

SECTION 03 01 32
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
 - a. 301, Specifications for Structural Concrete.
 - b. 506.2, Specification for Shotcrete.
2. ASTM International (ASTM):
 - a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
 - b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
 - c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
 - f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
 - g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens).
 - h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
 - i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
 - j. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
 - k. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - l. C596, Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
 - m. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
 - n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
 - o. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

- p. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
- q. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
- r. D4259, Standard Practice for Abrading Concrete.
- s. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

1.02 DEFINITIONS

- A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.
- B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.
- C. High-Pressure Water Blasting: Sometimes referred to as hydro-demolition. Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.
- D. Low-Pressure Spray Mortar: Mortar suitable to be applied by low-pressure spraying, and in small areas may be applied by hand troweling.
- E. New Concrete: As defined in Section 03 30 00, Cast-in-Place Concrete.
- F. Rebound: Shotcrete material, mostly aggregates, that bounce off a surface against which shotcrete was projected.
- G. Shotcrete: Mortar pumped through hose and projected at high velocity.

1.03 SUBMITTALS

- A. Action Submittals: Product data sheets for each material supplied.
- B. Informational Submittals:
 - 1. Repair Mortar System: Manufacturer's preparation and installation instructions.

2. Written description of equipment proposed for concrete removal and surface preparation.
3. Certificates:
 - a. Shotcrete Nozzleman: Current ACI Certification for each proposed nozzleman if Repair System A – Shotcrete Mortar, is used.
 - b. Manufacturer's Certificate of Compliance, in accordance with Section 01 67 00, Product Requirements, that proposed repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on vertical and overhead surfaces that are exposed to weather.
 - c. Mortar Manufacturer's Certificate of Proper Installation.
4. Statements of Qualification:
 - a. Repair mortar system applicator.
 - b. Repair mortar system manufacturer's representative.
 - c. Independent Testing Laboratory.
5. Field and laboratory test reports.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator:
 - a. For Repair System A – Shotcrete Mortar, trained and experienced applicator recognized or certified by repair mortar system manufacturer.
 - b. For Repair System B – Low-Pressure Spray Mortar, in lieu of recognition or certification, demonstrate application of repair mortar manufacturer's system and obtain Certification of Proper Installation, in accordance with Article Manufacturer's Services.
2. Repair Mortar System Manufacturer's Representative: Knowledgeable and experienced on technical data and application requirements for specified products.

B. Demonstration Mockup for Repair System B – Low-Pressure Spray Mortar Repair System:

1. For each noted type of repair mortar system to be used, prepare one demonstration mockup in each vertical and overhead orientation of at least 10 feet by 10 feet with average thickness, and containing reinforcement, representative of area being repaired on Project. Alternatively, a repair area in each vertical and overhead orientation that is representative of areas to be repaired in terms of size, thickness, and reinforcement, may be used for demonstration in lieu of mockups; subject to acceptance by Contracting Officer.

2. Repair Mortar System Manufacturer's Demonstration:
 - a. Schedule time for manufacturer's demonstration of repair system proposed for Project.
 - b. Prepare mortar to specified consistency for testing and placement.
 - c. Cure portions of each type of surface to be repaired using proposed curing procedure and materials, including overhead and vertical applications.
 - d. Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.
 - e. Demonstrate the following:
 - 1) Mixing and application equipment capabilities and procedures, including flow of material from nozzle or sprayer.
 - 2) Nozzle operator and person in charge of low-pressure sprayer, capabilities and ability to follow prescribed application procedures and properly operate equipment and apply surface repair materials.
 - f. Compression Strength Test: Make compression test samples from wet mortar during demonstration placement and deliver to independent testing laboratory for testing at 7 days and 28 days.
 - g. Tensile Bond Test: Test in situ for tensile bond at 7 days as specified in Paragraph Direct Tension Bond Test.

C. Where Required by Contracting Officer:

1. Demonstration Mockup for Repair System C – Polymer Modified Repair Mortar System:
 - a. Prepare one demonstration mockup in each vertical and overhead orientation of average size and thickness, and containing reinforcement, representative of area being repaired on Project. Alternatively, a repair area in each vertical and overhead orientation that is representative of areas to be repaired in terms of size, thickness, and reinforcement, may be used for demonstration in lieu of mockups; subject to acceptance by Contracting Officer.
 - b. Repair Mortar System Manufacturer's Demonstration:
 - 1) Schedule time for manufacturer's demonstration of repair system proposed for Project.
 - 2) Prepare mortar to specified consistency, for testing and placement.
 - 3) Cure portions of each type of surface to be repaired using proposed curing procedure and materials, including overhead and vertical applications.
 - 4) Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.

- 5) Demonstrate mixing and application procedures.
- 6) Compression Strength Test: Make compression test samples from wet mortar during demonstration placement and deliver to independent testing laboratory for testing at 7 days and 28 days.
- 7) Tensile Bond Test: Test in situ for tensile bond at 7 days as specified in Paragraph Direct Tension Bond Test.

D. Pre-repair Conference:

1. Required Meeting Attendees:
 - a. Contractor.
 - b. Repair Subcontractor.
 - c. Technical representative for repair material manufacturer.
 - d. Contracting Officer.
2. Schedule and conduct prior to conducting mockups and incorporation of respective products into Project. Notify Contracting Officer of location and time.
3. Agenda shall include, but not limited to:
 - a. Review of field conditions. Conduct field observations of Work to be performed.
 - b. Based on above observations, repair material manufacturer's technical representative shall confirm material selection and make Project-specific repair method recommendations.
 - c. Technical representative for repair material manufacturer shall review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
 - d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.
- B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR SYSTEM A – SHOTCRETE MORTAR

- A. Not used.

2.02 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR

A. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 488CI.
2. Or equal.

B. Physical Characteristics:

1. One or two-component, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.
2. Free of chlorides and other chemicals causing corrosion.

C. Functional Characteristics: Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only addition of water.

D. Performance Characteristics:

1. Cured materials mixed in accordance with manufacturer's instructions shall conform to the following criteria:
 - a. Compressive Strength, ASTM C109/C109M at 28 Days: 6,000 psi minimum.
 - b. Flexural Strength, ASTM C348 at 28 Days: 1,100 psi minimum.
 - c. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent, at 28 Days: 3,000 psi minimum.
 - d. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
 - e. Drying Shrinkage, ASTM C157/C157M Modified at 28 Days or ASTM C531: 0.1 percent maximum.
 - f. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 1,000 coulombs maximum.
 - g. System shall not produce a vapor barrier.

2.03 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR

A. Manufacturers and Products:

1. Sika Corp., Lyndhurst, NJ; SikaTop 123 PLUS.
2. Or equal.

B. Physical Characteristics: Polymer-modified, one-component or two-component, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

C. Functional Characteristics: None.

D. Performance Characteristics:

1. Cured Mortar Properties:
 - a. Compressive Strength, ASTM C109/C109M at 28 Days: 7,000 psi minimum.
 - b. Flexural Strength, ASTM C348 at 28 Days: 1,200 psi minimum.
 - c. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent at 28 Days: 2,000 psi minimum.
 - d. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
 - e. Drying Shrinkage, ASTM C596 at 28 Days: 0.12 percent maximum. Not required for small repair areas approximately 1 square foot in area or less.
 - f. Freeze Thaw Resistance, ASTM C666/C666M, at 300 Cycles: 90 percent RDM.
 - g. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum for liquid holding and belowgrade repairs.

2.04 REPAIR SYSTEM D – SITE-MIXED PORTLAND-CEMENT MORTAR

A. Mortar Materials:

1. Use same materials as concrete to be repaired with no coarse aggregate, per Section 03 30 00, Cast-in-Place Concrete. Use of 3/8-inch nominal pea gravel acceptable where repairs are in excess of 1 inch deep.
2. For repairs to exposed concrete, make trial batches to check color compatibility of repair mortar with existing surrounding concrete.
3. When repair is too dark, substitute white portland cement for part of the gray portland cement to produce desired color closely matching color of surrounding concrete.

2.05 WATER

- A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 00, Cast-in-Place Concrete.

2.06 REINFORCEMENT

- A. Deformed Steel Reinforcement: Per Section 03 21 00, Steel Reinforcement.
- B. Tie Wire: 16-gauge, galvanized.

2.07 EVAPORATION RETARDANT

- A. As specified in Section 03 39 00, Concrete Curing.

2.08 CURING COMPOUND

- A. As specified in Section 03 39 00, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

- A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system. Refer to Section 03 30 00, Cast-in-Place Concrete.
- B. Existing Concrete Work: Repair concrete damaged due to construction activities.

3.02 APPLICATION

- A. General:
 - 1. Repair System A: Large areas and number of repair areas.
 - 2. Repair System B: Medium to large areas and number of repair areas.
 - 3. Repair System C: Small and limited areas and number of repair areas.
 - 4. Repair System D: Coordinate with EOR.

3.03 PREPARATION

- A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Contracting Officer, and review proposed extent of repair with Contracting Officer.
- B. Remove unsound, honeycombed, deteriorated, or otherwise defective areas of concrete from work areas.
 - 1. Use 8,000 psi minimum high-pressure water or abrasive blasting machine as required for Site conditions.
 - 2. Remove concrete to abrade substrate concrete surfaces to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
 - 3. Where final surface is required to be flush with existing adjacent surface remove existing concrete depth as required for application of minimum thickness of repair mortar.

- C. Do not use power-driven jackhammers, chipping hammers, or scabblers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.
- D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.
- E. Remove unsound concrete to satisfaction of Contracting Officer.
- F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or feathered edges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting or abrasive blasting.
- G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to circumference of exposed steel reinforcement if one or more of the following surface conditions exist:
 - 1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
 - 2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
 - 3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Contracting Officer.
- H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.
- I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminants from prepared areas.
- J. Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar as required by and in accordance with repair mortar manufacturer's printed instructions.
- K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Contracting Officer.

3.04 PROTECTION

- A. Protect adjacent surfaces, and equipment, from being damaged by overshooting, rebound, and dust, as applicable for repair mortar system used, from shotcrete mortar or low-pressure spray mortar.

3.05 REPAIR SYSTEM A – SHOTCRETE MORTAR PLACEMENT

- A. Apply shotcrete mortar in accordance with manufacturer's instructions.
- B. Do not reuse rebound materials.
- C. Apply mortar using dry mix process, in accordance with ACI 506.2.
- D. Shotcrete mortar shall emerge from nozzle in a steady, uninterrupted flow. If flow becomes intermittent, direct flow away from the Work until flow of mortar becomes constant.
- E. Applied Shotcrete Mortar: Minimum thickness of 1-1/2 inches to 2 inches of cover over existing reinforcement, or to level of surrounding concrete surface, whichever results in thicker coat.
- F. Nozzle Position: Hold nozzle approximately at right angles to and at a distance from surface in accordance with shotcrete repair mortar system manufacturer's instructions for type of application, nozzle, and air pressure used.
- G. Steel Reinforcement Encasement:
 - 1. Modify procedure of shooting shotcrete mortar to better direct material around reinforcement bars.
 - 2. Prevent shotcrete mortar from building up on reinforcement steel when shooting on, around, through, and behind steel to eliminate voids.
 - 3. Provide dense void-free encasement of reinforcement steel.
- H. Shotcreting More than One Layer: In accordance with shotcrete repair mortar system manufacturer's printed instructions.
- I. Slice off excess material with a wire screed approximately 5 minutes to 10 minutes after initial set.
- J. Apply finish to exposed shotcrete mortar surface to match existing surface and in accordance with manufacturer's instructions.

K. Rebound Removal: Continuously throughout shotcrete mortar application, remove rebound, sand, and miscellaneous debris, and dispose off Site at an approved disposal facility.

L. Cure as specified in Article Curing.

3.06 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. After priming prepared substrate concrete surface per manufacturer's recommendations, apply mortar by low-pressure spraying equipment, unless noted otherwise.

C. Bonding Agent:

1. Use bonding agent when manufacture required for hand applied areas, in accordance with repair mortar manufacturer's instructions.
2. Application of repair mortar over bonding agent shall be completed within time frame recommended by bonding agent manufacturer.
3. Consult with manufacturer for optimum and minimum acceptable degrees of surface tackiness of coat.

D. Work mortar firmly and quickly into repair area.

E. Finish repair mortar to match adjacent concrete surface.

F. Provide evaporation retardant at full strength.

G. Cure as specified in Article Curing.

3.07 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions. Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.

C. Place mortar by hand or low-pressure spray and trowel to specified surface finish, in accordance with requirements of repair material's printed instructions.

- D. Finish repair mortar to match adjacent concrete surface.
- E. Cure as specified in Article Curing, and in accordance with manufacturer's printed instructions.

3.08 REPAIR SYSTEM D – SITE-MIXED PORTLAND-CEMENT REPAIR MORTAR PLACEMENT

- A. Prepare mortar to a stiff consistency with no more mixing water necessary for handling and placing.
- B. Mix site-mixed portland-cement repair mortar in accordance with requirements of ACI 301.
- C. Apply scrub coat of mortar worked into existing substrate surface with a stiff bristled brush. Use of epoxy resin bonding agent is not acceptable.
- D. Work mortar firmly and quickly into repair area before scrub slurry coat begins to dry.
- E. Finish repair mortar to match adjacent concrete surface.

3.09 CURING

- A. Prior to curing, apply water fog to repair mortar system in accordance with repair mortar system manufacturer's printed instructions.
- B. Cure in accordance with repair mortar manufacturer's printed instructions.
- C. Where permitted by repair mortar manufacturer's printed instructions, commence water curing after repair mortar system application and when curing will not cause erosion of mortar.
- D. Continuously water cure repair mortar system for a period of 7 days.
- E. Do not cure using curing compound or membrane, unless method is part of repair mortar system manufacturer's printed instructions and approval is obtained from Contracting Officer.
- F. Cure intermediate layers of repair mortar in accordance with repair mortar manufacturer's printed instructions.
- G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.10 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed wet mortar materials from nozzle, or mixer, during construction for compliance with Specifications for testing at 7 days, and 28 days.
3. Provide a minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Direct Tension Bond Test:

1. In Situ Bond Testing: Perform tension bond test in accordance with ASTM C1583/C1583M.
2. Record locations on in situ bond tests on each type of applied repair mortar.

D. Testing laboratory retained by Contractor will provide the following:

1. Compression Strength Test:
 - a. Testing will follow a “modified” ASTM C109/C109M.
 - b. A minimum of three production samples of mixed material will be obtained from each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days.
 - c. Record location where repair mortar is being applied at time production samples are obtained.
2. Direct Tension Bond Test:
 - a. Two core samples will be obtained and tested for each 2,000 square feet of repair work.
 - b. Cores will be 2-1/2-inch or 3-inch diameter to a total depth equal to at least 2.5 times repair mortar thickness.
 - c. Bond Strength of Repair Mortar to Substrate Concrete: 300 psi minimum in direct tension without failure or movement.
 - d. Record locations of Bond Tests on each type of applied repair mortar tested.

- E. Retest mortar repairs that do not meet test requirements.
- F. Repair and fill holes using same repair mortar where core samples have been removed.

3.11 MORTAR REPAIR FAILED TEST

- A. Remove and replace unacceptable Work.
- B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge. Remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.
- C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.
- D. Failed Bond Tests: Remove affected areas of repair mortar represented by failed bond test results. Prepare substrate surface and reapply repair mortar as specified herein above.
- E. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.12 MANUFACTURER'S SERVICES

- A. Provide repair mortar system manufacturer's representative at Site to review acceptability of surface preparation, mixing and installation assistance, training of repair mortar system applicators, inspection, and Certification of Proper Installation.

3.13 CLEANING

- A. Remove overshot shotcrete, Repair System A low-pressure spray, Repair System B site-mixed portland-cement, Repair System D repair mortar and rebound materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of or repair areas, finishing, and curing, and dispose offsite at an approved disposal site.

END OF SECTION