



**SPECIAL PROVISIONS  
FOR  
SHOTCRETE**

Hardin County  
BRFN-065-6(42)--39-42

Effective Date  
July 20, 2010

**THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.**

**090080.01 DESCRIPTION.**

This work consists of constructing one course of shotcrete on a prepared rock surface.

The Contractor shall be responsible for vibration and crack monitoring during demolition/construction activities near vulnerable structures. Refer to Special Provisions for Vibration Monitoring for requirements.

**090080.02 MATERIALS.**

**A. SHOTCRETE AGGREGATE.**

1. For fine aggregate, furnish rounded particles conforming to AASHTO M 6 Class B including the reactive aggregate supplementary requirement, except as amended or supplemented by the following:
  - Material passing No. 200 sieve, AASHTO T 11 ..... 3.0 % max
  - Sand equivalent value, AASHTO T 176..... 75 min. referee method
2. For coarse aggregate, conform to AASHTO M 80 class B, except as amended or supplemented by the following:
  - Los Angeles abrasion, AASHTO T 96 ..... 40% max.
  - Combine the aggregates to meet the designated gradation in Table 1.

**Table 1: Shotcrete Gradation Limits for Combined Aggregates.**

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27)		
	Grading Designation		
	A	B	C
3/4 inch	100	100	100
1/2 inch	100	100	80-95
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

**B. REINFORCING FIBERS.**

Contractor may elect to use reinforcing deformed steel or fibrillated polypropylene fibers conforming to ASTM C 1116. The use of reinforcing fibers shall be preapproved by the Engineer.

**090080.03 CONSTRUCTION.**

**A. GENERAL.**

Conform to the following:

1. ACI 506R            Guide to Shotcrete.
2. ACI 506.1         State of the Art Report on Fiber Reinforced Shotcrete.
3. ACI 506.2         Specifications for Proportioning Application of Shotcrete.
4. AASHTO C 311    Method for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Concrete.
5. ASTM C 1077      Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.

**B. PRECONSTRUCTION SUBMISSIONS.**

Submit the following to the Engineer for acceptance at least 30 days before placing shotcrete:

1. Description of proposed equipment for mixing and applying shotcrete conforming to Subsection 2.03. Include the manufacturer instructions, recommendations, literature, performance, and test data.
2. Proposed shotcrete mix design conforming to these Special Provisions with mix proportions.
3. Representative samples of shotcrete material, if requested by the Engineer.
4. Results of all shotcrete preconstruction testing conforming to these Special Provisions.
5. Proposed method for applying and curing shotcrete conforming to these Special Provisions.
6. Other information necessary to verify compliance with ACI 506.2.
7. Certification that shotcrete conforms to the standards specified herein.
8. Fiber samples, if used, with supplier or manufacturer recommendations for use.
9. *Project references.* Include project name, owner's name, and phone numbers from at least 3 projects of comparable nature completed in the last 2 years.
10. *Nozzle operator's experience and training.* For each nozzle operator, include shotcrete application experience on at least two projects of comparable nature.

11. *Shotcrete supervisor experience.* Include direct shotcrete application experience on comparable projects.
12. *Testing laboratory certification.* Include documentation that the strength-testing laboratory complies with ASTM C 1077 and has the experience to perform the tests specified in this Section. The testing laboratory shall be AASHTO accredited for ASTM C 1077 or demonstrate the ability to perform the requisite tests.

### C. EQUIPMENT.

#### 1. WATER SUPPLY SYSTEM:

For dry mix, provide a water storage tank at the job site. Provide a positive displacement pump with a regulating valve that is accurately controlled to provide water in the pressures and volumes recommended by the delivery machine manufacturer.

#### 2. MIXING:

Use equipment capable of handling and applying shotcrete containing the specified maximum size aggregate and admixtures. Provide an air hose and blowpipe to clear dust and rebound during shotcrete application.

#### 3. AIR SUPPLY SYSTEM:

Use an air supply system capable of supplying the delivery machine and hose with air at the pressures and volumes recommended by the machine manufacturer. Do not use air supply systems that deliver oil-contaminated air or are incapable of maintaining constant pressure.

#### 4. DELIVERY MACHINE:

Use a delivery machine capable of supplying material to the delivery hose at a uniform rate. The ejection from the nozzle must adhere to the treated surface with minimum rebound and maximum density when the nozzle is held in the range of 3 to 6 feet from the target surface.

### D. COMPOSITION (SHOTCRETE MIX DESIGN).

Design and produce shotcrete mixtures conforming to Table 2 for the type of shotcrete specified. Use the amount of water required to produce shotcrete of suitable strength, consistency, quality, and uniformity with the minimum amount of rebound. Use the same material types and sources as submitted with the mix design in the field trials and production work.

1. Fibers. If fibers are required, add them to the mix in the proportions recommended by the manufacturer.
2. Hydration stabilizing admixtures. Hydration stabilizing admixtures may be used to extend the allowable delivery time for shotcrete. Dosage is based on the time needed to delay the initial set of the shotcrete for delivery and discharge on the job. Design shall include discharge time limit in the dosage submittal. Dosage required to stabilize shotcrete shall be determined using job site material and field trial mixtures. The extended-set admixture shall control the hydration of all cement minerals and gypsum. The maximum allowable design discharge time is 3.50 hours.
3. If a hydration-stabilizing admixture is approved for use in the concrete mix, concrete shall be delivered and placed within the approved design discharge time limit. An approved and compatible hydration activator may be used at the discharge site to insure proper placement and testing.

4. Dosage and type of extended-set admixture shall be included with proposed mix design. When requested, the admixture manufacturer shall provide the service of a qualified person to assist in establishing the proper dose of extended-set admixture and make dosage adjustments required to meet changing job site conditions.

**Table 2: Composition of Shotcrete.**

Type of Shotcrete Process	Minimum Cement Content	Maximum W/C <sup>(1)</sup> Ratio	Air Content Range	Minimum 28 day Compressive Strength <sup>(3)</sup>
	(lb/cy <sup>3</sup> )		(%)	(psi)
Wet	550	0.55	NA	4000
Dry	550	0.50	NA	4000
Wet (w/EA <sup>(2)</sup> )	550	0.45	5 min.	4000
Dry (w/EA <sup>(2)</sup> )	550	0.45	5 min.	4000

Notes: (1) W/C = Water / Cement (by weight)  
 (2) EA = Entrained Air  
 (3) According to AASHTO T 23

**E. PRECONSTRUCTION TESTING.**

Conduct preconstruction shotcrete field trials before starting shotcrete production. Allow the Engineer the opportunity to witness all phases of the preconstruction testing.

1. **Field Trials:** Construct wood forms at least 6 inches thick by 3 feet by 3 feet in size. Have each proposed nozzle operator make test panels on two vertical wood forms. Cure the test panels according to AASHTO T 23, without immersing the panels.
2. **Coring:** Drill six 3 inch diameter cores from each test panel according to AASHTO T 24. Trim the ends of the cores according to AASHTO T 24 to make cylinders at least 3 inches long.
3. **Compressive Strength Testing:** Soak the cylinders in water for 40 hours immediately before testing. Test three cylinders from each test panel four days after field trial and test the remaining three cylinders 28 days after the field trial. Perform tests according to AASHTO T 23. All specified strength requirements shall be satisfied before the shotcrete mix design will be considered for acceptance.
4. **Mix Design Acceptance:** The Engineer will accept or reject the shotcrete mix design based on the results of the preconstruction field trials and testing. Before approving any changes to a previously accepted mix design, the Engineer may require additional preconstruction testing at no additional cost to the agency.

**F. SURFACE PREPARATION AND APPLICATION OF SHOTCRETE.**

1. **Surface Preparation** - Clean loose material, mud, rebound, and other foreign matter from all surfaces to receive shotcrete. Remove curing compound on previously placed shotcrete surfaces by sandblasting. Install approved depth gages to indicate the thickness of the shotcrete layers. Install depth gages on 6 foot centers longitudinally and transversely with no less than two gauges per increment of surface area to receive the shotcrete. Moisten all surfaces.
2. **Weather Limitations** - Place shotcrete when the ambient temperature is 40°F or higher. Do not perform shotcrete operations during high winds and heavy rains.
3. **Shotcrete Application.**
  - a. Do not apply shotcrete to frozen surfaces.

- b. Use acceptable nozzle operators who have fabricated acceptable test panels according to these Special Provisions.
  - c. Apply shotcrete within 45 minutes of adding cement to the mixture. Apply shotcrete at a temperature between 50o F and 86o F.
  - d. Direct the shotcrete at right angles to the receiving surface except when shooting ground reinforcing bars. Apply shotcrete in a circular fashion to build up the required layer thickness. Apply shotcrete in a steady uninterrupted flow. If the flow becomes intermittent, direct the flow away from the work area until it becomes steady.
  - e. Make the surface of each shotcrete layer uniform and free of sags, drips, or runs.
  - f. Limit the layer thickness of each shotcrete application to 2 inches. Thicker applications may be approved if the contractor can demonstrate that no sloughing or sagging is occurring. If additional thickness is required, broom or scarify the applied surface and allow the layer to harden. Dampen the surface before applying an additional layer.
  - g. Remove laitance, loose material, and rebound. Promptly remove rebound from the work area.
  - h. Taper construction joints to a thin edge over a distance of at least 1 foot. Wet the joint surface before placing additional shotcrete on the joint. Do not use square construction joint.
4. **Production Summary** - Prepare and submit a summary of shotcrete production application for each shift. Furnish the summary to the Engineer within 24 hours. Include the following information in the report:
- a. Quantity and location of shotcrete applied including sketches.
  - b. Observations of success or problems of equipment operation, application, final product conditions, and any other relevant issues during production and application.
  - c. Description of placement equipment.
  - d. Batch number(s) if applicable.

**G. SHOTCRETE FACING.**

Provide construction shotcrete facing in accordance with the plans. Where shotcrete is used to complete the top ungrouted zone of the nail drill hole near the face, position the nozzle into the mouth of the drill hole to completely fill the void.

**1. Final Face Finish:**

Shotcrete finish shall be either an undisturbed gun finish as applied from the nozzle or a rod, broom, wood float, rubber float, steel trowel or rough screeded finish as shown on the Plans.

**2. Attachment of Nail Head Bearing Plate and Nut:**

Attach a bearing plate, washers, and nut to each nail head as shown on the Plans. While the shotcrete construction facing is still plastic and before its initial set, uniformly seat the plate on the shotcrete by hand-wrench tightening the nut. Where uniform contact between the plate and the shotcrete cannot be provided, set the plate in a bed of grout. After grout has set for 24 hours, hand-wrench tighten the nut. Ensure bearing plates with headed studs are located within the tolerances shown on the plans.

**3. Shotcrete Facing Tolerances:**

Construction tolerances for the shotcrete facing from plan location and plan dimensions are as follows:

Horizontal location of welded wire mesh; reinforcing bars, and headed studs:	0.4 inch
Reinforcing lap, from specified dimension:	1 inch

Complete thickness of shotcrete:	
If troweled or screeded:	0.6 inch
If left as shot:	1.2 inch
Planeness of finish face surface-gap under 10 foot straightedge:	
If troweled or screeded:	0.6 inch
If left as shot:	1.2 inch

**H. QUALITY CONTROL RECORDS.**

Submit field quality control test reports within 2 working days of performing the tests. Include the following information in the reports:

1. Sample identification including mix design and test panel number and orientation.
2. Date and time of sample preparation including curing conditions and sample dimensions.
3. Date, time, and type of test.
4. Complete test results including load and deformation data during testing, sketch of sample before and after testing, and any unusual occurrences observed.
5. Names and signature of person performing the test.
6. Location of steel reinforcement, if used, covered by shotcrete.
7. Name of nozzle operator.

**I. PROTECTION AND CURING.**

Protect and maintain shotcrete at a temperature above 40° F until shotcrete has achieved a minimum strength of 3500 psi. Protect and cure shotcrete in accordance with ACI 306R and ACI 506R.

**090080.04 ACCEPTANCE.**

Material for concrete will be evaluated by visual inspection of the work, conformance testing and by certification for materials manufactured off-site. Compressive strength will be evaluated by conformance testing using Table 2 for specification limits. See Table 3 for minimum sampling and testing requirements and acceptance quality category.

**Table 3: Sampling and Testing of Shotcrete.**

Material or Product	Property or Characteristic	Category	Testing Methods or Specifications	Frequency	Sampling Point
Shotcrete	Air Content	-	AASHTO T 152 or AASHTO T 126	1 per load <sup>(1)</sup>	Truck, mixer or agitator <sup>(2)</sup>
	Unit Mass	-	AASHTO T 121	1 per load <sup>(1)</sup>	Truck, mixer or agitator <sup>(2)</sup>
	Compressive strength	II	AASHTO T 23	1 set per 33 cy, but not less than 1 set each day <sup>(3)</sup>	Production test panels <sup>(3)</sup>

- Notes: (1) When continuous mixing is used sample every 10 cubic yards  
 (2) Sample according to AASHTO T 141.  
 (3) Prepare production test panels according to this Special Provisions. Obtain two 3 inch diameter core specimens from each panel according to AASHTO 24. A single compressive strength test result is the average result from 3 inch diameter core specimens from the same test panel tested according to AASHTO T 23 at 28 days

**090080.05 METHOD OF MEASUREMENT AND BASIS OF PAYMENT.**

**A. METHOD OF MEASUREMENT.**

Shotcrete will be measured by square foot of wall face. Measurement will be made on the vertical plane of front face accepted in the final work.

**B. BASIS OF PAYMENT.**

The accepted quantity of shotcrete will be paid for at the contract unit price per square foot of shotcrete applied. No payment will be made for additional shotcrete needed to fill voids created by irregularities in the cut face, excavation overbreak or inadvertent excavation beyond the plan final wall face excavation line, or failure to construct the facing to the specified line and grade and tolerances. The contract unit price for shotcrete shall include all structural shotcrete, admixtures, reinforcement, welded wire mesh, wire holding devices, pre-fabricated drainage mats, horizontal drains, test panels and all sampling, testing and reporting required by the plans and these Special Provisions.