SECTION 03 30 04
CONCRETE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Material requirements.

1.2 REFERENCES

A. ACI 211.1: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
B. ACI 211.2: Standard Practice for Selecting Proportions for Structural Lightweight Concrete.
C. ACI 211.3: Standard Practice for Selecting Proportions for No-Slump Concrete.
D. ACI 214: Recommended Practice for Evaluation of Strength Test Results of Concrete.
E. ACI 301: Specifications for Structural Concrete for Buildings.
F. ACI 305: Hot Weather Concreting.
G. ACI 306: Cold Weather Concreting.
H. ACI 318: Building Code Requirements for Reinforced Concrete.
I. ASTM C 33: Standard Specification for Concrete Aggregates.
J. ASTM C 39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
K. ASTM C 88: Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
L. ASTM C 94: Standard Specification for Ready-Mixed Concrete.
M. ASTM C 117: Standard Test Method for Material Finer than 75μ (No. 200) Sieve in Mineral Aggregates by Washing.
N. ASTM C 138: Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.
O ASTM C 143: Standard Test Method for Slump of Hydraulic-Cement Concrete.
P. ASTM C 150: Standard Specification for Portland Cement.
Q. ASTM C 172: Standard Method of Sampling Freshly Mixed Concrete
R. ASTM C 227: Standard Test Method for Potential Reactivity of Cement-Aggregate Combinations (Mortar Bar Method).
S. ASTM C 231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
T. ASTM C 260: Standard Specification for Air-Entraining Admixtures for Concrete.
U. ASTM C 289: Standard Test Method for Potential Reactivity of Aggregates (Chemical Method).
V. ASTM C 295: Standard Practice for Petrographic Examination of Aggregates for Concrete.
W. ASTM C 441: Standard Test Method for Effectiveness of Mineral Admixtures or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to The Alkali-Silica Reaction.

X. ASTM C 494: Standard Specification for Chemical Admixtures for Concrete.
Y. ASTM C 595: Standard Specification for Blended Hydraulic Cements.
Z. ASTM C 618: Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
AA. ASTM C 1064: Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.
BB. ASTM C 1116: Standard Specification for Fiber-Reinforced Concrete and Shot Crete.
CC. ASTM C 1157: Standard Performance Specification for BlendedHydraulic Cement.
DD. ASTM C 1240: Standard Specification for Use of Silica Fume as a Mineral Admixture in Hydraulic Cement Concrete, Mortar, and Grout.
EE. ASTM C 1260: Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
FF. ASTM C 1293: Standard Test Method for Concrete Aggregates by Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
GG. ASTM C 1567: Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
HH. ASTM C 1602: Standard Specification for Mixing Water Used in The Production of Hydraulic Cement Concrete.
I I. ASTM D 1077: Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.
J J. ASTM STP 15-C: Manual on Quality Control of Materials.

1.3 **SUBMITTALS**

A. **Quality Assurance**: Submit names, certification levels, and years of experience of testing agency's laboratory and field technicians that are assigned to the Work. Verify laboratory complies with ASTM and ACI standards.
B. **Mix Design**: Submit.
1. Date of mix design. If older than 365 days, recertify mix design.
2. Cement source, type and chemical composition.
3. Aggregate soundness and potential reactivity.
4. Average Strength (fcr), per quality control chart.
5. Allowable range of slump and air content.
6. Water cement ratio.
7. Proportions of materials in the mix.
8. Unit weight.
9. Analysis of water if water is not potable.
10. Mortar bar test results if a pozzolan is included in the mix.
11. Technical data sheets for additives to be used at the plant and at the job site. Certify additives are compatible with each other.
C. **Pre-approved mix design**, submit name and address of Supplier.
D. **Before changing mix design**, submit a new design and give ENGINEER 10 days to evaluate the changes.
E. **Source Quality Control Inspections and Testing Report**: If requested, submit report

describing CONTRACTOR's and Supplier's quality control activities and test results.

1.4 **QUALITY ASSURANCE**

A. Use a laboratory that follows and complies with ASTM D 1077.
B. Reject concrete that does not meet requirements of this section.
C. Do not change material sources, type of cement, air-entraining agent, water reducing agent, other admixtures except as allowed by mix design.
D. Store bagged and bulk cement in weatherproof enclosures. Exclude moisture and contaminants.
E. Prevent segregation and contamination of aggregate stockpiles.
F. Avoid contamination, evaporation, or damage to admixtures. Protect liquid admixtures from freezing.
G. Use of admixtures will not relax hot or cold weather placement requirements.

1.5 **ACCEPTANCE**

A. Materials:
   1. At the Source: Verify aggregate gradation. Determine percent of combined aggregate passing No. 200 sieve.
   2. At the Site: Verify mix identification, batch time, slump, air content, and temperature.
   3. At the Laboratory: Verify strength in 28 days.
B. Placement:
   1. Concrete in general, Section 03 30 10.
   2. Pavement.
   3. Exterior flatwork.
C. Defective Material:
   1. Price adjustment, Section 01 29 00 and Section 03 30 10.
   2. Dispute resolution, Section 01 35 10.

PART 2 PRODUCTS

2.1 **CEMENT**

A. General:
   1. Do not use air entraining cement except for hand mixed applications.
   2. Do not use cement that contains lumps or is partially set.
   3. Do not mix cement originating from different sources.
B. Standard Set Cement:
   1. Type II cement per tables 1 and 3 in ASTM C 150, or Type V when necessary, or
   2. Low-alkali cement per table 2 in ASTM C 150.
C. Rapid Set Cement: As above and as follows.
   1. Initial set time: 15 minutes minimum.
   2. Color: Acceptable to the ENGINEER.
D. Blended Hydraulic Cement: The following are the cement equivalencies when substituting blended cement for a portland cement.

Table 1 - Cement Equivalencies		
ASTM C 150 (Low Alkali)	**ASTM C 595**	**ASTM C 1157**
Type I	IP	GU
Type II	IP (MS)	MS
Type III	–	HE
Type IV	–	–
Type V	–	HS

2.2 **WATER**

A. Clean, non-staining, non-detrimental per ASTM C 1602.
B. Screen out extraneous material.
C. Do not use alkali soil water.

2.3 **AGGREGATES**

A. Material: Clean, hard, durable, angular, and sound consisting of gravel, crushed gravel, crushed stone, crushed concrete, slag, sand or combination.
B. Source: Use the following requirements to determine suitability of aggregate source and not for project control.
1. Deleterious Substances and Physical Properties:
a. Coarse Aggregate: Class designation 4S in table 3 in ASTM C 33.
b. Fine Aggregate: Table 1 in ASTM C 33. Organic impurities producing a dark color concrete may cause rejection.
2. Reactivity:
a. Average prism length change in 12 months in an unmodified ASTM C 1293 test is less than 0.04 percent, or
b. Average mortar bar length change at 16 days in an unmodified ASTM C 1260 test is less than 0.10 percent, or
c. Historical data acceptable to ENGINEER, or
d. Petrographic limits per ASTM C 295.
1) Optically strained, micro fractured, or microcrystalline quartz: 5.0% maximum.
2) Chert or chalcedony: 3.0% maximum.
3) Tridymite or cristobalite: 1.0% maximum.
4) Opal: 0.5% maximum. 50 Natural volcanic glass volcanic rocks: 3.0% maximum

2.4 **ADMIXTURES**

A. Calcium Chloride: Not allowed.

B. Air Entrainment: ASTM C 260. For extrusion enhancement use nonvinsal resin.
C. Set Enhancement and Water Reducing Agents: ASTM C 494.
1. Type A: Water reducing.
2. Type B: Set retarding.
3. Type C: Set accelerating.
4. Type D: Water reducing and set retarding.
5. Type E: Water reducing and set accelerating.
6. Type F: High range water reducing (super plasticizer). *
7. Type G: High range water reducing and set retarding. *
* Keep the relative durability factor of water reducing additives not less than 90 and the chlorides content (as Cl^-) not exceeding 1 percent by weight of the admixtures.

D. Pozzolan:
1. Natural or fly ash per ASTM C 618.
2. Silica fume per ASTM C 1240

E. Special Admixtures: Allowed if mix design submittal is accepted.
1. Lithium nitrate based solution for control of reactive aggregates.
2. Calcium nitrite based solution for corrosion protection of reinforced structures subject to chloride-induced corrosion.
3. Shrinkage reducer for controlling drying shrinkage in concrete.
4. Viscosity modifier for enhancement of self consolidating concrete or for workability.

2.5 **MIX DESIGN**

A. Selection of Cement: ASTM C 150 or C 1157.
1. For sulfate resistance, use Type V portland cement, or Type II with Class F fly ash. Class F fly ash may be used as an addition to Type V portland cement.
2. Do not use fly ash with Type IP(MS) or Type III portland cement.

B. Selection of Aggregates.
1. Maximum Particle Size:
a. 1/5 of narrowest dimension between forms.
b. 1/3 of depth of slab.
c. 3/4 of minimum clear spacing between reinforcing bars.
2. Gradation: ASTM C 33.
a. Coarse Aggregate: Choose from the following grades. Gradations are based upon percent of material passing sieve by weight.

Sieve Size	Grade			
	357 (2")	**467 (1.5")**	**57 (1")**	**67 (3/4")**
2-1/2"	100	–	–	–
2 inch	95 - 100	100	–	–
1-1/2"	–	95 - 100	100	–
1"	35 - 20	–	95 - 100	100
3/4"	–	35 - 70	–	90 - 100
1/2"	10 - 30	–	25 - 60	–
3/8"	–	10 - 30	–	20 - 55
No. 4	0 - 5	0 - 5	0 - 10	0 - 10

b. Fine Aggregate:

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

c. Silts and Clays: The amount of material smaller than the No. 200 sieve in any combined gradation sample is limited to the following percentages by weight of the combined sample.

1. 1.75 percent maximum for concrete subject to abrasion.
2. 3.0 percent maximum for all other concrete. 194

C. Selection of Pozzolan:

1. General: If a blended aggregate passes an unmodified ASTM C 1293 test, use of a pozzolan is CONTRACTOR’s choice, otherwise select a pozzolan (or blended cement, or both) and determine the effective dosage to meet one of the following tests.
   a. ASTM C 1567. The expansion of a cement-pozzolan-aggregate job-mix mortar bar is less than or equal to 0.10 percent at 16 days. Do not use this test if a lithium admixture is used in the job-mix.
   b. ASTM C 441. The expansion of a test mixture at 56 days is less than or equal to a control mixture prepared with cement with equivalent alkalis between 0.5 and 0.6 percent.
2. Fly Ash (Class F): Allowed as a cement replacement under the following conditions.

a. Before replacement is made, use the minimum cement content in the design formula to establish the water/cement ratio.
b. Replace up to 20 percent of the cement by weight on a minimum basis of 1 part fly ash to 1 part cement.
c. Submit to ENGINEER a quality history of the fly ash identifying a minimum of 20 of the most current ASTM C 618 analysis.

3. Natural Pozzolan (Class N): Allowed as a cement replacement if the 14 day expansion test (ASTM C 1567) with job aggregates, job cement and natural pozzolan does no exceed the 14 day expansion test of job aggregates, job cement and Class F fly ash.
4. Silica Fume: Allowed as a cement replacement if replacement of hydraulic cement on a 1 part silica fume to 1 part cement does not exceed 10 percent, and water/cement ratio is established before cement is replaced with silica fume.

D. Selection of Fiber Reinforcement: The basis for determining material proportions of fiber-reinforced concrete is the Supplier's responsibility per ASTM C 1116 subject to mix property requirements of this Section. Unless specified otherwise provide synthetic fibers.
E. Selection of Mix Properties: Select and proportion mix to produce appropriate strength, durability and workability. Use ACI 211.1, 211.2, or 211.3, and meet the following properties and limitations.

Table 3 - Mix Properties and Limitations

Properties		Test Method	Class		
			2000	3000	4000
Compressive Strength (fc') at 28 days, psi, minimum		ASTM C 39	2000	3000	4000
Compressive Strength at 7 days, psi, (for reference only)		ASTM C 39	1340	2010	2680
Average Strength, psi (fcr)		ACI 214	(a)	(a)	(a)
Cement content, bags, minimum (b)		–	4.5	5.5	6.5
Water-cement ratio (by weight), maximum (d)		ACI 318	(c)	(c)	0.44
Entrained air, percent (based upon aggregate size) (e)	2" 1-1/2" 1" 3/4"	ASTM C 231	3.0 to 6.0 " " "	4.5 to 7.5 " " "	4.0 to 7.0 4.5 to 7.5 5.0 to 7.5 5.0 to 7.5
		ASTM			

Slump	C 143	(c)	(c)	(c)

NOTES:
(a) The amount by which average strength (fcr) exceeds compressive strength (fc') is based upon statistical assurance that no more than 1 test in 100 tests will fall below compressive strength (fc').
(b) Unless allowed otherwise by Engineer.
(c) Specific to exposure conditions and finishing need.
(d) Before pozzolan substitution.
(e) Comply with ACI 211.1 if air content is changed.
(f) 1 bag of cement = 94 pounds.

1. Cold Weather: ACI 306. Unless allowed otherwise by ENGINEER, increase cement content in the mix design by 1 bag between **October 1 and March 1,** i.e. 5.5 becomes 6.5, or 6.5 becomes 7.5, etc.
2. Hot Weather: ACI 305. Reduce temperature of mix ingredients or use an admixture appropriate to job conditions when air temperature is over 75 deg. F.
3. Concrete Deposited Under Water: Increase cement content 1 bag per cubic yard greater than the design required for concrete placed above water or use viscosity modifying admixture.

2.6 **SOURCE QUALITY CONTROL**

A. Once selected, do not change source quality control sampling point.
B. Aggregate:
   1. Soundness, ASTM C 88.
   2. Alkali-silica Reactivity: ASTM C 289, C 1567, C 227 and C 1293.
   3. Petrographically examine fine and coarse aggregate sources once every 3 years per ASTM C 295.
C. Concrete Mix: Obtain samples per ASTM C 172 and run the following tests.
   1. Compressive strength, ASTM C 39.
   2. Unit weight, ASTM C 138.
   3. Slump, ASTM C 143.
   4. Air, ASTM C 231.
   5. Temperature, ASTM C 1064.
D. Concrete Quality Charts: Comply with ACI 214 and ACI 301. Plot new results and identify trends on quality control charts that comply in form to ASTM STP 15-C. Show the Specified Strength (fc'), the required Average Strength (fcr), and the compressive strength versus date of Sample.
E. Equipment: Certify through the services of a professional engineer that trucks and plant equipment comply with the requirements of the National Ready Mixed Concrete Association. Do so at least every 2 years.
   1. Transit Trucks: Equip transit trucks with plates indicating total volume, agitating volume and mix volume.
   2. Weights and Measures: Comply with regulatory requirements of State of Utah.

PART 3 EXECUTION

3.1 **INSTALLATION**

A. Placement, Section 03 30 10.

B. Pavement restoration.

C. Driveways, sidewalks, curb, gutter.

D. Roadway pavement.

3.2 **FIELD QUALITY CONTROL**

A. Truck Mixed Concrete (Dry Batch): ASTM C 94.

1. Truck Mixer: Fill drum no more than 63 percent of the gross drum volume and no less than 2 cubic yards. Use drum manufacturer's recommended mixing speed (between 12 and 18 rpm).
2. Truck Agitator: Do not fill drum greater than 80 percent of the gross drum volume. Use drum manufacturer's recommended agitating speed (between 2 – 6 rpm).

B. Mixing Plant: ASTM C 94.

1. Use option C and requirements in this section for preparing ready-mixed concrete.
2. Use scales certified by the State of Utah. Do not use volume measurement except for water and liquid admixtures.
3. Mixing time must exceed 80 seconds after adding air entrainment admixture.

C. Hand Mixing:

1. Do not hand mix batches larger than 0.5 cubic yard.
2. Hand mix only on a watertight platform.
3. Ensure all stones are thoroughly covered with mortar and mixture is of uniform color and consistency prior to adding water.

END OF SECTION