

SECTION 03700

CONCRETE REPAIR AND REHABILITATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Repair of cracks, holes and surface defects, and repair of deteriorated concrete surfaces.
- B. Installation of embedded items into existing concrete.

1.02 UNIT PRICES

- A. Measurement for repair materials is on a lump-sum basis for each structure as bid. Payment includes work performed on these structures in accordance with related sections included in the Contract Documents.
- B. Measurement for extra removal of deteriorated concrete and placement of repair mortar is on a cubic-foot basis. Measurement for other repair materials is as defined in the appropriate related sections. Payment includes associated work performed in accordance with related sections included in the Contract Documents.

1.03 SUBMITTALS

- A. Submittals shall conform to all provisions and sections of these specifications. Submit manufacturer's product information, installation instructions and recommendations, and certification of compliance with required properties for all repair materials.

1.04 REPAIR SCOPE

- A. Patch and fill openings in existing concrete indicated to be patched or filled.
- B. Patch, fill holes in and otherwise repair damage to concrete and concrete surfaces resulting from removal of penetrating pipes and other embedded items, from installation of pipes or other items embedded in or passed through concrete, and from other construction activities.
- C. Crack Repair: Repair the full length of cracks in concrete members in new structures, and in existing structures as follows:
- D. Deteriorated Concrete:
 - 1. Repair interior concrete surfaces showing signs of deterioration in the following existing structures:

2. The level of deterioration of the concrete varies within each of the listed structures.

1.05 QUALITY ASSURANCE

A. Field Tests of Cement-based Grouts:

1. Compression test specimens will be prepared during construction by the Owner's Representative, or Owner's Representative's authorized representative, from the first placement of each type of mortar or grout, and at intervals thereafter as determined by the Owner's Representative, to ensure continued compliance with these specifications.
2. Specimen preparation and compression testing for repair mortar and non-shrink grout will be performed as specified in ASTM C109. A set of three specimens will be made for testing at 7 days, 28 days, and additional testing as appropriate.
3. Material failing to meet Contract requirements is subject to removal, and replacement with new material meeting requirements, at no additional cost to the Owner.
4. Cost of laboratory tests on mortar and grout will be borne by the Owner, except Contractor shall pay for tests failed, and additional testing and investigation work performed because of work not meeting Contract requirements.
5. Contractor shall supply all materials necessary for fabricating test specimens and assist the Owner's Representative in obtaining specimens for testing.

B. Repair concrete shall be tested as required in Section 03310 - Structural Concrete.

C. Epoxy grout shall be tested as required in Section 03600 - Structural Grout.

D. Chemical Grout:

1. Installer: A waterproofing contractor with a minimum of 3 years experience in the installation of chemical grout systems as specified herein, and shall be certified or approved by the manufacturer.
2. Waterproofing contractor shall submit a list of 5 previous jobs successfully completed by that firm that successfully utilized the specified chemical grout system.

E. Construction Tolerances: As specified in Section 03100 - Concrete Formwork, and Section 03345 - Concrete Finishing, except as otherwise indicated.

PART 2 PRODUCTS

2.01 REPAIR MORTAR

- A. Repair Mortar: Prepackaged polymer-modified cement-based product specifically formulated for repair of surface defects in concrete, having the following properties:

<u>Physical Property</u>	<u>Minimum Value</u>	<u>ASTM Standard</u>
Compressive Strength		C109
1 day	2000 psi	
28 days	6000 psi	
Bond Strength		C882 (modified)
1 day	1200 psi	
7 days	2000 psi	

- B. Manufacturer and Product: Emaco by Master Builders, SR93 by Euclid Chemical Company, Sikacem by Sika Corporation, Five Star Structural Concrete by Five Star Products, Inc., or equal. Where the manufacturer offers products in formulations intended for specific application conditions such as overhead and shotcrete application, use the formulation recommended by the manufacturer for the condition required.
- C. Minimum Repair Thickness: 0.50 inch.

2.02 NON-SHRINK GROUT

- A. Non-shrink Grout: Comply with requirements of Section 03600 - Structural Grout.

2.03 CONCRETE MATERIALS

- A. Cement: Type II Portland cement, unless indicated otherwise. Where repairs are made on wall surfaces exposed to view and above normal water surface elevation, blend white Portland cement with Type II cement as needed to match the color of adjacent existing concrete surface.
- B. Repair Concrete: Class A (4000 psi), (unless specified otherwise) concrete with one-inch maximum coarse aggregate, complying with Section 03310 - Structural Concrete; minimum repair thickness, 2 inches.

- C. Cement Grout: Comply with Section 03600 - Structural Grout; minimum repair thickness, one inch.
- D. Curing Materials, Bonding Agents and other Miscellaneous Materials: Comply with Section 03310 - Structural Concrete and Section 03370 - Concrete Curing.

2.04 AGGREGATE

- A. Aggregate for Extending Repair Mortar and Non-shrink Grout Products: 3/8 inch clean, washed gravel or crushed stone complying with Section 03310 - Structural Concrete.

2.05 CHEMICAL GROUT

- A. Chemical Grout: Hydrophobic urethane or polyurethane material of low viscosity suitable for pumped injection into cracks, which reacts with water to form a closed-cell foam material that completely fills and seals all cracks against leakage. Cured material shall remain elastic and maintain an expansive pressure through repeated wet-dry cycles.
- B. Manufacturer and Product: Scotch Seal 5600 by the Adhesives, Coatings, and Sealers Division of 3M Products; Flex LV by De Neef America, Inc.; SikaFix by Sika Corporation; or equal. Use different formulations in the same family of materials, accelerators, and other materials necessary for installation where recommended by the manufacturer for specific application conditions.
- C. Reacted and cured chemical grout shall be resistant to organic solvents, mild acids, alkali and microorganisms. Cured material shall be approved for use with potable water by the appropriate federal, state or local government agency.

2.06 EPOXY PRODUCTS

- A. Epoxy Grout: Comply with Section 03600 - Structural Grout, modified as specified herein.
- B. Epoxy for Crack Injection: ASTM C881, Type IV; low viscosity, moisture-insensitive material specifically formulated for that use; 2500 psi minimum bond strength when tested in accordance with ASTM C882 at 14 days, moist cured.

2.07 SEALANT

- A. Sealant: 2-part polyurethane complying with Section 03250 - Joints in Concrete Structures.

2.08 FORMWORK

- A. Formwork, Where Needed: Comply with Section 03100 - Concrete Formwork.

2.09 REINFORCEMENT

- A. Reinforcement, Where Required: Comply with Section 03210 - Reinforcing Steel.

2.10 SILIENT WATERSTOP

- A. Resilient Waterstop: Comply with Section 03250 - Joints in Concrete Structures.

PART 3 EXECUTION

3.01 PREPARATION AND CURING

- A. Where repairs are made on wall surfaces exposed to view and above normal water surface elevation, installed repair material shall match adjacent concrete surface in color.
- B. Surface Preparation:
 - 1. Clean entire area to be repaired of laitance, foreign material and loose or deteriorated concrete by chipping, hydroblasting or sandblasting; further roughen surfaces as specified herein. Where non-shrink grout or repair mortar is used, perform any additional surface preparation steps recommended by the manufacturer.
 - 2. Where cementitious repair materials are used, maintain surfaces to be repaired in a saturated surface dry condition and prevent concrete from drying until repair operations are completed. Re-wet surfaces to be repaired by water spray on at least a daily basis. Remove standing water in areas to be repaired prior to placement of repair material. Provide means to remove excess water from the structure.
 - 3. Where repair material manufacturer recommends use of an epoxy-bonding agent, follow recommendations of both the repair material and epoxy bonding agent manufacturers.
- C. Fully consolidate repair material, completely filling all portions of areas to be filled.
- D. Bring repair surfaces into alignment with adjacent existing surfaces to provide uniform, even surfaces. Unless indicated otherwise, repair surfaces shall match adjacent existing surfaces in texture and receive coatings or surface treatments provided for adjacent existing surfaces.
- E. Curing:
 - 1. Cure repair mortar and non-shrink grout according to manufacturer's recommendations, except that minimum cure period shall be 3 days.
 - 2. Cure other materials in accordance with Section 03370 - Concrete Curing.

3. If manufacturer recommends use of a curing compound, use no material that would interfere with the bond of any coating or adhesive required to be applied to the surface.

3.02 TREATMENT OF SURFACE DEFECTS

- A. Definition - Surface Defects: Depressions in concrete surfaces not extending all the way through a member, caused by physical damage, un-repaired rock pockets created during original placement, spalling due to corroded reinforcing steel or other embeds, or removal of embedded items or intersecting concrete members.
- B. Preparation:
 1. Remove loose, damaged concrete by chipping to sound material.
 2. Where existing reinforcing bars are exposed, remove concrete at least one inch deep all around the exposed bars. If the existing bars are cut through, cracked, or cross-sectional area is reduced by more than 25 percent, notify the Owner's Representative immediately.
- C. Repair Material:
 1. Use only repair mortar to repair surface defects in members normally in contact with water or soil, and defects in interior surfaces of structures which are intended to contain water.
 2. Repair of other surface defects may be by application of repair mortar, repair concrete or cement grout, as appropriate.

3.03 PATCHING OF HOLES IN CONCRETE

- A. General:
 1. Definition - Holes: For the purposes of this section, holes are defined as penetrations completely through a concrete member, with interior surfaces approximately perpendicular to the surface of the existing member. Chip interior surface areas which are inclined and do not meet this criterion as necessary to meet this requirement.
 2. Perimeter of holes at the surface shall form a regular shape composed of curved or straight line segments. Provide at least the minimum placement depth specified for the material used at all locations. Score existing concrete by sawcutting and chip as needed to meet this requirement.
 3. Roughen the interior surface of holes less than 12 inches in diameter to at least 0.125-inch amplitude. Roughen larger holes to at least 0.25-inch amplitude.

4. At holes not filled with repair mortar or non-shrink grout, and where otherwise recommended by the repair material manufacturer, coat existing surfaces to be repaired with epoxy bonding agent.
5. Where a surface of a member is exposed to view and the repair material cannot be adjusted to match the color of the existing concrete, hold back the repair material 2 inches from the surface. Fill the remaining 2 inches with color-adjusted cement grout. Roughen the surface of the repair material when placed to improve bond with the cement grout.

B. Patching Small Holes:

1. Fill holes less than 12 inches in least dimension and extending completely through concrete members with repair mortar or non-shrink grout.
2. Fill holes in members normally in contact with water or soil with Class I non-shrink grout in accordance with Section 03600 - Structural Grout.

C. Patching Large Holes:

1. Fill holes larger than 12 inches in least dimension with repair concrete, repair mortar or non-shrink grout.
2. Provide large holes normally in contact with water or soil and not filled with Class I non-shrink grout with resilient waterstop placed in a groove approximately 0.25 inch deep ground into the interior edge of the hole at the center of the wall providing a smooth surface in which to place the resilient waterstop. Alternatively, bond bentonite waterstop to the surface using an epoxy grout which completely fills all voids and irregularities beneath the waterstop material. Install waterstop in accordance with Section 03250 - Joints in Concrete Structures.
3. Provide reinforcing steel in layers matching existing reinforcement locations, except provide concrete cover required by the Contract Documents for the applicable service condition.
4. For holes smaller than 48 inches, reinforcement shall be at least #5 bars on 12 inch centers in each layer required. At all holes larger than 30 inches, drill and grout the reinforcement into the existing concrete.
5. For holes larger than 48 inches, see the drawings for reinforcement details.

3.04 PATCHING OF LINED HOLES

- A. These provisions apply to openings which have embedded material over all or a portion of the inside edge. Requirements for repairing holes in concrete specified above shall apply as modified herein. The Owner's Representative will determine when the embedded material is allowed to remain.

- B. Where embedded material is allowed to remain, trim it back a minimum of 2 inches from the concrete surface. Roughen or abrade the embedded material to promote good bonding to the repair material. Completely remove any substance that interferes with good bonding.
- C. Completely remove embedded items not securely and permanently anchored in the concrete.
- D. Completely remove embedded items larger than 12 inches in least dimension unless composed of a metal to which reinforcing steel can be welded. Where reinforcement is required, weld it to the embedded metal.
- E. Following additional requirements apply to concrete in contact with water or soil.
 - 1. Fill lined openings less than 4 inches in least dimension with epoxy grout.
 - 2. Coat lined openings greater than 4 inches but less than 12 inches in least dimension with an epoxy-bonding agent prior to filling with Class I non-shrink grout.
 - 3. Coat lined openings greater than 12 inches in least dimension with an epoxy bonding agent and bond bentonite waterstop to the interior of the opening prior to filling with approved repair material.

3.05 INSTALLATION OF PIPES AND FRAMES

- A. The following applies to installation of permanent pipes and frames in openings cut into existing concrete members.
- B. Cut opening to a size which is a minimum of one inch and a maximum of 3 inches larger than the outside edge of the embedded item. At openings with sharp corners, take care not to sawcut beyond the opening so as to damage existing reinforcing bars. At openings which are greater than 24 inches in least dimension, chip a keyway into the center of the wall. Keyway shall be at least 1.5 inches in depth and from 3 inches to 1/3 the member thickness in width. All surfaces except at the keyway shall be perpendicular to the member surface as specified herein for patching holes.
- C. Provide embedded items with a flange or other positive means of anchorage to repaired members. At members in contact with soil or water, provide continuous waterstop flanges around embeds. Where concrete pipe will be embedded, provide resilient waterstop around pipe at wall centerline.
- D. Roughen the interior surface of openings to at least 1/4-inch amplitude. Sandblast the embed surface to be in contact with concrete clean to promote good bonding to the repair material.
- E. Fill the space between the frame and the existing concrete with Class I non-shrink grout.

- F. Where surface of a member is exposed to view and the repair material cannot be adjusted to match the color of the existing material, hold back the repair material 2 inches from the surface. Fill the remaining 2 inches with color-adjusted cement grout.

3.06 NON-FIXED INSTALLATION OF PIPES

- A. The following applies to installation through existing concrete of piping to be sealed with adjustable linked seals, resilient connectors, or packing and sealant. When more appropriate, the Owner's Representative may require installation of a sleeve instead of the core-drilled hole specified herein.
- B. Size core-drilled opening to permit installation of the required seal; locate to minimize cutting of existing reinforcing steel.
- C. Where linked or resilient seals are to be installed, coat the interior surface of the opening with epoxy at least 1/8 inch thick for a smooth and even surface promoting a good seal.
- D. Where packing and sealant are required, seal exposed reinforcing bars with at least an 1/8-inch thick layer of epoxy extending 1/2 inch beyond the bars on all sides. Prepare the surface of the cut concrete and the pipe as recommended by the sealant manufacturer.

3.07 GENERAL CRACK REPAIR

- A. Repair cracks identified by the Owner's Representative as caused by shrinkage or thermal movement by injection with chemical grout as specified herein.
- B. Repair cracks not caused by shrinkage or thermal movement by epoxy injection or as otherwise directed by the Owner's Representative.

3.08 CHEMICAL GROUT CRACK REPAIR

- A. Inject chemical grout into all cracks as directed by the Owner's Representative in those structures included in the scope of work listed herein in accordance with the chemical grout manufacturer's installation instructions and recommendations.
- B. Location of Injection Ports: Locate injection ports as recommended by the chemical grout manufacturer and as needed to insure complete penetration of the joint or crack with the grout. Spacing of injection ports shall not exceed 2 feet.
- C. Drilling Ports: Drill holes for injection ports to the depth needed for proper distribution of the chemical grout. Take care to not damage any reinforcing steel.
- D. Port preparation: Clean holes for injection ports of all debris and fit with an injection fitting as provided by the manufacturer of the chemical grout, or equal. Install injection fittings in accordance with manufacturer's instructions; allow fittings to

remain in place until chemical grout injection work is complete in that area. Install caps or valves at injection ports to prevent back flow of uncured chemical grout after it has been injected.

E. Chemical Grout Injection:

1. Follow instructions and recommendations of the chemical grout manufacturer and its representatives for chemical grout mixing and injection procedures.
2. Seal cracks at the surface where needed to assure complete penetration of injected chemical grout and prevent loss of material.
3. Prior to chemical grout injection, inject water into ports to provide water for the reaction process, flush out foreign matter and verify continuity between adjacent ports. Inject water into each port until it begins to flow from an adjacent or nearby port.
4. If the water injection procedure indicates the potential presence of voids within members or behind members resting against soil, notify the Owner's Representative immediately.
5. Beginning at the lowest injection port, inject chemical grout until the grout begins to flow from an adjacent or nearby port. Repeat the process until the crack is completely filled. In general, port-to-port travel of the injection process will be from low to high in a continuous operation.
6. If port-to-port continuity does not occur at locations where continuity was verified through water injection, mark location and notify the Owner's Representative.
7. Avoid sudden application of high pressure during the injection process.
8. After completion of the grouting operation, remove all ports and surface sealing materials leaving an undamaged surface.

3.09 EPOXY CRACK REPAIR

- A. Inject epoxy into all cracks in damaged concrete as indicated by the Owner's Representative in structures included in the scope of work listed herein. Follow installation instructions and recommendations of the epoxy manufacturer.
- B. Inject cracks with sufficient pressure to ensure full penetration of epoxy but without causing further damage.
- C. Location, drilling and preparation of ports for injection: As specified for chemical grout herein.
- D. Epoxy Injection:

1. Follow instructions of the epoxy manufacturer and its representatives for all mixing and injection procedures.
2. Seal all cracks at the surface where needed to provide for complete penetration of the injected epoxy and to prevent loss of material.
3. Beginning at the lowest injection port, inject the epoxy until it begins to flow from an adjacent or nearby port. Repeat the process until the crack is completely filled.
4. If port-to-port continuity does not occur, mark the location and notify the Owner's Representative.
5. Avoid sudden application of high pressure during the injection process.
6. After completion of injection operations, remove all ports and surface sealing materials to leave an undamaged surface.

3.10 REPAIR OF DETERIORATED CONCRETE

- A. These provisions pertain to concrete damaged by abrasion, chemical attack or corrosion of reinforcing steel. The only material acceptable for surface repair is repair mortar as specified herein. Where the repaired surface is to be subsequently covered with a PVC liner or other protective material, coordinate finishing details with the liner material manufacturer.
- B. Surface Preparation:
 1. Remove loose, broken, softened and acid-contaminated concrete to sound, uncontaminated concrete.
 2. Notify the Owner's Representative when removal of deteriorated concrete is complete. Schedule two weeks for the Owner's Representative to inspect the surface, perform testing for acid contamination, determine if additional concrete must be removed, and to develop any special repair details that may be needed. Should it be determined that additional concrete must be removed to reach sound, uncontaminated material, schedule another two-week period for further evaluation after completion of the additional removal.
 3. Follow repair mortar manufacturer's instructions for additional surface preparation.
- C. Repair Mortar Placement:
 1. Follow manufacturer's recommendations for mixing and placement of repair mortar. After the initial mixing of the repair mortar, do not add additional water to change the consistency should the mix begin to stiffen.

2. Place repair mortar to the minimum thickness recommended by manufacturer but not less than 2 inch. Should there be areas where less than the minimum repair mortar depth of concrete is removed, Contractor may remove additional concrete to attain the minimum repair mortar thickness or may place repair mortar so as to increase the original thickness of the member. In any case, add repair mortar so that minimum cover over existing reinforcing steel is 2 inches. Do not place repair mortar so as to create locally raised areas. Where there is a transition with wall surfaces which are not in need of repair, do not feather the repair mortar at the transition. Sawcut a score line to not less than the minimum repair mortar depth and chip concrete out to it to form the transition. Take care not to cut or otherwise damage reinforcing steel.
 3. Finish repair mortar in an even, uniform plane to restore the member to its original surface. Out-of-plane tolerance: No localized depressions or projections; 0.25 inch maximum gap between repair mortar surface and a 10-foot straight edge in any orientation at any location.
- D. Finishing:
1. Apply a smooth magnesium float finish to repair mortar.
 2. When completed: No sharp edges. Exterior corners, such as at penetrations: One-inch radius. Interior corners: Square, except 2-inch repair mortar fillet at corners to receive PVC lining.

END OF SECTION