SP-151111
(New)

SPECIAL PROVISIONS FOR SHOTCRETE

Polk County
EDP-PA26(001)--7Y-77

Effective Date
December 21, 2021

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

151111.01 DESCRIPTION.

A. General.

This work consists of constructing pneumatically applied concrete (both shotcrete and plaster) onto designated surfaces at locations and thicknesses with the lines and dimensions shown on the plans or as designated by the Engineer. Shotcrete shall be used in all locations identified as Sculpted Concrete, Type II and optionally for Sculpted Concrete, Type I.

Inform Engineer at least 2 weeks in advance of time and places at which Contractor intends to place pneumatically applied concrete. All preparation work for concrete placements shall be substantially completed at least 2 workdays prior to the scheduled start of concrete placement to allow for the Engineer's review and any necessary corrections.

B. Related Work Specified Elsewhere:

- Special Provision for In-River Structural Concrete
- Special Provision for In-River Concrete Forming
- Special Provision for Sculpted Concrete
- Special Provision for Rock

C. Referenced Standards

The following Reference Standards are referred to in this specification and declared to be part of this Specification:

ACI 301 Specification for Structural Concrete for Buildings, paragraph 5.7.1 and Chapter 9.
SSPC-SP6 Surface Preparation Specification No. 6, Commercial Blast Cleaning

ASTM
A 185 Specification for Wire Fabric, Plain, Welded Steel for Concrete Reinforcement
A 615 Specification for Bars, Deformed and Plain, Billet-Steel, for Concrete Reinforcement
A 820 Specifications for Steel Fibers for Fiber Reinforced Concrete

C 31 Practice for Making and Curing Concrete Test Specimens in the field.
C 33 Specification for Concrete Aggregates
C 94 Specification for Ready-Mixed Concrete
C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars
C 150 Specification for Portland Cement
C 171 Specification for Sheet Materials for Curing Concrete
C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
C 330 Specification for Lightweight Aggregates for Structural Concrete
C 595 Specification for Blended Hydraulic Cements
C 618 Specification for Fly Ash and Raw or Calcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete
C 642 Test Method for Specific Gravity, Absorption, and Voids in Hardened Concrete
C 685 Specification for Concrete made by Volumetric Batching and Continuous Mixing
C 856 Standard Practice for Petrographic Examination of Hardened Concrete
C 989 Specification for Ground Granulated Blast-Furnace Slag for use in Concrete and Mortars
C 1116 Specification for Fiber-Reinforced Concrete and Shotcrete
C 1140 Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels
C 1141 Standard Specification for Admixtures for Shotcrete
C 1480 Standard Specification for Packaged, Pre-Blended, Dry, Combined Materials for Use in Wet or Dry Shotcrete Application
C 1604 Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete

D. Submittals

The following documents and shop drawings shall be submitted in accordance with project specifications. Shotcrete shall not be placed on the project before the submittals have been reviewed and approved by the Engineer.

1. Mix Design: A shotcrete mix design meeting the requirements of Special Provisions for In-River Structural Concrete.

2. Shotcrete Application Method Statement: The Shotcrete Application Method Statement shall be a wet-mix process and shall include drawings and notes describing equipment, procedures and sequences for shotcrete production, application, curing plan, and applicable manufacturer's literature and recommendations. The Shotcrete Application Method Statement shall also include written documentation that verifies the qualifications of the nozzlemen that will be performing the work. All nozzlemen shall have had at least 1 year of experience in the application of shotcrete and hold a current certification for ACI Shotcrete Nozzleman for the methods and orientations to be used.

3. Sculpted Concrete Applications: Where Sculpted Concrete is specified or shown on the plans, the Contractor shall submit in accordance with Special Provisions for Sculpted Concrete.

E. Quality Assurance

1. Preconstruction Testing (Shotcrete Quality): Onsite preconstruction testing shall be completed by the Contracting Authority. The Contractor shall provide all materials, labor and equipment to produce test panels in accordance with this special provision.
   a. Prepare preconstruction test panels for examination by Engineer prior to job shotcrete placement. Preparation and testing shall comply with ASTM C 1140.
   b. Produce test panels for each proposed mix proportion, each anticipated shooting orientation, and each proposed nozzleman. Mixes shall meet requirements of Article SP-151111.02, A. In half of the test panels provide reinforcement of the same size and spacing required for the work. Obtain six test specimens from each panel, three nonreinforced specimens and three with reinforcing steel.

c. Test the nonreinforced specimens for compliance with the specified physical properties in accordance with ASTM C 1604.
d. Visually grade the reinforced specimens for compliance with specified core grade (SP-151111.01, E – Shotcrete Core Grades).
e. Test admixtures for compatibility with cement in accordance with ASTM C 1141.
f. Unless otherwise specified, only nozzlemen with a test panel mean core grade less than or equal to 2.5 shall be allowed to place job shotcrete. When the prequalification test panel is rejected, a second panel may be shot. If the nozzleman's second mean core grade is greater than 2.5, the nozzleman shall not be permitted to shoot on the project.

2. Construction Testing (Shotcrete Quality): Construction testing will be completed by the Contracting Authority. The Contract Authority reserves the right to test all panels or a reduced number (i.e. every other) based on results of previous tests.
a. Produce a material test panel for each mix and each workday or every 50 cubic yards placed, whichever is less. Test panels shall be produced in accordance with ASTM C 1140 with a minimum size of 18 inches by 18 inches. Test panels shall be constructed in the same manner as that being used on the project, including distance from nozzle, angle and orientation. Test panels shall be cured in similar conditions to what is anticipated in the field and shall be field cured until test specimens are taken. Test specimens from test panels in compliance with ASTM C 1140.
b. The field compressive strength shall be determined from at least three test specimens from each test panel in accordance with ASTM C 1140 and tested at 28 days. The mean compressive strength of a set of three cores shall equal or exceed the required compressive strength with no individual core less than 0.85 of the required compressive strength.
c. The Contractor shall remove and replace shotcrete that exhibits segregation, honeycombing, de-lamination, voids, sand pockets, excessive cracking, or does not meet the specified material properties, at the Contractor's expense. If there is a dispute between the Contractor and Engineer in regard to the quality of in-place shotcrete, the following procedure shall be applied:
1) Three cores shall be taken for each 100 square feet of shotcrete identified with defects in accordance with ASTM C 1604 at locations designated by the Engineer. The shotcrete shall be at least 28 days old. Cores containing reinforcing steel shall not be tested.
2) Cores will be immediately tested for compressive strength. A core break during coring operations such that it cannot be tested in accordance with ASTM C 1604 will be assigned a compressive strength of 0 psi.
3) If a set of cores does not produce an average compressive strength equal or in excess of the required compressive strength (28 day), the shotcrete represented by the cores shall be removed and replaced at the Contractor's expense.
4) All costs associated with coring and testing shall be at the Contractor's expense, regardless of the outcome.
5) The Contractor shall patch areas used for sampling and testing immediately after samples have been removed in accordance with Chapter 9 of ACI 301. Do not fill holes by shooting.

F. Shotcrete Core Grades:

1. Grade 1: Shotcrete specimens are solid; there are no laminations, sandy areas or voids. Small air voids with a maximum diameter of 1/8 inch and maximum length of ¼ inch are normal and acceptable. Sand pockets, or voids behind continuous reinforcing steel are unacceptable. The surface against the form or bond plane shall be sound, without a sandy texture or voids.

2. Grade 2: The core shall have no more than two laminations or sandy areas with dimensions not to exceed 1/8 inch thick by 1 inch long. The height, width and depth of void shall not exceed 3/8 inch. Porous areas behind reinforcing steel shall not exceed ½ inch in any direction except

along the length of the reinforcing steel. The surface against the form or bond plane shall be sound, without a sandy texture or voids.

3. Grade 3: The core shall have no more than two laminations or sandy areas with dimensions exceeding 3/16 inch thick by 1¼ inch long, or one major void, sand pocket, or lamination containing loosely bonded sand not to exceed 5/8 inch thick and 1¼ inch in width. The surface against the form or bond plane may be sandy with voids containing overspray to a depth of 1/16 inch.

4. Grade 4: The core shall meet, in general, the requirements of Grade 3 cores, but may have two major flaws such as described for Grade 3 or may have on flaw with a maximum dimension of 1 inch perpendicular to the face of the core with a maximum width of 1½ inch. The end of the core that was shot against the form may be sandy and with voids containing overspray to a depth of 1/8 inch.

5. Grade 5: A core that does not meet the criteria of core Grade 1 through Grade 4, by being of poorer quality, shall be classified as Grade 5.

6. Determination of grade shall be by computing the mean of a minimum of 3 test specimens.

7. A mean grade of 2.5 or less is acceptable unless otherwise specified. Individual shotcrete cores with a grade greater than 3 are unacceptable.

8. The above core grades are based on cores with a surface area of 50 square inches. For cores with greater or lesser area than 50 square inches, adjust allowable flaws relative to 50 square inches.

G. Acceptance

1. Acceptable shotcrete shall consist of a dense and uniform mixture without rebound, inclusions, segregations, or discernible weakness of bond between the rock or structure and the shotcrete. Acceptance will be based on the requirements of this Special Provision and the visual inspection and sounding of the shotcrete.

2. Shotcrete that exhibits movement or settlement after placement while still in the plastic state shall be repaired or replaced at the Contractor's expense.

3. Shotcrete work that meets applicable requirements will be accepted by the Engineer.

4. Shotcrete work that has previously failed to meet one or more requirements, but which has been repaired to bring it into compliance, will be accepted by the Engineer.

5. Shotcrete work that fails to meet one or more requirement and which cannot be brought into compliance may be accepted or rejected by the Engineer. Modifications may be required to assure that remaining work complies with the requirements.

151111.02 MATERIALS.

A. Concrete Materials:

1. Shotcrete and plaster materials, proportioning and placement shall comply with the requirements of ACI 506.2, "Specifications for Materials, Proportioning and Application of Shotcrete", the requirements of Special Provisions for In-River Structural Concrete, and as modified below in this Special Provision.

2. Prepackaged material shall meet the requirements of ASTM C1480 and meet the sulfate resistance requirements indicated in Special Provisions for In-River Structural Concrete.

3. **Strength and General Requirements.**
Design and proportion Shotcrete and plaster materials shall meet the following minimum compressive strengths and other criteria:

Location	Aggregate Size (Inch)	Design Strength 28 Day (psi)	Required Strength 7 Day (psi)	Minimum Cement Content* (lbs/yd)	Flyash Content %	Air Content % Range (Total)	Maximum Water Cement Ratio*
Shotcrete**	1/2	4,500	3,000	N/A	20 max.	7-10***	0.38
Plaster**	3/8 max.	4,500	3,000	N/A	20 max.	7-10***	0.38

*The maximum water-cementitious materials ratio by weight, which shall be based on all water in the mix, including correction for moisture in aggregates, and shall be based on the total cementitious materials including cement and fly ash.
**Add fibrous reinforcement. See Admixtures in the Special Provisions for In-River Structural Concrete.
***Prior to pumping.

4. Admixtures shall meet the requirements of Special Provisions for In-River Structural Concrete.
   a. Admixtures for use in shotcrete shall meet the requirements of ASTM C 1141.
   b. Integral Color Additives for shotcrete, where indicated on the plans, shall be in accordance with Special Provisions for Sculpted Concrete.

B. Reinforcement: Reinforcement for shotcrete shall be in accordance with Special Provisions for In-River Structural Concrete. Plaster shall not be reinforced.

C. Concrete Accessory Materials: Accessory materials for shotcrete shall be in accordance with Special Provisions for In-River Structural Concrete.

D. Sealants and Curing Materials: Sealants and curing materials for shotcrete shall be in accordance with Special Provisions for In-River Structural Concrete.

151111.03 CONSTRUCTION.

A. General:

1. Shotcrete shall be applied at the locations and to the thicknesses shown on the plans. The thickness of shotcrete shall not be less than the dimensions shown on the plans.

2. For rock and soil cuts, surfaces shall be prepared to the line and grade shown on the plans. The Contractor shall provide documentation, including survey data, to show that the excavated face conforms to the plans so that the minimum thickness is achieved. If the Engineer determines that irregularities are excessive, additional reinforcing may be required. All costs associated with additional shotcrete required to bring an over excavated cut to the proper line and grade shall be borne by the Contractor. The Contractor shall fill all voids, holes, and pits created during the excavation process. Where additional shotcrete in excess of the plan thickness is required to make the final shotcrete face conform to the plans, the Contractor shall provide a plan and method statement for applying the additional shotcrete. The work shall not proceed until the proposed plan and methods have been reviewed and approved by the Engineer.

B. Batching and Mixing:

1. Per Special Provisions for In-River Structural Concrete.

2. Shoot shotcrete materials within 90 minutes after batching.

C. Surface Preparation:

1. General: Do not apply shotcrete to frozen surfaces. De-icing compounds shall not be used to thaw ice, snow, or frost.

2. Earth: Prepare surfaces to line and grade. Dampen surface immediately prior to shooting.

3. Concrete, Masonry, and Shotcrete: When bonding is required, remove all deteriorated, loose, unsound material or contaminants that may inhibit bonding. Chip areas to be repaired to remove offsets causing abrupt changes in thickness. Taper edges to eliminate square shoulders at the perimeter of a cavity. Surfaces shall be a saturated surface dry condition immediately prior to shooting.

   When multiple layers of shotcrete are to be applied, each layer of shotcrete shall be cleaned. If curing compound is used, the curing compound shall be removed by sandblasting or a method approved by the Engineer.

4. Structural/Reinforcement: The surface shall be free of deleterious materials that inhibit bonding. For new construction, reinforcement laps shall be separated with a clearance of at least three times the diameter of largest aggregate. Reinforcement shall be secured to prevent movement. Existing rebar and metals shall be sandblasted clean prior to shotcrete placement.

5. Rock: Remove loose material, mud, or other foreign material that will prevent bonding. Clean surface. Pre-wet surface and apply epoxy immediately prior to shooting.

6. Forms: Use form-release coating material on removable forms. Secure forms to minimize the effects of vibration. Construct forms to allow escape of placement air and rebound.

D. Joints:
Taper construction joints at a 1 to 1 slope where joint is not subject to compression loads. Surface preparation of joints shall comply with Article SP-151111.03, C.3. Continue reinforcement through construction joint.

E. Alignment Control: Install taut ground wires or other means to establish thickness and plane of required surface. Install taut ground wires or other means at corners of offsets not established by forms.

F. Application:

1. Placement Techniques: Provide a platform that permits nozzleman unobstructed access to the receiving surface. Place shotcrete first in corners, recesses, and other areas where rebound and overspray cannot escape easily. Remove rebound and overspray from previously prepared surfaces prior to shotcrete placement.

   Place shotcrete with nozzle held approximately perpendicular to the receiving surface. In corners, direct nozzle at approximately 45 degree angle or bisect the corner angle. Apply shotcrete so sags or sloughing do not occur. Discontinue shooting or shield the nozzle stream if wind causes separation of ingredients during shooting.

   Do to reuse rebound or overspray. Remove laitance from shotcrete surfaces to receive additional shotcrete layers. Surface preparation after final set shall comply with Article SP-

151111.03, C.3. Do not apply shotcrete on surfaces with standing water from adjacent surfaces, including exposed reinforcement.

2. Encasement of Reinforcement: Place shotcrete to completely encase reinforcing steel. Encase reinforcement by shooting with enough velocity and plasticity so material flows around and behind the reinforcement. Front face of reinforcement shall remain clean during encasement.

Place shotcrete to provide the cover over reinforcement required by ACI 301. Minimum slump of shotcrete is 1 inch.

3. When reinforcing fibers are required, the fibers shall be uniformly dispersed in the shotcrete. Production shall be suspended when visible fiber clumps are observed.

G. Finishes:

Surface finishes for shotcrete shall be as indicated on the plans and shall meet the following requirements:

1. Unfinished (Gunned Finish): Finished surface created from the shotcrete process with no additional finishing work.

2. Sculpted Concrete: See Special Provisions for Sculpted Concrete.

H. Curing:

1. Per requirements of Special Provisions for In-River Structural Concrete.

2. Natural curing shall be permitted if ambient relative humidity is maintained above 95%.

3. Curing method shall be compatible with and not cause any discoloration or damage to surface finishes and color treatments.

4. The following procedures shall be followed if the temperature of the shotcrete structure falls below 32°F before the minimum curing period is complete:

- **a.** Cores shall be taken following the procedures of ASTM C 1604 at locations designated by the Engineer.
- **b.** The Engineer will take immediate possession of the cores and submit the cores for a petrographic examination in accordance with ASTM C 856.
- **c.** All costs associated with coring, transmittal of cores, and petrographic examination shall be borne by the Contractor regardless of the outcome of the petrographic examination.
- **d.** Shotcrete damaged by frost as determined from petrographic examination shall be removed and replaced at the Contractor's expense.
- **e.** The Contractor shall patch areas used for sampling and testing immediately after samples have been removed.

I. Cold/Hot Weather Shotcreting:

1. Cold and hot weather shotcreting shall be performed per requirements of Special Provisions for In-River Structural Concrete.

2. Do not place shotcrete when material temperature is above 90°F.

3. Shooting may proceed when ambient temperature is 40°F and rising. 50°F for latex modified shotcrete. Shooting shall be discontinued when ambient temperature is 40°F and falling unless protective measures are taken to protect shotcrete. Shotcrete shall not be placed against frozen surfaces.

J. Protection:

1. Protect surfaces not intended for shotcrete placement against deposit of rebound and overspray or impact from nozzle stream.

2. Remove rebound and hardened overspray from final shotcrete surfaces and from areas not intended for shotcrete placement.

K. Tolerances: Thickness of shotcrete as indicated on the Plans shall be a minimum.

151111.04 METHOD OF MEASUREMENT AND BASIS OF PAYMENT.

Shotcrete will be measured and paid per Special Provisions for Sculpted Concrete.