

SECTION 03 37 13
SHOTCRETE

SPEC WRITER NOTE: Delete between //---//
if not applicable to project. Also delete
any other item or paragraph not applicable
in the section and renumber the
paragraphs.

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the requirements for materials, proportioning, and application of shotcrete using either dry-mix or wet-mix process.

1.2 DEFINITION

Mortar or concrete pneumatically projected at high velocity onto a surface; also known as air-blown mortar; also pneumatically applied mortar or concrete, sprayed mortar and gunned concrete.

1.3 RELATED WORK

- A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.
- B. Formwork and reinforcement: Section 03 30 00, CAST-IN-PLACE CONCRETE.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Design Mix: Test Reports and Proportions.
- C. Shop Drawings: Reinforcing Steel.
- D. Two 300 mm x 300 mm x 25 mm (12 inch by 12 inch by 1 inch) sample panels showing required finish. Submit panels within 30 days after receipt of notice to proceed.
- E. Aggregate gradation.
- F. Certificates: Contractor's qualifications as specified.

1.5 QUALITY CONTROL

- A. Contractor Qualifications.
 - 1. Work in this section shall be provided only by a Contractor specializing in and possessing the equipment, knowledge, and skilled operators for application of shotcrete.
 - 2. Furnish evidence to Resident Engineer that Contractor conforms to above requirements, has been specializing in this work for a period of at least five years, and will use only experienced shotcrete foremen, nozzle men and delivery equipment operators on the work.
 - 3. Conform to ACI 506R, Paragraphs 4.2 and 4.3, for qualifications and duties of craftsmen.
- B. Tolerances:
 - 1. Cover of reinforcement: ACI 506.2, Paragraph 3.6.2.

2. Alignment and thickness of shotcrete shall be controlled by installing ground wires. Alignment and thickness control shall conform to ACI 506R Section 5.6.

1.6 PRECONSTRUCTION TESTING

- A. Conform to the requirements of ACI 506R, Paragraph 6.4.
- B. Testing laboratory approved by the Resident Engineer and reimbursed by Contractor shall design dry or wet mix, as applicable, to produce compressive strengths indicated on drawings.
- C. Make 2 test panels for each mix design, 450 mm (18 inches) square and 75 mm (3 inch) minimum thickness. Take 5 cores or cubes from each 75 mm (3 inch) panel for compressive strength testing in accordance with ACI 506R, Paragraph 6.4.

SPEC WRITER NOTE: Tests of modulus of rupture, absorption, drying shrinkage, resistance to freeze-thawing along with others may also be specified depending on the application.

Using the proposed mix design make at least two job-site sample panels approximately 2400 mm (8 feet) high and 1800 mm (6 feet) wide with thicknesses shown. The job-site panels shall contain reinforcing typical of the work to be installed and other details to simulate actual job conditions. Finish sample panels as required for work to be installed. Sample panels must be approved by the V.A. before any work can begin.

1.7 CONSTRUCTION TESTING

- A. Make one test panel 450 mm (18 inches) square and 75 mm (3 inches) thick for each half-day's work or portion thereof. Provide test panels to a testing laboratory approved by Resident Engineer and reimbursed by the contractor. Five compressive strength specimens will be obtained from each panel and tested for compressive strength in accordance with ASTM C42. Two (2) samples are to be tested at 7 days and 28 days after application. The fifth sample should be retained for 56 days should additional testing be required. Strength test results are to be reported to the Resident Engineer 24 hours after completion of test.

1.8 DELIVERY, HANDLING, AND STORAGE

- A. Properly deliver and handle materials to prevent contamination, segregation, or damage to materials.
- B. Store cement in weathertight enclosures to protect against dampness and contamination.
- C. Prevent segregation and contamination of aggregates by proper arrangement and use of stockpiles.

- D. Store admixtures properly to prevent contamination, evaporation, freezing, or other damage.

1.9 APPLICABLE PUBLICATIONS

- A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by basic designation only.
- B. American Concrete Institute (ACI):
- 214-77(1989R) Recommended Practice for Evaluation of Strength Test Results of Concrete
 - 301-96 Specification for Structural Concrete for Buildings
 - 304R-89 Guide for Measuring, Mixing, Transporting, and Placing Concrete
 - 506R-90 Guide to Shotcrete
 - 506.2-95 Specification for Materials, Proportioning, and Application of Shotcrete
 - 506.4-94 Guide for the Evaluation of Shotcrete
- C. American Society for Testing and Materials (ASTM):
- A185-94 Steel Welded Wire Fabric, Plain, for Concrete
 - A615/A615M-95 Deformed and Plain Billet Steel Bars for Concrete Reinforcement
 - C33-01 Concrete Aggregates
 - C94/C94M-00e2 Ready-Mixed Concrete
 - C150-00 Portland Cement
 - C260-00 Air-Entraining Admixtures for Concrete
 - C494-92(1998) Chemical Admixtures for Concrete

PART 2 - PRODUCTS

SPEC WRITER NOTE: Make material requirements agree with applicable requirements specified in the referenced Applicable Publications. Update and specify only that which applies to the project.

2.1 MATERIALS

- A. Portland Cement: ASTM C150, Type I or II.
- B. Aggregate: ASTM C33, Gradation Table 2.1

TABLE 2.1 -- GRADATION LIMIT FOR COMBINED AGGREGATES

Sieve Size, U.S. standard square mesh	Percent by Weight Passing Individual Sieves		
	Gradation No. 1	Gradation No. 2	Gradation No. 3
20 mm 3/4 inch	---	---	100
13 mm 1/2 inch	---	100	80-95
10 mm 3/8 inch	100	90-100	70-90
No. 4	95-100	70-85	50-70
No. 8	80-100	50-70	35-55
No. 16	50-85	35-55	20-40
No. 30	25-60	20-35	10-30
No. 50	10-30	8-20	5-17
No. 100	2-10	2-10	2-10

C. Chemical Admixtures: ASTM C494.

D. Air-entraining Admixture: ASTM C260.

E. Water: Fresh, Clean, and Potable

F. Reinforcing Steel: ASTM A615, grade as shown.

G. Welded Wire Fabric: ASTM A185.

PART 3 - EXECUTION

3.1 PROPORTIONING, DELIVERY AND MIXING

A. Proportioning: Mix shall be designed by Contractor-retained testing laboratory; see "PRECONSTRUCTION TESTING" hereinbefore. Maintain water-cement ratio between 0.35 to 0.50 by weight.

B. Mixing Processes:

1. Mixing, General: Strength of mix is specified on the drawings. At Contractor's option, use either the dry or wet mix process. Discharge entire batch before recharging. Clean mixer at least once every 8-hour shift or portion thereof. Reject material mixed and standing for 45 minutes; remixing or tempering not permitted.
2. Dry Mix Process: Conform to ACI 506R, Paragraph 1.6.1.
3. Wet Mix Process: Conform to ACI 506R, Paragraph 1.6.2.

3.2 EQUIPMENT, DRY MIX PROCESS

A. Batching and Mixing Equipment: Batch by weighing, use rotating mixer or adequate capacity for dry-mixing aggregate and cement for continuous supply of material to gun, all conforming to ACI 506R, Paragraph 3.5.

B. Delivery equipment:

1. Gun and Nozzle: Premixing type conforming to the requirements of ACI 506R, Paragraphs 3.2 and 3.7 designed for material delivery and water injection.
2. Air Compressor and Hoses: Standard type, of capacity to provide without interruption, pressures and volume of air necessary for longest hose delivery; conform to ACI 506R, Table 3.1. Make allowances for air consumed by separate blow pipe in blowing away rebound, cleaning reinforcing and incidental uses.
3. Water Supply: Conform to ACI 506R, Paragraph 3.8.1 with adequate capacity to maintain water pressure approximately 65 N (15 pounds) higher than highest air pressure required, both air and water pressure uniformly steady, non-pulsating.

3.3 EQUIPMENT, WET MIX PROCESS

- A. Batching and Mixing Equipment: ACI 506R, Paragraph 3.5. Batch by weighing; use rotating mixing equipment and mix in accordance with ACI 304R, and ASTM C94 for ready-mixed concrete.
- B. Delivery Equipment: Use pneumatic feed or positive displacement type of design and size capable of delivering premixed materials accurately, uniformly and continuously through the hose, all in accordance with ACI 506R, Paragraphs 3.3 and 3.7.
- C. Air Supply: ACI 506R, Paragraph 3.4.2.

3.4 ALIGNMENT CONTROL

- A. General: To establish thickness and surface planes or shotcrete build-up provide ground wires, taut, secure, true to line and plane, conforming to ACI 506R, Paragraph 5.6.
- B. Reinforcing Positioning: Check that reinforcing is positioned and sized all in accordance with ACI 506R, Paragraph 5.4.

3.5 EXHAUST SYSTEM

- A. Construct a sealed air barrier around immediate area of work as approved by Resident Engineer. Construct a sealed air barrier prior to any application within confines of the Medical Center.
- B. Continuously exhaust work area to outside creating a negative pressure within area. Do not locate air exhaust near any Medical Center air intakes.

3.6 SHOOTING

- A. General: ACI 506R, Paragraph 8.5.7. Shoot and fill corners first, with continuous uniform material flow from nozzle held approximately 600 mm to 1500 mm (2 to 5 feet) from the work, at angle normal to the surface.
 1. Shoot around reinforcing with nozzle close to encase reinforcement as illustrated in ACI 506R, Figure 8.4, left column.

2. If flow is not uniform and slugs, sand spots or wet sloughs result, turn nozzle away until faulty work is cut out and repaired.
 3. Do no shotcrete work if temperature is below 4⁰ C (40⁰ F) without providing continuous heat and adequate protection from freezing.
- B. Preparation of Surfaces to Receive Shotcrete: ACI 506R, Paragraph 5.2, as applicable to the work, as approved.
- C. Rebound: ACI 506R, Paragraph 8.5.10. Do not work rebound into construction nor salvage rebound for subsequent batching.
- D. Suspend application if:
1. High wind prevents nozzlemen from proper application of material.
 2. Weather approaches freezing and shotcrete cannot be protected.
 3. Rain, other than a very light sprinkle, occurs which would wash cement out of freshly placed material.
- E. Time Between Coats:
1. In sloping, vertical or overhanging work, allow interval of time sufficient for initial, but not final, set to develop.
 2. At development of initial set, lightly broom surface to remove any laitance to provide better bond with succeeding applications.
- F. Construction Joints:
1. ACI 506R, Paragraph 5.7, tapering over a width of 300 mm (1 foot) to a 25 mm (1 inch) edge from board laid flat.
 2. Before proceeding with additional shotcrete work, thoroughly clean joint and adjacent shotcrete, then wet and scour surfaces with air jet.
- G. Warm Weather Application: Prevent dryout resulting in cracking and separation by keeping surfaces continuously moist and/or covered with continuously moistened burlap for 7 days after shotcreting.
- H. Surface Finish: Bring final surfaces of shotcrete to an even plane, well formed corners either square or to radius shown, working up to ground wires using somewhat lower placing velocity than normal.
1. Remove ground wires to 20 mm (3/4 inch) back from surface and fill holes with shotcrete to adjacent surface elevations.
 2. Wood float surfaces to provide a smooth true finish.

3.7 CURING

ACI 506.2, Paragraph 3.7.

3.8 HOT WEATHER SHOTCRETING

ACI 506R, Paragraph 8.8.

3.9 COLD WEATHER SHOTCRETING

ACI 506R, Paragraph 8.9.

3.10 PROTECTION AND CLEAN-UP

- A. Protection: Protect adjacent walls, windows, doors, other building surfaces, grounds and/or shrubs and property of others from damage by shotcreting, rebound and dust.
1. Construct a sealed dust partition to confine rebound and dust to immediate work area. Dust partition shall be integral with exhaust system. A negative air pressure shall be maintained within partitioned area during shotcrete applications to prevent dust leakage beyond area.
 2. Immediately clean all shotcrete materials and remove all rebound from site.
- B. Clean-up: Continuously remove rebound material to ensure that base, intermediate, and finish surfaces are clean and ready for bonding layers.

3.11 DEFECTIVE WORK

General work will be evaluated by the Resident Engineer or designated agent in accordance with ACI 506.4. If the evaluation reveals unbonded work or cores fail to meet specified strengths, or finishes are unsatisfactory, repair such defective work, as approved, without additional cost to the Government.

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