

SECTION 336350

CAST-IN-PLACE CONCRETE FOR UTILITIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Cast-in-place concrete for tunnel walls and slabs; steam manholes, chases, precast items and other miscellaneous structures; control, expansion and contraction joint devices associated with concrete work.

1.2 REFERENCES

- A. ACI 301 - Structural Concrete for Buildings.
- B. ACI 302 - Concrete Floor and Slab Construction.
- C. ACI 304R - Measuring, Mixing, Transporting and Placing Concrete.
- D. ACI 305R - Hot Weather Concreting.
- E. ACI 306.1 - Cold Weather Concreting.
- F. ACI 308 - Curing Concrete.
- G. ACI 318 - Building Code Requirements for Structural Concrete and Commentary.
- H. ASTM C 33 - Concrete Aggregates.
- I. ASTM C 94 - Ready-Mixed Concrete.
- J. ASTM C 150 - Portland Cement.
- K. ASTM C157 – Change of Hardened Hydraulic-Cement Mortar and Concrete
- L. ASTM C 260 - Air Entraining Admixtures for Concrete.
- M. ASTM C 295 – Guide for Petrographic Examination of Aggregates for Concrete.
- N. ASTM C457 – Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete.
- O. ASTM C 494 - Chemicals Admixtures for Concrete.
- P. ASTM C 595M - Blended Hydraulic Cements (Metric).

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- Q. ASTM C 618 - Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
- R. ASTM C 989 – Ground Granulated Blast-Furnace Slag for use in Concrete and Mortar
- S. ASTM D 994 - Preformed Expansion Joint Filler for Concrete (Bituminous Type).
- T. ASTM C 1017 - Chemical Admixtures for Use in Producing Flowing Concrete.
- U. ASTM C 1107 - Packaged Dry, Hydraulic Cement Grout (Nonshrink).
- V. ASTM C 1202 – Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration
- W. ASTM C 1240 – Silica Fume Used in Cementitious Mixtures
- X. ASTM C 1260 – Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
- Y. ASTM D 1752 - Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
- Z. ASTM C 1567 – Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar Bar Method)
- AA. ASTM D 6690 - Concrete Joint Sealer, Hot-Poured Elastic Type.

1.3 SUBMITTALS

- A. Product Data: Submit data for bonding agent, joint devices, and attachment accessories.
- B. Manufacturer's Installation Instructions: Submit installation procedures and interface required with adjacent work.
- C. Material Certificates: Submit mill certificates for the cement, supplementary cementitious materials, and admixtures intended for inclusion in the concrete mixtures.
 - 1. Cement: Submit certification of compliance with ASTM C 150 for cement manufactured within 3 months of submittal date.
 - 2. Fly Ash and Pozzolan: Submit certification of compliance with ASTM C 618 performed within 6 months of submittal date.

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3. Ground Granulated Blast-Furnace Slag: Submit certification of compliance with ASTM C 989 performed within 6 months of submittal date.
 4. Silica Fume: Submit certification of compliance with ASTM C 1240 performed within 6 months of submittal date.
 5. Chemical Admixtures: Submit certificate of compliance with ASTM C 494 Level 1 or Level 2, performed within one year of the submittal date. If a chemical admixture does not fit into a defined C 494 type, admixture certificate shall provide documentation that the admixture has no detrimental effect on strength development, time of setting, shrinkage, air entrainment, scaling, and freeze-thaw resistance (ASTM C 666 Procedure A).
- D. Project Record Documents:
1. Accurately record actual locations of embedded utilities and components that are concealed from view.
 2. Submit upon request for record copies of all concrete delivery tickets.
 3. Submit upon request for record copy of plan with locations and dates for concrete placements shown on drawing.
- E. Aggregates: Submit test results for each aggregate intended for use in the concrete mixtures, showing conformance to ASTM C 33 and additional requirements as follows:
1. Aggregate source and identification
 2. Maximum nominal aggregate size, or gradation size number.
 3. Gradation analysis, including percentage retained and passing each sieve, and a graph of individual percentage retained versus sieve size.
 4. Quantity and identification of deleterious substances in the aggregates
 - a. The limits for deleterious materials contained in coarse aggregate as defined in ASTM C 33 – Table 3 Class 4S.
 5. ASTM C 1260 test report performed within 6 months of the submittal date with the following modifications.
 - a. Expansion limit shall be 0.1% at 28 days in 1 N NaOH soak solution.
 - b. Measure mortar bar expansion at 3 to 4 day intervals.
 - c. Aggregates that exceed the 0.1% expansion limit may be used with ASR mitigation. ASR mitigation options include cement replacement with fly ash/slag/silica fume or addition of lithium nitrate admixture. The combination of reactive aggregate and cementitious materials and/or lithium nitrate admixture must be

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tested in accordance with ASTM C1567 and have an expansion not exceeding 0.1% at 28 days.

Note:

It is recommended to prepare ASTM C 1567 tests over a range of supplementary cementitious material replacement levels to identify the appropriate combination for mitigation.

- 1) If 30% lithium nitrate admixture is used to mitigate ASR expansion, the minimum lithium admixture dose shall be determined by ASTM C 1567 tests performed at three or more dose levels, one of which will be a 100% dose. The 100% dose is defined as 0.55 gallons of admixture per pound of sodium equivalent in the Portland cement. For cement with 1% sodium equivalent, the 100% dose of 30% lithium nitrate admixture is 0.0455 mL/gram of cement.
 - 2) If 30% lithium nitrate admixture is used to mitigate ASR expansion, the ASTM C 1567 soak solution shall be 1 N NaOH containing lithium nitrate admixture in proportion to the dose added to the mortar. For the 100% dose of 30% lithium nitrate admixture, use 71 mL of admixture per liter of soak solution.
6. Submit complete data regarding concrete aggregates prior to any change in aggregate source.
- F. Concrete Mixture Submittal: At least 30 days minimum prior to concrete placement, submit mixture proportions and prequalification test data for each type of concrete along with material certifications. Submit complete list of ingredients including type, brand, source and amount of: cement, fly ash, silica fume, ground-granulated blast-furnace slag, aggregates, and admixtures.
- G. Prequalification of Concrete Mixtures: Provide test data for each class of concrete meeting the performance requirements for each class of concrete required in Section 3.9.
1. Laboratory Qualifications: Prequalification testing shall be performed by a laboratory selected or approved by the Owner's Representative.
 2. Submit copies of testing reports showing the concrete mixture has been successfully tested to produce the properties specified and that the mix will be suitable for the job conditions. The laboratory tests shall include mill certificates and other test data for all cementitious materials, aggregates, and admixtures required by this specification. Materials used

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in the trial mixtures shall have the same source as proposed for use on the project. If source material changes, resubmit mixture data using revised source material, unless approved in writing by the Owner's Representative.

3. No concrete shall be placed unless proven by trial mix studies to meet the requirements of this specification, unless otherwise approved in writing by the Owner's Representative.
4. The submittal shall clearly indicate the concrete producer's mixture identification name or code, the class of concrete, and intended use.
5. Prequalification criteria are as follows. Specification limit values for each class of concrete are listed in Table 1.
 - a. Report trial mixture proportions, slump, air content, unit weight, and mixture temperature.
 - b. ASTM C 39 – Submit compressive strength development of the trial mixture from at least two cylinders tested at 3, 7, 28, and 56 days age. Tests may be performed on either 6-inch diameter or 4-inch diameter standard concrete cylinders.
 - c. ASTM C 39 - Provide documentation for establishing the required average strength, f'_{cr} .
 - 1) If available, submit test data for 30 individual batches of production concrete tested at 28 days age. Determine the mean and standard deviation, s . Calculate the required average strength of concrete from the specified strength, f'_c , and standard deviation, s , as follows.
$$f'_{cr} = f'_c + 1.34s \text{ [psi]}$$
 - 2) In the absence of historical data, calculate the required average strength as follows
$$f'_{cr} = f'_c + 1200 \text{ [psi]}$$
 - d. ASTM C1152 – Acid-soluble chloride ion content of the concrete mixture shall not exceed 0.20 percent of the mass of cement. Report the average of two tests taken from the trial concrete mixture. Obtain a representative sample of concrete by cutting and pulverizing a disk from the center of a cylinder that is at least as thick as the maximum aggregate size.
 - e. ASTM C 457 – Submit test report for the hardened air content and air-void system parameters of the trial concrete mixture when

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required in Table 1. The minimum acceptable hardened air content shall be identified in Table 1. The maximum acceptable air-void spacing factor shall be 0.008 inches. The minimum acceptable specific surface shall be 600 in²/in³.

- f. ASTM C 1202 – Submit test results for three cylinders tested at 28 days when required in Table 1. Moist cure test cylinders in a water bath held at 73 (± 3) degrees Fahrenheit for seven days followed by 100 (± 3) degrees Fahrenheit for 21 days prior to test.
- g. ASTM C 157 – Submit test results for 28 day drying shrinkage as the average of three specimens in accordance with ASTM C 157 and the following modifications when required in Table 1.
 - 1) Record and report the initial length upon removal from the mold as described in ASTM C 157, then cure test specimens in 73 (± 3) degree F lime water for 7 days followed by air storage in standard conditions. (73 ± 3 F and 50% ± 4% RH)
 - 2) Record and report drying shrinkage measurements weekly.
 - 3) Calculate the drying shrinkage as the difference between the length of the specimen upon removal from curing and the length measured in air storage expressed as a percentage of the length measured upon removal from curing at eight days age.
 - 4) For maximum coarse aggregate size ≤ 1 inch, specimens shall be 3-in by 3-in by 11.25-in prisms with a 10-inch gage length. For larger aggregate, use a minimum specimen dimension that is at least 3 times the maximum aggregate size.
 - 5) If the concrete mixture drying shrinkage at 28 days exceeds the limit listed in Table 1, mixture proportions shall be adjusted, or a shrinkage reducing admixture shall be incorporated into the mixture.
- H. Silica Fume Manufacturer's Representative: Submit statement that silica fume manufacturer's representative will be present at mix plant to ensure proper mix, including high range water reducer, superplasticizer, and batching methods during the first 3 days of concrete mix preparation and placement. After which, manufacturer's representative will designate representative at concrete producer's plant to ensure concrete mix procedures meet silica fume manufacturer's recommendations. Silica fume manufacturer's representative shall attend and advise at placement and finishing of initial phases of tunnel construction.

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1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with ACI 301.
- B. Maintain one copy of each document on site.
- C. Acquire cementitious materials and aggregate from same source contained in the submittals for all Work.
- D. Conform to ACI 305R when concreting during hot weather.
- E. Conform to ACI 306.1 when concreting during cold weather.
- F. A preconstruction meeting shall be held with concrete supplier, contractor, finisher, admixture supplier(s) and Owner's Representative. A sample pour shall be performed with each of the proposed concrete mixes to verify methods of placing, finishing and curing to ensure concrete quality. Test cylinders may be cast for the sample pour at the discretion of the Owners Representative.

1.5 COORDINATION

- A. Coordinate the placement of joint devices with erection of concrete formwork and placement of form accessories.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

- A. Cement: ASTM C 150, Type II
- B. Fine and Coarse Aggregates: ASTM C 33.
- C. Water: Clean and not detrimental to concrete.

2.2 ADMIXTURES

- A. Air Entrainment: ASTM C 260.
- B. Chemical: ASTM C 494, Type A - Water Reducing, Type B – Retarding, Type C – Accelerating, Type F - Water Reducing, High Range.
- C. Fly Ash and Calcined Pozzolan: ASTM C 618.
- D. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 80, 100 or 120

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E. Plasticizing: ASTM C 1017.

F. Silica Fume: ASTM C 1240

2.3 ACCESSORIES

A. Bonding Agent: Polymer resin emulsion or Latex emulsion.

B. Non-Shrink Grout: ASTM C 1107, premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 2,400 pounds per square inch in 48 hours and 5,000 pounds per square inch in 28 days.

2.4 JOINT DEVICES AND FILLER MATERIALS

A. Joint Filler: ASTM D 1752; closed cell molded vinyl foam, resiliency recovery of 95 percent if not compressed more than 50 percent of original thickness.

2.5 CONCRETE MIX

A. Mix concrete in accordance with ACI 301. Deliver concrete in accordance with ASTM C 94.

B. Select proportions for normal weight concrete in accordance with ACI 301 trial mixtures.

C. Optimize the combined aggregate gradation to minimize the paste content required to make workable concrete.

D. Use accelerating admixtures in cold weather only when approved by Owner's Representative. Use of admixtures will not relax cold weather placement requirements.

E. Admixtures containing ingredients corrosive to reinforcing steel such as chloride ion, bromide ion, or thiocyanate are not permitted.

F. Use set retarding admixtures during hot weather only when approved by the Owners Representative.

G. Add air entraining agent to normal weight concrete mix for work exposed to exterior.

PART 3 - EXECUTION

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3.1 EXAMINATION

- A. Verify requirements for concrete cover over reinforcement.
- B. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.

3.2 PREPARATION

- A. Prepare previously placed concrete surfaces by abrasive blast cleaning, to remove debris and laitance and expose aggregate. Thoroughly wet the substrate prior to placement of fresh concrete against prepared surface.
- B. In locations where new concrete is doweled to existing work, drill holes in existing concrete, insert steel dowels in an approved epoxy or adhesive.

3.3 PLACING CONCRETE

- A. Place and consolidate concrete in accordance with ACI 301 and ACI 318.
- B. Notify Owner's Representative and testing agency minimum 24 hours prior to commencement of operations.
- C. Ensure reinforcement, inserts, embedded parts, and formed expansion and contraction joints are not disturbed during concrete placement.
- D. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.
- E. Place concrete continuously between predetermined expansion, control, and construction joints.
- F. Do not interrupt successive placement; do not permit cold joints to occur.

3.4 CONCRETE FINISHING

- A. Finish concrete surfaces to requirements of Section 03350.

3.5 CURING AND PROTECTION

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- A. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.
- B. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
- C. Cure concrete floor surfaces to requirements of Section 03390.
- D. Remove any curing materials containing waxes or other products that may interfere with adhesion of waterproofing membrane installed under Section 07132 and 07140.

3.6 FIELD QUALITY CONTROL

- A. Field inspection and testing will be performed in accordance with ACI 301 by ACI certified technicians.
- B. Provide free access to Work and cooperate with appointed firm.
- C. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of Work.
- D. Concrete for casting test specimens and fresh concrete properties shall be sampled at the end of the chute in accordance with ASTM C 172.
- E. No water other than the incidental water used to prewet the delivery chute and fins shall be added to the concrete after the truck leaves the batch plant, unless directed in writing by the Owners Representative.
- F. Adjustment of slump on site shall only be accomplished by the addition of water reducing or plasticizing admixture. Admixture shall be placed directly onto the concrete and the revolving drum mixer shall mix at high speed for 5 minutes, or 100 revolutions, before discharge.
- G. Obtain concrete for casting test samples after slump adjustment.
- H. Tests for fresh concrete properties (slump ASTM C 143, air content ASTM C 231, temperature ASTM C 1064, and unit weight ASTM C 138) shall be performed whenever casting test cylinders.
- I. One additional slump test will be taken at the point of pump discharge for each set of test cylinders taken.
- J. Additional fresh concrete property tests shall be performed when requested by the Owners Representative.

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- K. Six concrete test cylinders (6-in dia. x 12-in) will be cast for each placement, or for every 75 cubic yards, whichever is greater, for each class of concrete placed. Compressive strength of test cylinders shall be determined as follows:
1. One cylinder shall be tested at 3 days
 2. One cylinder shall be tested at 7 days
 3. Two cylinders shall be tested at 28 days
 4. One cylinder shall be tested at 56 days,
 5. One extra cylinder will be cast for discretionary use
- L. Two additional test cylinders shall be cast during cold weather concreting and shall be cured on the job site under the same conditions as the concrete it represents. Compressive strength of field cured cylinders shall be determined prior to form removal, and at 56 days age.
- M. Two concrete test cylinders (preferably 4-in dia. x 8-in) will be cast for ASTM C 1202 quality assurance testing for every 500 cubic yards, or portion thereof. ASTM C 1202 cylinders shall be cured in the same manner as the prequalification test cylinders.

3.7 PATCHING

- A. Allow Owner's Representative to inspect concrete surfaces immediately upon removal of forms.
- B. Excessive honeycomb or embedded debris in concrete is not acceptable. Notify Owner's Representative upon discovery.
- C. Patch imperfections in accordance with ACI 301.

3.8 DEFECTIVE CONCRETE

- A. Defective Concrete: Concrete not conforming to required lines, details, dimensions, tolerances, or specified requirements.
- B. Remedy for defective concrete (payment penalty, repair, or replacement) will be determined by Owner's Representative.
- C. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Owner's Representative for each individual area. Repairs made shall be in accordance with ACI 301.

3.9 SCHEDULE - CONCRETE TYPES AND TEST REQUIREMENTS

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- A. Class A concrete shall include concrete for tunnels, chases, vaults, manholes and other tunnel system components:
- B. Class B concrete shall include concrete for retaining walls, power plant slabs on grade, exterior stairs, ramps, and other miscellaneous structures:
- C. Class C concrete shall include concrete for flowable fill for backfill at over-excavation in rock:

Table 1 – Concrete Proportioning and Testing Requirements

Concrete Class	A	B	C
Materials and Proportions			
Cement, ASTM C 150	Type I/II	Type I/II	Type I/II
Supplementary Cementitious Materials, <i>cm</i>	50% max [†]	50% max [†]	No limit
Maximum Aggregate Size	1 inch	1 inch	3/8-inch
Water-cementitious materials ratio, <i>w/cm</i>	0.40 max	0.40 max	No limit
Prequalification Requirements			
Aggregates	ASTM C 1260	ASTM C 1260	
Slump - ASTM C 143	6 to 8 in.	>6 in.	>8 in.
Chloride Content – ASTM C 1152	< 0.20% wt of cement	< 0.20% wt of cement	Not required
Air Content - ASTM C 231	Not required	5.5% to 7.5%	Not required
Hardened Air Content - ASTM C457	Not required	> 5%	Not required
28 day Strength - ASTM C 39	$f'_c = 5000$ psi	$f'_c = 4500$ psi	$f'_c = 700$ psi
Drying Shrinkage - ASTM C 157	≤ 0.04%	Not required	Not required
28 day Permeability – ASTM C 1202	≤1500 Coulomb	Not required	Not required
Permeability			≥ 0.4 cm/sec
Field Testing for Process Control			
Slump - ASTM C 143	6 to 8 in. at point of placement	>6 in. at point of placement	>8 in. at point of placement
Air Content - ASTM C 231	Not required	5.5% to 7.5%	Not required
28 day Strength - ASTM C 39	$f'_c = 5000$ psi	$f'_c = 4500$ psi	$f'_c = 700$ psi
28 day Permeability – ASTM C 1202	≤1500 Coulomb	Not required	Not required

[†] Maximum combined supplementary materials content of ternary or quaternary blends.

Limitations on supplementary materials shall include quantities contained in blended cement. Fly ash content shall not exceed 25%. Ground granulated blast-furnace slag content shall not exceed 45%. Silica fume content shall not exceed 10%.

END OF SECTION

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