

SHOTCRETE

{Note to Specifier: The paragraphs below are meant to be incorporated into Parts 1, 2 and 3 of a standard CSI 3 Part Format specification, project’s General Structural Notes or directly onto the plans. They must be carefully reviewed by a qualified design professional and edited to meet the particular requirements of the project at hand, assure compliance with any governing building codes, and coordinate with other specification sections and drawings. In no case shall these Guide Specifications be considered to be Contract Documents or serve as installation instructions for the product being discussed. In any cases of discrepancy the manufacturer's most recently published data sheet shall take precedent.}

03 37 13 SHOTCRETE

**PART 1: GENERAL**

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

*Note to Specifier: Retain language below if shotcrete is to be structural. Consult ACI 506 for more information.*

A. This section includes **[structural]** shotcrete applied by [dry-mix] [or] [wet-mix] process.

1.03 DEFINITIONS

A. Shotcrete: Mortar or concrete pneumatically projected onto a surface at high velocity.

B. Dry-Mix Shotcrete: Shotcrete in which most of the water is added at the nozzle.

C. Wet-Mix Shotcrete: Shotcrete in which plastic concrete with cement, aggregate, and water are first mixed together before introduction into the delivery hose.

D. Ground Wire—Wire used to establish line and grade for shotcrete work

1.04 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer employing nozzle operators who attain mean core grades not exceeding 2.5, according to ACI 506.2, on preconstruction tests.

B. Comply with provisions of the following, unless more stringent requirements are indicated:

1. ACI SPEC 117-10 Specification for Tolerances of Concrete Construction and Materials.

1. ACI SPEC 301 - 20 Specifications for Concrete Construction.

2. ACI SPEC 506.2 - Specification for Shotcrete.

*Note to Specifier: Select and retain appropriate language below to indicate who will be responsible for obtaining services of testing agency and required size of test panels.*

C. Preconstruction Testing Service: [Owner will engage] [Engage] a qualified independent testing agency to perform preconstruction testing and inspections indicated below:

1. Produce test panels before shotcrete placement according to requirements in ACI 506.2 and ASTM C 1140 for each design mix, shooting orientation, and nozzle operator. Produce test panels with dimensions of [24 by 24 inches (600 by 600 mm) minimum] and of average thickness of shotcrete, but not less than 3-1/2 inches (90 mm). From each test panel, testing agency will obtain six test specimens: one set of three specimens unreinforced and one set of three specimens reinforced. Agency will perform the following:

a. Test each set of unreinforced specimens for compressive strength according to ASTM C 42.

b. Visually inspect each set of reinforced shotcrete cores taken from test panels and determine mean core grades according to ACI 506.2.

D. Mockups: Before installing shotcrete, construct mockups for each finish required and for each design mix, shooting orientation, and nozzle operator to demonstrate aesthetic effects and set quality standard for installation.

E. Preinstallation Conference: Conduct conference at Project site to comply with requirements in **<<Division 1 Section "Project Management and Coordination.">><<insert section>>**

1.06 PROJECT CONDITIONS

A. Cold-Weather Shotcreting: Protect shotcrete work from physical damage or reduced strength caused by frost, freezing, or low temperatures according to ACI 306.1 and as follows:

1. Discontinue shotcreting when ambient temperature is 40 deg F (4.4 deg C) and falling. Uniformly heat water and aggregates before mixing to obtain a shotcrete shooting temperature of not less than 50 deg F (10 deg C) and not more than 90 deg F (32 deg C).

2. Do not use frozen materials or materials containing ice or snow.

3. Do not place shotcrete on frozen surfaces or surfaces containing frozen materials.

4. Do not use calcium chloride, salt, and other materials containing antifreeze agents.

B. Hot-Weather Shotcreting: Mix, place, and protect shotcrete according to ACI 305.1 when hot-weather conditions and high temperatures would seriously impair quality and strength of shotcrete, and as follows:

1. Do not place shotcrete when material temperature is above 90 deg F for wet mix; 100 deg F for dry mix.

2. Lower temperature of reinforcement and receiving surfaces below 100 deg F prior to shooting.

**PART 2: PRODUCTS**

2.01 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A 615/A 615M, Grade <insert grade> deformed.

B. **[Galvanized][Plain]** Steel Welded Wire Fabric shall be manufactured to meet ASTM A82, ASTM A185, and ASTM A884, where specified, 65 KSI yield strength. Fabric shall be manufactured of cold drawn wire of size specified on drawings and welded at intersections. Furnish flat sheets only.

C. Synthetic Macrofiber: Polypropylene/polyethylene synthetic macrofiber complying with ASTM C 1116 Type 3, minimum 2 inch length, aspect ratio 50 to 90. Provide manufacturer’s recommended dosage to provide post crack equivalent residual strength (fe3) of 150 psi when measured in accordance with ASTM C1609.

1. Fiber manufacturer shall have ISO 9001 certification.

2. Synthetic macrofiber shall be tested in concrete to meet the requirements of ICC-AC383

3. Basis for Design Product:

**a. Euclid Chemical Company (The); Tuf-Strand SF; euclidchemical.com**

{Note to Specifier: Remove PRE PACKAGED SHOTCRETE MATERIALS if Vandex AM-10 crystalline waterproofing admixture is to be specificied. Admixture is designed to be used with job site mixed shotcrete materials only.

This specification section is written based on Euclid EUCOSHOT. If desired another shotcrete product from Euclid Chemical’s full line of shotcrete materials can be chosen from Euclid’s website (<https://www.euclidchemical.com/products/construction-products/repair/repair-vertical-overhead/shotcrete/eucoshot/>) and inserted below with appropriate material property edits.}

2.02 PREPACKAGED SHOTCRETE MATERIALS

A. Shotcrete: Prepackaged, single component, microsilica modified, cement based mortar designed for use on vertical and overhead surfaces by dry mix shotcrete or wet mix shotcrete application. Material shall exhibit the following properties;

1. Compressive Strength per ASTM C 109 2” cubes

1 day 3,500 psi (24 MPa)

3 days 5,000 psi (34 MPa)

7 days 7,000 psi (48 MPa)

28 days 9,500 psi (65 MPa)

2. Flexural Strength per ASTM C 348 modified

1 day 550 psi (3.8 MPa)

7 days 775 psi (5.3 MPa)

28 days 1100 psi (7.6 MPa)

3. Shear Bond Strength per ASTM C 882 modified

3 days 2,000 psi (14 MPa)

7 days 2,500 psi (17 MPa)

28 days 3,000 psi (21 MPa)

4. Direct Tensile Bond (German Test)

14 days 350 psi (2.4 MPa)

28 days 425 psi (2.9 MPa)

5. Length Change ASTM C 157, 50% R.H.

2 days -0.003%

7 days -0.003%

14 days -0.007%

21 days -0.025%

28 days -0.033%

6. Rapid Chloride Permeability ASTM C 1202

7 days 4,000 coulombs

14 days 1,600 coulombs

21 days 975 coulombs

28 days 575 coulombs

7. Freeze/Thaw Resistance per ASTM C 666 Procedure A

300 cycles >98% RDM

8. Scaling Resistance per ASTM C 672

10 cycles 0

20 cycles 0

30 cycles 0

50 cycles 0

9. Volumetric Resistivity: 11,490 ohm/cm

10. Basis of Design Product:

a. [**EUCOSHOT**](https://www.euclidchemical.com/products/construction-products/repair/repair-vertical-overhead/shotcrete/eucoshot/) **by Euclid Chemical Co. (The) www.euclidchemical.com**

B. Ground Wire: High-strength steel wire, 0.8 to 1 mm in diameter.

2.03 JOB SITE MIXED SHOTCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I or ASTM C595 Type IL

B. Silica Fume: ASTM C 1240, amorphous silica

1. Products:

**a. Euclid Chemical Co. (The); Eucon MSA; www.euclidchemical.com**

*Note to Specifier: Retain language below to specify aggregate size, gradation and durability factors. Refer to ACI 318, ACI 350 and ASTM C33 for guidance.*

C. Normal-Weight Aggregates: ASTM C 33, from a single source, and as follows:

1. Aggregate Gradation: ACI 506.2, Gradation [No. 1 with 100 percent passing 3/8-inch (10-mm)] [No. 2 with 100 percent passing 1/2-inch (13-mm)] [No. 3 with 100 percent passing 3/4-inch (19-mm)] sieve.

2. Coarse-Aggregate Class: ASTM C33 [3S] [3M] [1N] <Insert class>.

D. Water: Potable, complying with ASTM C 94, free from deleterious materials that may affect color stability, setting, or strength of shotcrete.

E. Ground Wire: High-strength steel wire, 0.8 to 1 mm in diameter

2.04 ADMIXTURES

A. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures. Calcium chloride or admixtures containing more than 0.05 percent chloride ions are not permitted.

B. Air-Entraining Admixture: ASTM C 260.

1. Basis of Design Products

**a. Euclid Chemical Company (The); Air Mix or AEA-92 Series**

C. Water-Reducing Admixture: ASTM C 494, Type A.

1. Basis of Design Products:

**a. Euclid Chemical Company (The); Plastol 341**

D. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

1. Basis of Design Products:

**a. Euclid Chemical Company (The); Plastol Series**,

E. Water-Reducing and Accelerating Admixture: ASTM C 494, Type C or E.

1. Basis of Design Products:

**a. Euclid Chemical Company (The); Accelguard 80, 90, or NCA**;

F. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.

1. Basis of Design Products:

**a. Euclid Chemical Company (The); Eucon 37 or Plastol Series**

{Note to Specifier: Insert paragraph below to request crystalline waterproofing admixture.}

**G.** Crystalline Waterproofing Admixture: Integral crystalline admixture specifically formulated to interact with capillary pore structures to provide a waterproofing system that is a permanent part of the concrete matrix. Admixture shall provide the following properties:

Water Penetration per DIN 1048 40% Reduction at 72 psi.

Water Permeability per CRD C48-92 >70% Reduction at 200 psi

1. Basis of Design Product:

**a. Euclid Chemical Company (The); Vandex AM-10, www.euclidchemical.com**

2.05 CURING MATERIALS

A. Absorbent Covers: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry. Material must be free of harmful substances, such as sugar or fertilizer, or substances that may discolor the surface. To remove soluble substances, burlap should be thoroughly rinsed in water before placing it on the concrete.

B. Moisture Retaining Covers:

1. Plastic Film: ASTM C171, 10 mil minimum thickness polyethylene film

2. White burlap-polyethylene sheet meeting ASTM C171

{Note to Specifier: Retain paragraph below and insert appropriate liquid membrane curing compound if liquid curing compound is to be used. Note that liquid curing compounds are not compatible with subsequent treatments such as coatings and penetrating sealers.}

C. Clear, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class A, nondissipating.

1. **[Solvent Bourne Products VOC’s <350 g/l:**

**a. Euclid Chemical Co. (The): Diamond Clear 350]**

2. **[Waterborne Products:**

**a. Euclid Chemical Company (The); Kurez W VOX]**

2.06 SHOTCRETE MIXES, GENERAL

A. Prepare design mixes for each type and strength of shotcrete.

B. Limit water-soluble chloride ions to maximum percentage by weight of cement or cementitious materials permitted by ACI 301.

C. Admixtures: When included in shotcrete design mixes, use admixtures according to manufacturer's written instructions.

2.7 NORMAL-WEIGHT SHOTCRETE MIXES

*Note to Specifier: Insert appropriate text below. Refer to ACI 318 and ASTM C33 for guidance regarding exposure class, compressive strength, w/cm ratios and air entrainment.*

A. Exposure Class: ACI 318 (ACI 318M) **[F0] [F1] [F2] [F3] [S0] [S1] [S2] [S3] [W0] [W1] [C0] [C1] [C2]**

B. Proportion **[dry mixes by field test data methods] [and] [wet mixes according to ACI 211.1 and ACI 301]**, using materials to be used on Project, to provide normal-weight shotcrete with the following properties:

1. Compressive Strength (28 Days): [5,000 psi (34.5 MPa)] [4,500 psi (31 MPa)] [4,000 psi (27.6 MPa)] [3,500 psi (24.1 MPa)] [Insert strength].

2. Maximum w/cm ratio of **[0.40][0.45][0.50][0.55]<<insert value>>**

3. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight, wet-mix shotcrete having an air content before pumping of [7] [8] [Insert number] percent with a tolerance of plus or minus 1-1/2 percent.

PART 3: EXECUTION

3.01 SURFACE PREPARATION

A. Concrete Removal: Remove all loose and unsound concrete per ICRI Guideline 310.1R “Guide for Surface Preparation”.

1. Repair areas shall have perimeter boundaries saw cut to minimum depth of 1” inch or less if such depth will cause saw to come in contact with embedded reinforcing steel. All concrete removal boundaries shall be straight and aligned parallel to opposite boundary edges resulting in repair areas that are rectangular in shape. Taper remaining edge into cavity 1:1 slope.

2. All concrete shall be removed from within repair boundary to uniform minimum depth of 1” inch. Provide a surface with suitable profile for bond, as defined in repair mortar manufacturer’s written recommendations. If delaminations, cracking, or unsound materials exist beyond minimum removal depth, then removal shall continue until all unsound, delaminated, or cracked concrete has been removed from cavity.

B. Preparing Reinforcing Steel: Clean and prepare any exposed embedded reinforcing steel per ICRI Guideline 310.1R. “Guide for Surface Preparation”

1. Where ½ or more of diameter of reinforcement steel is exposed either by existing conditions or concrete removal, bond between the concrete and reinforcing steel is broken, or corrosion is present, the concrete shall be removed to provide a minimum ¾” clearance around entire perimeter of steel and along entire exposed length.

2. Clean all exposed reinforcing steel to bright steel, prior to installation of shotcrete mortar.

a) Where section loss on a reinforcing bar is more than [insert number] percent or [insert number] percent in two or more adjacent bars contact Engineer.

C. Concrete Preparation and Cleaning: Areas to receive shotcrete repair shall be structurally sound and free from deteriorated concrete, dust, dirt, debris, loosened concrete, paint, oil, efflorescence, laitance, and other contaminants, and shall have a minimum Concrete Surface Profile CSP of 7 or greater as defined by ICRI Guideline 310.2, and as called for in manufacturer’s literature.

*Note to Specifier: Insert language below to require bond testing of substrate prior to shotcrete application.*

D. **[Following surface preparation the cleaned concrete floor shall be tested for compliance with the following:]**

**1. [Minimum surface tensile strength of 200 psi when tested with a “Elcometer” or similar pull tester per ASTM C1583.]**

E. Surface shall be saturated surface dry immediately prior to application of shotcrete.

3.02 FORMS

A. General: Design, erect, support, brace, and maintain forms, according to ACI 301, to support shotcrete and construction loads and to facilitate shotcreting.

B. Secure forms to minimize effects of vibration of shotcrete placement.

C. Construct forms to allow escape of placement air and rebound.

3.03 STEEL REINFORCEMENT

*Note to Specifier: Show minimum cover of steel on drawings.*

A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.04 JOINTS

A. Taper construction joints at 1:1 slope where joint is not subject to compression loads.

B. Continue reinforcement through construction joints unless otherwise indicated.

C. Place control joints as indicated on drawings.

3.05 ALIGNMENT CONTROL

A. Ground Wires: Install ground wires to establish thickness and planes of shotcrete surfaces. Install ground wires at corners and offsets not established by forms. Pull ground wires taut and position adjustment devices to permit additional tightening.

3.06 SHOTCRETE APPLICATION

A. Protect adjacent surfaces from rebound, overspray, and impact from nozzle stream.

B. Batch, mix, and apply shotcrete in accordance with manufacturer’s written instructions and ACI 506.2.

*Specify tolerances based on function and appearance. Shotcrete can be built to same tolerances as cast in place concrete. However, for some structures such as tunnels only cover thickness is required and tolerances are not specified unless project specific requirements dictate. Sometimes, shotcrete tolerances are increased by a factor of two from those in ACI 117. Refer to ACI 318 or 350 to determine project requirements.*

C. Dimensional tolerances shall comply with **[ACI 117].**

3.07 SHOTCRETE FINISHES

A. Gun Finish: Textured, natural finish to exposed surfaces unless otherwise indicated.

**[B. Broom Finish: Level exposed surface of shotcrete to required plane by rod, cutting screed, or trowel and apply broom finish upon initial set.]**

3.08 CURING

A. Immediately after conclusion of shotcrete finishing operations, cure newly placed shotcrete to receive exterior concrete penetrating sealer or other subsequent treatments, for (7) days, in accordance with ACI 308.1 utilizing one or a combination of the following methods.

1. Water Cure continuously for seven days utilizing sprinklers, soaker hoses, ponding, or fog spray. Take care to prevent erosion damage to the surface of the concrete.

2. Absorbent Cover: Water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers when placing. Provide continuous supply of moisture such as sprinklers or soaker hoses when high temperature, low humidity, or windy conditions prevail. Do not allow Absorbent Cover materials to dry out during specified curing period.

3. Moisture Retaining Cover Curing: Cover concrete surfaces with moisture-retaining cover meeting ASTM C 171 as soon as possible after final finishing without marring the surface. Place in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. On flat surfaces such as pavements, the cover shall extend beyond the edges of the slab at least twice the thickness of the slab. The cover shall be placed flat on the concrete surface, avoiding wrinkles, to minimize mottling immediately after wetting the slab to rejection. It shall be placed and weighted so that it remains in contact with the concrete during the specified duration of curing. Windrows of sand or earth, or pieces of lumber shall be placed along all edges and joints in the film to retain moisture and prevent wind from getting under the film and displacing it. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

*{Note to Specifier: Retain paragraph below a if liquid curing compound is to be used. Note that liquid curing compounds are not compatible with subsequent treatments such as coatings and penetrating sealers.}*

4. Curing Compound: Immediately after conclusion of concrete finishing operations cure exposed shotcrete not receiving penetrating sealer, or other subsequent treatments with specified liquid curing compound meeting ASTM C 309. Product shall be applied in a uniform, continuous operation by power spray or roller according to manufacturer's written instructions.

END SECTION