SECTION 03055

PORTLAND CEMENT CONCRETE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Materials and procedures for producing Portland Cement Concrete.

1.2 REFERENCES

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

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

C. AASHTO M 92: Wire-Cloth Sieves for Testing Purposes

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

E. AASHTO M 157: Ready Mixed Concrete

F. AASHTO M 241: Concrete Made by Volumetric Batching and Continuous Mixing

G. AASHTO T 22: Compressive Strength of Cylindrical Concrete Specimens

H. AASHTO T 23: Making and Curing Concrete Test Specimens in the Field

I. AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregates

J. AASHTO T 119 Slump of Portland Cement Concrete

K. AASHTO T 121: Mass per Cubic Foot, Yield and Air Content (Gravimetric) of Concrete

L. AASHTO T 141: Sampling Fresh Concrete

M. AASHTO T 152 Air Content of Freshly Mixed Concrete by the Pressure Method

N. AASHTO M 194: Chemical Admixtures for Concrete

O. ACI 301

P. ASTM C 150: Portland Cement

Q. ASTM C 595: Blended Hydraulic Cements

R. ASTM C 618: Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete

S. ASTM C 1157: Blended Hydraulic Cement

T. ASTM C 1240: Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout

U. ASTM C 1260: Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

PART 2 PRODUCTS

2.1 CEMENT

A. Use Type II Portland Cement, or Blended Portland Cement, unless otherwise specified.

B. Portland Cement, Type II.
1. Follow Tables 1 and 3 in ASTM C 150.
2. Follow the requirements of Table 2 of ASTM C 150 for low-alkali cement.

C. Blended Portland Cement.
1. Type IP blended cement may be substituted for Type I cement. Conform to ASTM C 595.
2. Type IP (MS) blended cement may be substituted for Type II cement.
3. Type (HS) blended cement may be substituted for Type V cement, as specified in ASTM C 1157. Conform to requirements of ASTM C 595.
4. When blended cement is used in conjunction with reactive aggregate, use Option R as specified in ASTM C 1157. Conform to requirements of ASTM C 595.
5. Pretest the cement aggregate mixture and meet the specified design criteria at no additional cost to the Department.
6. Do not use fly ash as a replacement for any blended cement.

D. Do not use cement that contains lumps or is partially set.

E. Use cement from the list of UDOT pre-qualified sources maintained by the UDOT Materials Quality Assurance Section.

F. Do not mix cement originating from different sources.

G. Do not use air-entrained cement.

H. Cement may be sampled and tested for compliance at any time.

2.2 COARSE AGGREGATE

A. As specified in AASHTO M 80, and as modified, using one of the gradations found in Table 1.

Table 1

Aggregate Gradations - Percent Passing (by weight)								
Aggregate or Sieve Size (inches)	**2-1/2**	**2**	**1-1/2**	**1**	**3/4**	**1/2**	**3/8**	**No. 4**
2 to No. 4	100	95-100		35-70		10-30		0-5
1-1/2 to No. 4		100	95-100		35-70		10-30	0-5
1 to No. 4			100	95-100		25-60		0-10
3/4 to No. 4				100	90-100		20-55	0-10

B. Use sieve screens with square openings as specified. Meet AASHTO M 92.

C. Do not exceed percentages of deleterious substances as shown in AASHTO M 80, Table 1, for Class A aggregates.

D. Determine the suitability of coarse aggregate sources using the requirements for soundness, percentage of wear and potential reactivity as specified in AASHTO M 80.

2.3 FINE AGGREGATE

A. As specified using one of the gradations shown in Table 2. Meet AASHTO M 6.

Table 2

Sieve Size	Percent Passing (by weight)
3/8 inch	100
No. 4	95 to 100
No. 16	45 to 80
No. 50	10 to 30
No. 100	2 to 10

B. Do not exceed percentages of deleterious substances as outlined in AASHTO M 6 for class A aggregates.

C. Soundness: As specified to determine suitability of fine aggregate. Meet AASHTO M 6.

2.4 COMBINED AGGREGATE

A. Do not allow the material passing the No. 200 sieve to exceed 1.75 percent by weight of the combined fine and coarse aggregates.

2.5 CONTRACTOR FURNISHED AGGREGATE

A. Engineer evaluates aggregate from a non-state specified source.
   1. Proportion mix designs accordingly to mitigate any potential performance problems inherent to the aggregate source.
   2. Pay additional costs incurred from using a Contractor furnished source.

2.6 WATER

A. Potable, or water that meets the specified test standard in AASHTO M 241.

B. Screen out extraneous material when pumping water from streams, ponds, lakes, etc.

2.7 ADMIXTURES

A. Air Entrainment: as specified. Meet AASHTO M 154, including Section 5.

B. Water Reducing Agents: as specified. Meet AASHTO M 194.
   1. The chlorides content (as Cl^-) not exceeding 1 percent by weight of the admixtures.

C. Do not use calcium chloride.

D. Protect all admixtures from freezing.

2.8 POZZOLAN

A. Fly Ash:
   1. Class F, as specified.
      a. Conform to ASTM C 618, Class F.
      b. Loss on Ignition (LOI): not to exceed 3 percent.
      c. Maximum allowable CaO content: not to exceed 15 percent.
   2. Allowed as a Portland cement replacement under the following conditions:
      a. If used, replace 15 to 20 percent of the Portland cement by weight.
      b. Use the minimum cement content in the design formulas before replacement is made.
      c. Use fly ash from the list of UDOT pre-qualified sources maintained by the UDOT Materials Quality Assurance.
      d. Label the storage silo for fly ash to distinguish it from cement.
      e. Use different size unloading hoses and fittings for cement and fly ash.
   3. Fly ash may be sampled and tested for compliance at any time.

B. Natural Pozzolan (Class N)
   1. Conform to ASTM C 618.
   2. May use instead of fly ash provided that the 14 day expansion test (ASTM C 1260) with job aggregates and job cement does not exceed that for the same aggregates and cement with a UDOT approved Class F fly ash.

C. Silica Fume: Conform to ASTM C 1240.

2.9 MIX DESIGN

A. Furnish to the Engineer a mix design for each class of concrete to be used.
   1. Do not change the mix design without written approval.
   2. Base concrete mix designs for all A concrete classes on trial batch test results or on past history (same materials used in previous mix designs within the past year).

3. Use the same components in the trial batches that are to be used in the project including coarse and fine aggregate, water, source and type of cement, air-entraining agent, fly ash, etc.
4. The Department or its representative witnesses the trial batch.
5. Mix concrete (trial batches) as specified.

PART 3 EXECUTION

3.1 PREPARATION

A. Aggregate stockpiles:
1. Clear, grub, smooth, and compact the site.
2. Construct stockpile platforms so that subgrades are prevented from intruding into aggregates.
3. Build stockpiles at least two days before use.
4. Provide an operator and front end loader to help the Engineer take aggregate samples.
5. Acceptance is made in daily increments, but not more than 30 days before use.
6. Provide separate stockpiles for coarse and fine aggregate.
7. Construct stockpiles in thin layers (5 ft maximum) that have uniform thickness and a regular form.
    a. Do not build high, cone-shaped piles above the maximum height of 10 ft before distribution.
    b. Do not dump or spill aggregate over the sides of the stockpile.
    c. Minimize segregation of aggregate.
8. Allow washed aggregates to drain to a uniform moisture content before use (12 hours minimum).
9. Move conveyor continuously across the stockpile as aggregate is discharged.
10. Do not drop material more than 10 ft from conveyor.

B. Heating Aggregate and Water
1. Provide and operate heating devices at no additional cost to the Department when heated aggregates are required.
2. Aggregates must be free of ice.
3. Heat aggregates uniformly, when required. Avoid overheating or developing hot spots.
4. Meet temperature control requirements found in this Section, article, “Limitations,” paragraph C.
5. Meet cold weather limitations found in this Section 03310.
6. Use either steam or dry heat.

7. Do not allow the products of fuel combustion to contact the aggregate.
8. Heat the mixing water to between 70 degrees F and 180 degrees F when introduced into the mixer.

3.2 CONCRETE CLASSES AND MIX REQUIREMENTS

A. Meet the requirements in Table 3.

Table 3

Concrete Classes and Mix Requirements							
Class	**Coarse Aggregate or Sieve Size (inch)**	**Max. Water/ Cement Ratio**	**Min. Cement Content (lb/yd^3)**	**Slump (inch)**	**Air Content Percent (%)**	**Mix Design Compress f'_{cr} (Psi)**	**28 Day Minimum Compress f'_c (Psi)**
7A(AE)	**	**	**	**	**	10500	8000
6A(AE)	**	**	**	**	**	9000	7000
5A(AE)	**	**	**	**	**	7750	6000
4A(AE)	**	**	**	**	**	6500	5000
3A(AE)	2 to No. 4 1-1/2 to No. 4 1 to No. 4 3/4 to No. 4	0.44 0.44 0.44 0.44	611 611 658 658	5/8 to 3-1/2 5/8 to 3-1/2 5/8 to 3-1/2 5/8 to 3-1/2	4.0 - 7.0 4.5 - 7.5 5.0 - 7.5 5.0 - 7.5	5200 5200 5200 5200	4000 4000 4000 4000
AA(AE)	2 to No. 4 1-1/2 to No. 4 1 to No. 4 3/4 to No. 4	0.44 0.44 0.44 0.44	564 564 611 611	1 to 3-1/2 1 to 3-1/2 1 to 3-1/2 1 to 3-1/2	4.0 - 7.0 4.5 - 7.5 5.0 - 7.5 5.0 - 7.5	4750 4750 4750 4750	3650 3650 3650 3650
A(AE)	1-1/2 to No. 4 1 to No. 4 3/4 to No. 4	0.53 0.53 0.48	470 470 517	1 to 3-1/2 1 to 3-1/2 1 to 3-1/2	4.5-7.5 4.5-7.5 4.5-7.5	3900 3900 3900	3000 3000 3000
B or B(AE)		0 62	376	2 to 5	-- 3.0-6.0	3250	2500
C or C(AE)		0.70	376	2 to 5	-- 3.0-6.0	2600	2000

** Design and proportion mixes according to ACI 301 and project specific criteria.

B. Minimum strength is based on a coefficient of variation of 10 percent, and one test below the minimum strength per 100 tests.

C. Maximum size of coarse aggregate:
   1. Not larger than 1/5 of the narrowest dimension between sides of forms.
   2. Not larger than 1/3 the depth of slabs.
   3. Not larger than 3/4 of the minimum clear distance between reinforcing bars or between bars and forms, whichever is least.

D. Do not exceed water/cement ratio.

E. When a Pozzolan is used in the mix, calculate the water/cement ratio (w/c) according to the following formula:

$$\frac{W}{C} = \frac{Water}{Cement + pozzolan}$$

F. When concrete is deposited in water, use 94 lbs. more cement per cubic yard than the design requires for concrete placed above water.

G. When not using water reducing admixtures, use Table 3 to determine the slump requirements.
   1. Slump requirements when using low range water reducers: 1 inch to 5 inches for all classes of concrete.
   2. Slump requirements when using high range water reducers: 4 inches to 9 inches for all classes of concrete.

3.3 ADDITIONAL REQUIREMENTS FOR USING HIGH RANGE WATER REDUCERS (SUPER PLASTICIZERS)

A. Establish the effective life of the High Range Water Reducer (HRWR) by trial batch.
   1. Trial batch will approximate field conditions including time of placement (see this Section, article, “Limitations General - Timing”), and concrete temperature.
   2. Engineer witnesses the trial batch.
   3. Slowly agitate the mix throughout the test period.
   4. Record and plot slump and mix temperature at 15 minute intervals. Maintain the required slump (4 to 9 inches) throughout the time allowed for placement. Re-dose if necessary.
   5. If re-dosing is required, record the time of re-dose and the amount of admixture added.
   6. Do not exceed any manufacturers recommendations for the use of the HRWR.
   7. Submit results of the trial batch to the Engineer.

B. High Range Water Reducer (HRWR) may be added at the job site.
   1. Record on the batch ticket, the time at which the HRWR was added.
   2. Maintain the mixing period for truck mixers between 70 and 100 revolutions at mixing speed.
   3. Engineer conducts a standard slump test before adding the HRWR to a transit mixer. Meet the requirements of Table 3.
   4. Engineer conducts additional slump tests at the job site after adding the HRWR.

C. If the HRWR is added to a central mixer, no preliminary slump test is required.

D. Show on batch tickets the amount of admixture used.

E. Do not exceed the requirements established by the trial batch.

F. Contractor is responsible for changes in placement and finishing operations due to the addition of admixtures.

3.4 ADDITIONAL REQUIREMENTS FOR USING SET RETARDING ADMIXTURES

A. If set retarding admixtures are specified due to haul times exceeding the time limitations in this Section, article, "Limitations - Timing," establish the effective life of the set retarding admixture by trial batch.
   1. The trial batch will approximate field conditions including concrete mix temperature.
   2. Engineer witnesses the trial batch.
   3. Slowly agitate the mix throughout the test period.
   4. Record and plot slump and mix temperature at 15 minute intervals.
   5. Do not exceed any manufacturers recommendations for the use of the set retarding admixture.
   6. Do not re-dose the concrete with additional set retarding admixture.
   7. Submit results of the trial batch to the Engineer.

B. Add set retarding admixture at the batch plant at the time of initial batching operations, or immediately after.

C. Show on batch tickets the amount of admixture used.

D. Time of placement is established by the trial batch and supersedes the requirements in this Section, article, "Limitations - Timing."

E. Do not exceed the requirements established by the trial batch.

F. Contractor is responsible for changes in placement and finishing operations due to the addition of admixtures.

3.5 BATCHING MATERIALS

A. Meet AASHTO M 157.

B. Meet the requirements of the *UDOT Quality Management Plan for Ready-Mix Concrete.*

C. Operate the batch mixer at the manufacturer's recommended drum speed.

D. Keep drums and blades free from excessive cement and mortar buildup.

E. Add the admixtures separately to the mix water.

F. Do not use any process which will cause “flash set” of the mix.

G. At central mix plants, mix all materials for at least 80 seconds at recommended drum speed.
   1. When adding more water or cement, mix 30 additional seconds.
   2. Introduce the cement into the batcher before the fly ash.

H. Conduct mixing efficiency tests as specified.
   1. AASHTO M 157, Annex A-1.
   2. Engineer may order mixing efficiency tests at the beginning of concrete operations, or anytime deemed necessary.

I. Maintain the mixing period for truck mixers between 70 and 100 revolutions at mixing speed.
   1. Maintain a minimum of 90 revolutions for front end discharge trucks.
   2. Complete concrete mixing before the truck leaves the batch plant yard.

J. Hand Mixing:
   1. Only Class B and C concrete may be hand mixed.
   2. Hand-mixed batches cannot exceed 0.5 cubic yard.
   3. Hand mix on a watertight platform.
   4. Spread the aggregate evenly on the platform, and thoroughly mix in the dry cement until the mixture becomes uniform in color.

3.6 TRANSPORTING

A. Transport ready-mixed concrete in transit mixers or agitator trucks.

1. Do not load trucks in excess of their rated mixing capacity, or 63 percent of the drum gross volume, or less than 2 cubic yards.
2. The truck rating plate must be readable.

B. Equip transit mixers or agitator trucks with a visible water meter and revolution counter (electronic or mechanical). Use the water meter to measure all water discharged from the tank of the truck.

C. Obtain approval to add water after the transit mixer or agitator truck leaves the batch plant.
1. Add water within the specified time limits.
2. Do not add more water than the batch ticket indicates.
3. Do not add water after more than 0.5 cubic yard of concrete has been discharged from the drum and do not exceed the water/cement ratio.
4. When adding water, rotate the drum at least 30 revolutions at the mixing speed recommended by the manufacturer.

3.7 LIMITATIONS - GENERAL

A. Timing. Reject concrete if:
1. It is not placed within 90 minutes when the air temperature is below 80 degrees F.
2. It is not placed within 75 minutes when the air temperature is between 80 and 85 degrees F.
3. It is not placed within 60 minutes when the mix temperature is between 86 and 90 degrees F.
4. Initial set has developed.

B. Do not temper concrete by adding water or by any other means after initial set or false set has taken place.

C. Concrete Temperature:
1. Place concrete in the forms when the concrete temperature is between 50 and 90 degrees F.
2. Do not place concrete when the mix temperature exceed 90 degrees F.
3. Cold and Hot Weather Limitations: Refer to this Section.

D. 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.
2. At the direction of the Engineer, Contractor is responsible for verification and/or monitoring of air loss.

3.8 LIMITATIONS - COLD WEATHER

C. Cold weather limitations apply when the temperature is likely to fall below 40 degrees F within 14 days of placement.

B. Comply with the following regulations for placing concrete in cold weather:

1. Submit a written plan for approval 14 calendar days before concrete placement.
2. Do not use chemical additives in the concrete to prevent freezing.
3. Provide all necessary cold weather protection for in-place concrete (cover, insulation, heat, etc.).
4. Do not place concrete in contact with frozen surfaces.
5. Produce concrete with a temperature between 60 degrees F and 90 degrees F at the time of placing.
6. Adequately vent combustion-type heaters that produce carbon monoxide.
7. Maintain the concrete temperature above 50 degrees F for the first 14 days after placing.
8. Protect the concrete from freezing until a compressive strength of at least 3,500 psi has been achieved.
9. Maintain moist conditions for exposed concrete not in contact with forms; avoid loss of moisture from the concrete due to heat applied.
10. Limit the drop in temperature next to the concrete surfaces when removing heat to 20 degrees F during any 12-hour period until the surface temperature of the concrete reaches that of the atmosphere.
11. Determine the concrete temperature with a surface thermometer insulated from surrounding air.

C. **Paving:**

1. Paving may begin when base surface temperature is 36 degrees F in the shade and ascending.
2. Maintain the mix temperature at a minimum 60 degrees F.
3. Cease operations when the ambient temperature is 45 degrees F in the shade and decreasing.
4. Do not add chemical admixtures to prevent freezing.
5. Remove and replace concrete damaged by frost action at no additional cost to the Department.
6. Do not use material containing frost or lumps.
7. Do not heat water or aggregate to more than 150 degrees F.
8. Protect the concrete from freezing until a compressive strength of at least 3500 psi has been achieved.

3.9 LIMITATIONS - HOT WEATHER

A. Begin batching operations when the ambient air temperature in the shade is 85 degrees F and declining.

B. Discontinue placing when the ambient air temperature reaches 80 degrees F in the shade and is increasing.

C. Paving: Discontinue paving when mix temperature reaches 90 degrees F. either at point of placement or batch plant platform, or when ambient air temperature exceeds 100 degrees F. in the shade.

3.10 FIELD QUALITY CONTROL - SAMPLING

A. Engineer conducts sampling and testing.
   1. When testing concrete from a concrete pump, Engineer takes the samples from the hose after all of the priming grout has been wasted.
   2. When testing concrete used on bridge decks, Contractor places a small pile of concrete in front of the deck screed and provide suitable access for the Engineer to obtain samples.

B. Provide and maintain cylinder storage devices to control the temperature within the specified range.
   1. Maintain cylinders at a temperature range of 50 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 with an accuracy of ±1 degree F.
   4. Have the storage devices available at the point of placement at least 24 hours before placement.
   5. Engineer stops placement of concrete if the storage device cannot accommodate the required number of test cylinders.
   6. Use water containing hydrated lime if water is to be in contact with cylinders.
   7. A 24-hour test run may be required.

C. Do not place concrete without approval.

D. Cure cylinders representing steam-cured concrete as specified. Leave the cylinders with the product while steam is applied and then standard cured for the remaining 28 days. AASHTO T 23.

END OF SECTION