
3. Silica Fume
a. Refer to AASHTO M 307.

F. Synthetic Fiber Reinforcement
1. Fibrillated microfiber
a. Use fibrillated polypropylene fibers at 2 lb/yd^3 of concrete mix.
2. Macrosynthetic fiber
a. Use 4 lb/yd^3 of concrete mix.
b. Provide a minimum flexural strength ratio ($R_{e,3}$) of 25 percent when tested according to ASTM C 1609.
3. Store the fibers in a dry, covered area, free of contamination.
4. Evaluate trial batches to verify workability of the concrete.
5. Conform to ASTM C 1116, Type III and the requirements of ICC-ES AC32 Section 3.1.1 (plastic shrinkage reinforcement) and Section 3.1.2 (shrinkage and temperature reinforcement).
6. Do not introduce fibers at the same time as the cement is being introduced.
7. Mix for at least five minutes after the addition of the fibers.

2.3 MIX DESIGN

A. Design mixes to meet the requirements of this Section and project specific criteria.

B. The Contractor assumes responsibility for the compatibility of admixtures with the mix design and their potential effects on concrete properties.

C. Design the cementitious system to mitigate potential alkali-aggregate reactivity.
   1. Use at least 20 percent pozzolan by weight of the total cementitious system.

D. Obtain approval from the Engineer for the project specific application of an approved mix design.

2.4 TRIAL BATCHES

A. Use the same components in the trial batches that will be used in the project.
   1. Accelerators and site-added air-entrainment can be incorporated in the trial batch but are not required.

B. Use Department certified TTQP Concrete and Concrete Strength Testing personnel to perform trial batches and strength tests.

C. The Department or its certified representative may witness the trial batch.

D. Mix concrete trial batches according to the UDOT Materials Manual of Instruction 974: Guidelines for Portland Cement Concrete Mix Design Trail Batches.

E. Use a Department qualified laboratory to verify trial batch compressive and flexural strength testing.

2.5 AGGREGATE STOCKPILES

A. Construct stockpile platforms so that subgrades are prevented from intruding into aggregates.

B. Build stockpiles at least two days before use.

C. Provide an operator and front-end loader to help the Engineer take aggregate samples.

D. Provide separate stockpiles for coarse and fine aggregates.

E. Construct stockpiles to minimize segregation of aggregates

F. Allow washed aggregates to drain to uniform moisture content before use (12 hours minimum).

2.6 BATCH MATERIALS

A. Batch Tolerances. Refer to AASHTO M 157.
   1. Cementitious Material : ± 1 percent of the required mass
   2. Aggregate: ± 2 percent of the required mass
   3. Total Water: ± 3 percent of the required mix amount

B. Truck-Mixed Concrete (Dry-Batch)
   1. Do not load trucks in excess of their rated mixing capacity, 63 percent of the drum gross volume, or less than 2 yd^3.
   2. The truck rating plate must be readable.

PART 3 EXECUTION

3.1 LIMITATIONS

A. Timing – Deliver, place, and consolidate concrete as follows unless otherwise specified:
   1. Within 90 minutes of batching when the air temperature is below 80 degrees F.
   2. Within 75 minutes of batching when the air temperature is between 80 and 85 degrees F.
   3. Within 60 minutes of batching when the air temperature is above 85 degrees F.

B. Concrete Temperature – Place concrete when the concrete temperature is between 50 and 90 degrees F unless otherwise specified.

C. Pumping and Conveying Equipment
   1. Do not use equipment or a combination of equipment and the configuration of that equipment that causes a loss of entrained air content that exceeds one-half of the range of air content allowed by specification.
      a. Replace, reconfigure, or repair equipment that does not meet this requirement.

   2. Contractor is responsible to verify and monitor air loss.

D. Cold Weather – Comply with the following when placing, finishing, curing, and protecting concrete exposed to cold weather during the protection period. Cold weather applies when the temperature is forecast to fall below 35 degrees F during the protection period.

1. Provide necessary cold weather protection for placing, finishing, curing and protecting in-place concrete such as covers, insulation, and heat.
    a. Follow the authorized Cold Weather Concreting Plan when placing cast-in-place concrete.
    b. Follow the prequalified supplier's approved Quality Control Plan when fabricating precast concrete members.
2. Concrete materials
    a. Do not use chemical anti-freeze additives in the concrete. This does not apply to normal accelerators. Refer to AASHTO M 194.
    b. Remove and replace concrete damaged by frost action at no additional cost to the Department.
    c. Do not use material containing frost or lumps.
3. Determine the concrete compressive strength by one of the following methods:
    a. Field cured cylinders cured and protected the same as the concrete being protected.
    b. Maturity method. Refer to AASHTO T 325.
4. Maintain the temperature of the concrete at or above 50 degrees F during and after placement until the end of the protection period.
    a. Measure the specified concrete temperature at the concrete surface. Use surface thermometers insulated from the surrounding air.
5. Placing concrete
    a. Do not place concrete during adverse weather including rain, snow, and high winds without adequate protection approved by the Engineer.
    b. Do not proceed with the placement of concrete if the temperature of all contact surfaces, including reinforcement, is less than 36 degrees F or greater than 95 degrees F.
    c. Cease placement operations when the ambient temperature is 40 degrees F and decreasing unless adequate precautions are taken according to the approved Cold Weather Concreting Plan.
6. Protection of in-place concrete
    a. Maintain the concrete above 50 degrees F during placement and until the end of the protection period.
        1) The protection period is the time required for the concrete to reach a compressive strength of at least 3,500 psi.
        2) Extend the duration of the protection period at least 24 hr beyond the termination of the cure before exposing the concrete to freezing temperatures when curing by the water method. Refer to Section 03390.
    b. Comply with the following when heating is required.

1) Adequately vent combustion-type heaters that produce carbon monoxide.
2) Position heaters and ducts so the hot dry air does not cause areas of the concrete surface to overheat or dry.
3) Keep concrete surfaces moist to avoid excessive loss of moisture from the concrete when applying external heat.

7. Termination of protection
   a. Limit the drop in temperature of concrete surfaces to 40 degrees F during any 24 hour period when removing cold weather protection until the surface temperature of the concrete reaches that of the ambient air temperature.

E. Hot Weather – Comply with the following when placing, finishing, curing, and protecting concrete exposed to hot weather during the protection period.
   1. Hot weather limitations apply at any time of the year when a combination of high ambient temperature, high concrete temperature, low relative humidity, and high wind speed have the potential to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and the rate of cement hydration, or otherwise causes detrimental results.
   2. Monitor site conditions, including air temperature, relative humidity, and wind speed, to assess the need for evaporation control measures.
      a. Begin monitoring no later than 1 hour before beginning concrete placing operations.
      b. Continue to monitor site conditions at intervals of 20 minutes or less until required curing procedures are applied.
   3. Provide necessary hot weather protection.
      a. Follow the approved Hot Weather Concreting Plan when placing cast-in-place concrete.
      b. Follow the prequalified supplier's approved Quality Control Plan when fabricating precast concrete members.
      c. Initiate evaporation control measures when concrete and air temperatures, relative humidity of the air, and wind speed have the capacity to evaporate free water from the fresh concrete surface at a rate equal to or greater than 0.2 $lb/ft^2/hr$.
         1) Determine the evaporation rate of surface moisture using the NRMCA Nomograph in Appendix B of ACI 305.1.
   4. Cool all surfaces that will come in contact with the concrete to below 95 degrees F

3.2 CYLINDER STORAGE DEVICE

A. Provide and maintain cylinder storage device.
   1. Maintain cylinders at a temperature range of 60 degrees F to 80 degrees F for the initial 16 hour curing period.
   2. Do not move the cylinders during this period.
   3. Equip the storage device with an automatic 24 hour temperature recorder that continuously records on a time/temperature chart with an accuracy of ±1 degree F.
   4. Have the storage device available at the point of placement at least 24 hours before placement.
   5. Stop placement of concrete if the storage device is not provided or cannot accommodate the required number of test cylinders. Cylinder strength results may not be disputed if storage devices are not provided.
   6. Use water containing hydrated lime if water is to be in contact with cylinders.
   7. The Engineer may require a 24 hour test run to determine the storage device capability to maintain and record temperature.

END OF SECTION