

SECTION 03371

SHOTCRETE

PART 1 - GENERAL

1.01 SUMMARY

- A. Provisions of Division 01 apply to this section
- B. Section Includes:
 - 1. Pneumatically placed concrete.
- C. Related Sections:
 - 1. Section 03300: Cast-In-Place Concrete.

1.02 SYSTEM DESCRIPTION

- A. Regulatory Requirements: Comply with CBC requirements, Section 1913A.

1.03 SUBMITTALS

- A. Shop Drawings: Submit Shop Drawings indicating locations to receive shotcrete. Provide details of installation and reinforcement.
- B. Product Data: Submit detailed product information identifying types and quality of materials, including admixtures.
- C. Mix Design Data:
 - 1. Submit name, address and telephone number of the concrete production facility which the contractor intends to engage to design the shotcrete mixes. Submit name and qualifications of the proposed concrete technologist. Mix shall be signed and sealed by a Civil or Structural Engineer currently registered in the State of California.
 - 2. Mix Design: Submit a mix design for each strength and type of shotcrete indicated in the drawings or specified. Include water/cement ratio, source, size and amount of aggregates and admixtures. Predict minimum compressive strength, maximum slump and air content percentage. Clearly indicate locations where each mix design will be used.
 - 3. Test Reports: Submit copies of test reports showing that the proposed mixes produce shotcrete with the strengths and properties specified. Include tests for cement, aggregates and admixtures. Provide gradation analysis.

1.04 QUALITY ASSURANCE

A. American Concrete Institute (ACI):

1. ACI 506.2 - Specification for Materials, Proportioning and Application of Shotcrete.
2. ACI 506.3R - Guide to Certification of Shotcrete Nozzlemen.

B. American Society for Testing and Materials (ASTM):

1. ASTM C33 - Standard Specification for Concrete Aggregates.
2. ASTM C42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
3. ASTM C150 – Standard Specification for Portland Cement.
4. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete.
5. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
6. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
7. ASTM C989 - Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.
8. ASTM C1140 - Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels.
9. ASTM C1141 - Standard Specification for Admixtures for Shotcrete.
10. ASTM C1240 - Standard Specification for Silica Fume Used in Cementitious Mixtures.
11. ASTM C1604 - Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete.

B. Qualifications of Installer:

1. Work shall be performed by a firm with a minimum of three years in the application of shotcrete.
2. Nozzle operators shall be certified in the application of shotcrete per ACI 506.3R.

C. Mock-ups:

1. Test Panels: Construct a test panel representative of the project and simulate job conditions as closely as possible. The panel thickness and reinforcing shall

reproduce the thickest and most congested area specified in the structural design. It shall be shot at the same angle, using the same nozzleman and with the same concrete mix design that will be used on the project. The equipment used in constructing the test panels shall be the same equipment used in the construction. Test panel shall be at least 4 feet by 4 feet.

2. Strength Tests: Cores from the panel will be taken for testing in accordance with ASTM C1140 to determine the compressive strength of the shotcrete. Test results to be acceptable shall meet the acceptance criteria of CBC Section 1913.A.10.3.
3. Application of shotcrete in the Work shall not proceed until test results are accepted by the Architect.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Ensure materials and surrounding air temperature are a minimum 50 degrees F. prior to, during, and for at least 7 days after completion of Work.
- B. During freezing or near freezing weather, provide equipment and cover to maintain 50 degrees F. and to protect Work completed or in progress.
- C. Suspend installation during high winds, rainy weather, or low temperature when Work cannot be protected.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Cement: ASTM C 150 Type II, low alkali.
- B. Aggregate: ASTM C33 normal weight aggregate with combined gradation of coarse and fine aggregates conforming to ACI 506.2,
 1. Coarse aggregate shall not exceed 3/4 inch.
- C. Fly ash, pozzolan and ground granulated blast-furnace slag:
 1. Fly ash or other pozzolan shall conform to ASTM C618 for Class N or F materials. [] per cent by weight of fly ash or other pozzolans shall substitute for ASTM C 150 Portland cement.
 2. Ground-granulated blast-furnace slag shall conform to ASTM C989. [] per cent by weight of ground-granulated blast-furnace slag shall substitute for ASTM C 150 Portland cement.
 3. Silica Fume shall conform to ASTM C1240. [] per cent by weight of silica fume shall substitute for ASTM C150 Portland cement.
- D. Water: Clean and potable and free from deleterious matter.

- E. Admixtures: Shall comply with ASTM C1141 and shall be compatible with the cement and produce no deleterious effects.
- F. Reinforcing Steel: Refer to Section 03200, Concrete Reinforcement.
- G. Curing Paper and Liquid Curing Compounds Not detrimental to application of subsequent surface finish materials.
 - 1. Curing Paper: Conforming to ASTM C171, waterproof paper, polyethylene film or white burlap-polyethylene sheet, non-staining.
 - 2. Liquid Curing Compounds: A standard brand, clear liquid conforming to ASTM C309 and providing no detrimental effects to finish surface, Master Builders, Grace, Antihydro, Creteseal, or equal.
- H. Reinforcement Fibers: Chop strands of alkali-resistant polypropylene or nylon fibers added to the concrete mix for protection against shrinkage cracks.

2.02 SHOTCRETE MIX

- A. Conform to following requirements:
 - 1. Compressive strength as indicated on Drawings; 28 day minimum. Compressive strength shall in no case be less than 3,000 psi.
 - 2. Slump: 2 inches maximum.
- B. Thoroughly mix shotcrete. Apply mix within 45 minutes.
- C. Develop mix design to provide compaction and low percentage of rebound, but stiff enough not to sag.
- D. Maintain quality control records during production of shotcrete. Submit records to the Architect.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surfaces to receive shotcrete and verify unsuitable conditions have been corrected before proceeding. Verify that field conditions are acceptable and are ready to receive Work.
- B. Verify fabricated forms are true to line and dimension, adequately braced against vibration, and constructed to permit escape of air and rebound during installation.
- C. Ensure correct placement of reinforcement. Provide sufficient clearance around reinforcement to permit complete encasement.
- D. Provide safe access to shotcrete surfaces for screeding and finishing, to permit uninterrupted application.

3.02 PREPARATION

- A. Remove existing unsound concrete from substrate surfaces by chipping.
- B. Minimize abrupt changes in thickness of repair. Remove square external corners from substrate by rounding the edge.
- C. Sandblast existing surfaces that do not require chipping to remove oil, grease, and other contaminants, and to provide a roughed surface for proper bonding of the material.
- D. Determine operating procedures for placement in close quarter, extended distances, or around unusual obstructions where placement velocities and mix consistency must be adjusted.
- E. Clean and wet cementitious surfaces prior to installation. Maintain porous surfaces damp for several hours before installation. Do not install when there is visible free water present.

3.03 BATCHING AND MIXING

- A. Shotcrete mixes shall be proportioned, batched and transported to assure complete mixing. Truck mixers shall be charged to not more than 75 percent of their rated capacity. Mixes shall be batched to provide a maximum slump at the mixer at time of discharge. Water may be added at the Project site but in no case may the maximum slump at the pump be exceeded..
- B. Thoroughly mix cement and aggregate for at least one minute before adding water.

3.04 APPLICATION

- A. Install with suitable delivery equipment and procedures that will result in meeting the requirements of the Drawings and Specifications. Whenever possible, except when enclosing reinforcing steel, the nozzle shall be held at right angles to the surface to be placed and at a distance from 30 inches to 36 inches. When enclosing reinforcing steel, the nozzle shall be held so as to direct the material behind the bars. Each side of each bar shall be installed separately. Any deposits of loose sand or rebound shall be installed separately. Any deposits of loose sand or rebound shall be carefully removed from surfaces before material is installed. A second experienced nozzle operator equipped with an air jet shall attend the operator whenever reinforcing steel is being enclosed and shall carefully precede the nozzle and blow out rebound and sand which may have lodged behind the steel. Horizontal members shall not be installed from the top unless special methods are specified to eliminate rebound. The use of "puddled" shotcrete in which the water content of the mix is increased to facilitate the installation in difficult locations is not permitted. Shotcrete shall not be installed where the stream from the nozzle cannot directly impinge on the surface on which the shotcrete is to be installed.
- B. No rebound material shall be installed in the Work.
- C. The film of laitance, which forms on the surface of the shotcrete, shall be removed within approximately 2 hours after installation by brushing with a stiff broom. If this film is not removed within 2 hours, it shall be removed by wire brushing or sand

blasting. Construction joints over 8 hours old shall be thoroughly cleaned before the installation of shotcrete.

- D. Damage: Pneumatically placed concrete subsiding after installation shall be removed and replaced. Rebound pockets, sags, sloughing or other defects shall be cut out and replaced.
- E. Surfaces to receive shotcrete shall have their entire surface thoroughly cleaned and roughened by sand blasting. Concrete shall be wetted before shotcrete is installed, but not so wet as to inhibit the installation. Sand for sand blasting shall be clean, sharp and uniform size, with no particles that will pass a 50 mesh screen.
- F. Reinforcement: Before installing shotcrete around or upon reinforcement, reinforcement shall be thoroughly cleaned of grease, oil, paint, loose mill scale, heavy rust and hydrated concrete.
- G. Reinforcing shall be supported and secured in place in such a manner that resulting vibrations from shotcrete installation will not damage and or dislodge reinforcing.
- H. Walls: Where structural wet mix shotcrete is to be installed to walls, minimum spacing of reinforcing steel shall be 6 bar diameters for walls with one curtain of steel. Where 2 curtains of steel are provided, curtain nearest nozzle shall be provided with a minimum spacing of 12 bar diameters and remaining curtain shall be provided with a minimum spacing of 6 bar diameters. Reinforcing steel shall be provided with a minimum of 3 bar diameters at splices. Minimum clear distance between reinforcing bars, other than mesh, shall be a minimum of 3 times maximum aggregate size.
 - 1. Non-contact, back to back splices shall be provided for bars larger than No. 5.
- I. Shotcrete forms shall be substantial and rigid. Forms shall be fabricated and installed to permit the effects of rebound.
 - 1. Rigid or other required backing shall be installed against earth during application of wet mix shotcrete. Rigid or other required backing shall be provided where a void in embankment is to be bridged. Forms to be provided where required.
- J. Line and Thickness Control: Provide adequate wires or other required means to establish thickness, surface planes, and finish lines of shotcrete. Maintain specified tolerances by maintaining wires secure and taut.
- K. Placement Precautions: Do not install shotcrete if hydrating or stiffening of mix takes place at any time before delivery to nozzle.
- L. The height of a layer shall be limited to not more than 3 feet and a succeeding layer shall not be installed in less than 3 hours. Sloughing or sagging is not permitted.

3.05 FINISHING

- A. Install to a true, even surface by floating or rodding and providing a [wood float] finish to surfaces. Finish surfaces shall be within a tolerance of 1/8 inch in 10 feet. Finish to match existing conditions.

3.06 CURING AND PROTECTING

- A. Initial Curing: Immediately after finishing, maintain shotcrete continuously moist for at least 20 days by one of the following materials or methods:
 - 1. Continuous sprinkling.
 - 2. Absorptive mat or other covering maintained continuously wet.
- B. Final Curing: Provide additional curing immediately following the initial curing and before shotcrete has hydrated with one of the following materials or methods:
 - 1. Continue the method provided for initial curing.
 - 2. Material conforming to ASTM C171.
- C. Duration Of Curing. Maintain curing for the first 14 days after installation. During the curing period, maintain shotcrete above 40 degrees F. and in a moist condition as specified previously. Prevent rapid drying at end of curing period.

3.07 FIELD QUALITY CONTROL

- A. Shotcrete Work shall be continuously inspected during installation. A special inspector approved by DSA to inspect the Work of this section shall inspect the materials, placing equipment, details of construction, and construction procedure. The IOR shall be responsible for monitoring the work of the special inspector and testing laboratories to ensure that the testing program is satisfactorily completed.
- B. No less than 2 cores each day shall be obtained from the Work at locations designated by the special inspector. At least one core shall be obtained for each 50 cubic yards of shotcrete. Cores shall be tested at approximately 28 days. Cores shall be 4 inches in diameter or larger. In addition, cores shall be obtained from 2 test panels each day. Test panels must be correlated with locations of wall being installed at same time as test panels.
- C. The special inspector shall observe coring operations and will prepare a report of coring operations for the testing laboratory.
- D. Obtain representative core samples in accordance with CBC requirements, and test in accordance with ASTM C42 and ASTM C1140.
- E. Remove and replace shotcrete which lacks uniformity, exhibits segregation, honeycombing, or lamination, or which contains any dry patches, slugs, voids, or sand pockets.
- F. Remove and replace damaged shotcrete which cannot be satisfactorily repaired.
- G. Repair core holes in accordance with Chapter 9 of ACI 301. Do not fill core holes with shotcrete. Repair holes with non-shrink non-staining concrete.

3.08 PROTECTION

- A. Before installation, protect interior and exterior trim, sash, doors, transoms, floors, ceilings and equipment. Debris shall be immediately cleaned up after installation but not less than once each day.
- B. Protect the Work of this section until Substantial Completion.

3.09 CLEANUP

- A. Remove rubbish, debris, and waste materials and legally dispose of off the Project site.

END OF SECTION