SECTION 00542 - CONCRETE REPAIR

(Follow all instructions. If there are no instructions above a subsection, paragraph, sentence, or bullet, then include it in the project. The specifications may be modified to include project specific specifications, but all additions, deletions, or modifications must be sent to the ODOT Technical Resource and State Specifications Engineer for review and approval.)

Section 00542, which is not in the Standard Specifications, is included in this Project by Special Provision.

Description

00542.00 Scope - This Work consists of locating and repairing damage concrete and reinforcement in Structures, and providing mortar or resin buildup over shallow reinforcement.

00542.01 Definitions:

(Delete the "Anode" paragraph if no anodes are used on the project).

Anode - A galvanic unit consisting of a sacrificial zinc core and a cementitious mortar outer cover for corrosion prevention and on-going corrosion control of surrounding reinforcing steel.

Damaged Concrete - Concrete that is spalled or delaminated due to corroded reinforcement or metal appurtenances such as bearing devices, drains, and conduits; concrete that is debonded from corroded reinforcing bars; concrete with near-surface rock pockets; unsound or delaminated existing patches; and concrete that has been drilled, excavated, or removed during prior maintenance work or during the Work of this Contract.

Hand Patch - Installing hand-troweled repair mortar in concrete cavities up to 0.50 square foot surface area.

Pumped Repair - Installing pumped repair mortar in concrete cavities greater than 0.50 square foot surface area.

Saturated Surface Dry Condition - Surface condition where hardened concrete is thoroughly saturated with water, but any free water has been removed from the surface.

Shallow Rebar - Steel reinforcement with 1/2 inch or less of concrete cover.

00542.02 Submittals - Submit the following at least 21 Calendar Days before beginning concrete repair Work according to 00150.37. Within 21 Calendar Days after receipt of submittals, the Engineer will review the submittals and designate them in writing as "approved", "approved as noted", or "returned for correction".

(a) Concrete Repair Mortar - Submit before concrete repair work the following:

- A description of all relevant constituents and properties of the material. Data published by manufacturer is acceptable unless certifications of the material characteristics are required by the Specifications.
- For prepackaged products, the manufacturer's certification that the contents include cement and Aggregate and do not include silica fume, fly ash, or any other porosity-reducing admixture. Provide the proportion (by weight) of portland cement to Sand according to the provisions of 00165.35.
- The Specifications subsection with which each repair mortar complies.
- If proposing alternative repair mortar to those specified in 00542.10, test data demonstrating compliance with 00542.10.

For alternate repair mortar submit three 4 by 8-inch cylinders of repair mortar cast in the presence of the Engineer using the proposed mix proportions, admixtures, and mixing and application Equipment, at least 10 Calendar Days before starting concrete repair Work. Cast and cure the cylinders according to AASHTO T 23 or R 39.

Submit records of mix proportions and which mix design was used in each repair location. Maintain and provide records that are complete enough to be able to match repaired areas with the mix records.

(b) Concrete Repair Procedure - Prior to beginning Work under this Section, submit a concrete repair procedure that includes the following:

- Manufacturer's specifications and operating instructions for all Equipment.
- Details of each step to accomplish the Work.
- Steps to regularly maintain quality control of all newly applied mortar.
- Plan to maintain records of verification of proportion (by weight) of Sand to portland cement and quantity of any additives for all mortar mixed on-site.
- Plan to maintain records identifying the mix design for each repaired area.

(c) Repair Damaged Reinforcing Bars - Submit a plan for accomplishing reinforcing bar repair that includes the following:

- Welder certifications according to AWS D1.4
- Pre-approved welding procedure specification (WPS) or procedure qualification record / welding procedure specification (PQR/WPS)
- Detailed procedure for electrode control measures
- Detailed procedure for achieving, maintaining, and monitoring pre-heat and inter-pass temperatures.

00542.03 Pre-welding Conference - Before beginning concrete repair Work, meet with the Contractor's supervisory personnel, concrete repair Subcontractor's supervisory personnel, the Contractor's certified welding inspector (CWI), and the Engineer at a mutually agreed upon time. The pre-welding conference includes discussion of the Contractor's quality control responsibilities, documentation requirements, welding procedures and Equipment, and demonstration of welder skills.

Materials

00542.10 Patch Material:

(a) Pumped Repair Mortar - Provide one of the following mortars with the required admixture as specified in 00542.15.

- Pumped BASF MasterEmaco S 440MC (formerly BASF LA Repair Mortar).

Alternative repair mortar conforming to the following:

- Non-polymer flowable micro-concrete
- Suitable for pumping
- At least 4,000 psi 28-Day compressive strength
- "Low" potential for cracking and no cracking in 28 Calendar Days when tested according to ASTM C1581, including Appendix
- Electrical resistivity in the range of 2,000 to 20,000 ohm-cm

Submit proposed alternative Materials for approval according to 00542.02.

(b) Hand Patch Material - Provide hand patching Materials according to 02015.20 or 02015.30. Observe QPL remarks and follow the manufacturer's recommendation for application.

00542.11 Non-conductive Resin - Non-conductive resin is acceptable for filling cavities of 0.05 square feet or less and for resin buildup over Shallow Rebar in sound concrete. Furnish a non-conductive resin from the category "Concrete Anchor, Resin HS High Strength" of the QPL, mixed at a 1:1 ratio with clean abrasive blasting Material.

00542.12 Abrasive - Furnish clean, dry, non-metallic grit abrasive material with no mineral constituents that break down and remain on the surface in visible quantity. Furnish hard angular shaped abrasives from 16 - 30 mesh.

00542.13 Water - Furnish water according to Section 02020.

00542.14 Reinforcement and Added Steel - Furnish ASTM A706 Grade 60 uncoated reinforcing bars conforming to 02510.10. Furnish uncoated, ungalvanized welded wire fabric conforming to 02510.40. Other metal embedded in the mortar to facilitate concrete replacement shall be uncoated and ungalvanized.

00542.15 Admixtures - Use only admixtures approved by the Engineer.

If using admixtures to reduce the water-cement ratio, or to retard or accelerate the development of strength, use only admixtures compatible with the mortar and at the rate specified by the manufacturer.

000542.16 Hollow Wall Anchors - Furnish the following plastic hollow wall anchors:

- Powers 2345 Nylon Zip-It
- Simpson Strong Tie SWN06 Nylon Sure Wall Drywall Anchor
- ITW Red Head EZP100 Nylon E-Z Drywall Anchor

(Use the following subsection .17 when zinc Anodes are required.)

00542.17 Galvanic Zinc Anode - Furnish one of the following galvanic zinc Anodes:

Galvashield XP2 (100 grams zinc)
Vector Corrosion Technologies
2237 Twelve Oaks Way, #103
Wesley Chapel, FL 33544
(813) 830-7566
Fax (813) 830-7565
www.vector-corrosion.com

Sentinel Silver (100 grams zinc)
The Euclid Chemical Company
19218 Redwood Rd.
Cleveland, OH 44110
(216) 531-9222
Fax (216) 531-9596
www.euclidchemical.com

Emaco CP Intact Blue (105 grams zinc)
BASF The Chemical Company
889 Valley Park Drive.
Shakopee, MN 55379
(800) 433-9517 (Customer service)
www.BuildingSystems.BASF.com

Labor

00542.30 Welders - Provide certified welders and welding inspectors according to AWS D1.4.

Construction

00542.40 Work Access, Containment, and Disposal - Provide Work access and debris containment according to Section 00253.

Dispose of waste according to 00290.20.

00542.41 Locating and Marking - Locate and mark the following:

- All concrete having visible spalling or delamination due to corrosion of reinforcement or metal appurtenances such as bearing devices, drains, and conduits. Include within the repair boundaries all Damaged Concrete at the edges of spalls.
- All visible unsound patches of material.

- All concrete that is visibly loose, or that becomes dislodged or loosened when struck with a 16-ounce masonry hammer or by other approved technique.

Verify the presence of steel with a metal detector.

The Contractor is advised that concrete containing Aggregate larger than 2 inches can cause false readings. If no steel is present, readings in such areas should be disregarded.

Investigate all spots of rust visually and with a metal detector to determine if a metallic object is present. If a metal object is present mark the location.

In areas where spalling or delamination is not visually detectable, but is indicated by sounding, use a rebar locator and mark reinforcing bars and their minimum concrete cover. Remove a 4 inch wide (perpendicular to the bar) exploration area centered over the bar. The exploration boundary area shall have an initial length of 8 inches if splitting cracks are present directly over and parallel to reinforcing bar and suggest a potential for corrosion; remove as much splitting crack length as needed until clean bar is exposed. If rust scale or pitting is found on the exposed reinforcing bar, or if the remaining concrete is separated from the bar, mark the Damaged Concrete area for removal.

Do not use internal angles less than 45 degrees in defining the repair boundaries. Make all repairs at least 2 inches wide in each direction. Within these restrictions, mark boundaries such that repair areas can be efficiently sawed and excavated.

Determine and mark the location and extent of each repair excavation. Do not begin concrete removal until location and extent have been verified by the Engineer.

The Engineer will perform verification surveys of selected sections of the Work and determine the final quantity of repairs. Do not begin excavation until the Engineer has completed the verification surveys.

00542.42 Concrete Removal - Saw-cut the boundaries of concrete to be removed, to a depth just missing the reinforcing bars with less than 1/2 inch concrete cover or to a minimum of 1/2 inch, whichever is less. Saw cuts shall not overrun at the corners of the marked boundaries. Saw cutting is not required if the Contractor can consistently provide, by another technique, a minimum 1/2 inch deep excavation surface that is uniformly perpendicular to the original concrete surface along the marked boundary.

Remove concrete within the marked boundaries with high-pressure waterjet blasting Equipment, pneumatic hammers, chipping guns, manual picks and chisels, or other Equipment approved by the Engineer. Do not use pneumatic hammers heavier than a nominal 15-pound class. Remove concrete in such a way that removal of sound concrete beyond established boundaries is kept to a minimum. When working around reinforcing bars, avoid loosening the reinforcement or fracturing the concrete around it beyond the repair area.

Remove all Damaged Concrete within the marked boundaries to the depth of sound concrete. In areas where the reinforcing bar lacks bond with the existing concrete, continue to excavate to 1/2 inch beyond the depth of the reinforcing bar. In areas where it is difficult to determine if the reinforcing bar lacks bond with the existing concrete do not excavate beyond the depth of the reinforcing bar if a 4 inch wide exploration area shows the

reinforcing bar to be free of rust scale or pitting and the reinforcing bar is not separated from the remaining concrete.

The depth of concrete damage, due to corrosion, in any member is not expected to be substantially greater than 1/2 inch beyond the depth of the reinforcing bar.

Do not remove sound concrete over Shallow Rebar.

00542.43 Repair Damaged Reinforcement Bars - Repair reinforcing bar showing 50 percent or greater section loss according to the following:

- Remove all Damaged Concrete
- Remove sound concrete as necessary so that there is a minimum of 3/4 inch clearance between the concrete and splice bars over entire length of repair
- Blast-clean all exposed reinforcing steel and concrete
- If feasible, place splice bars so as to allow 1/2 inch of concrete cover without raising the concrete surface
- Perform all weld splicing according to ANSI/AWS D1.4, “Structural Welding Code - Reinforcing Steel”. Since the carbon content of existing reinforcement is unknown, assume that preheating is required under ANSI/AWS D1.4. Limit the temperature of reinforcing bar at concrete interface to 500 °F or less, verified using an infrared thermometer.
- Remove any additional concrete that cracks or spalls during welding
- Keep the existing spliced bars in place and avoid gouging and loosening reinforcing bar or damaging sound concrete outside of splice areas
- Keep the splice bar in the proper position during placement of concrete cover

Repair round bars with new splice bars the same size as the original bars. Repair square bars with new round splice bars with a diameter equal to the thickness of the square bars.

00542.44 Shallow Rebar in Sound Concrete - If Shallow Rebar exists in sound concrete and passes the sounding test, no concrete repair is necessary.

00542.45 Shallow Rebar in Damaged Concrete - Where directed, treat prefabricated mesh and other closely spaced shallow metals in the same manner as Shallow Rebar in Damaged Concrete. Place additional cover Material over Shallow Rebar in Damaged Concrete according to the following:

(a) Mortar Buildup ~~on~~ over Shallow Rebar - Place additional mortar as needed to achieve at least 1/2 inch of cover over Shallow Rebar repairs.

(b) Resin Buildup ~~on~~ over Shallow Rebar - In areas where additional buildup is not feasible, or where buildup would detract from the aesthetic appearance of the Structure, provide additional cover using non-conductive resin conforming to 00542.12. Apply the resin in 2 inch wide strips over the Shallow Rebar.

00542.46 Surface Preparation - Abrasive-blast or water-blast all concrete surfaces that are to receive additional mortar cover or patches, to remove all debris, loose concrete, concrete pulverized during removal, scale, and loose rust. Blast exposed reinforcing bars

according to SSPC Standard SP6 “Commercial Blast Cleaning” or equivalent procedure. Do not allow prepared surfaces to remain exposed more than 36 hours before placing repair mortar.

Prepare surfaces that are to receive additional mortar or resin cover with a surface profile according to International Concrete Repair Institute (ICRI) Guideline 310.2R-2013 surface profile CSP 6 (1/8 inch surface profile).

Provide hollow wall anchors for concrete surfaces that are to receive more than 1 inch of repair mortar and have reinforcing bar spacing greater than 9 inches. Install anchors by drilling 1/4 inch diameter holes 1/2 to 3/4 inch deep on a 9 inch (maximum) grid in the concrete substrate. Apply non-conductive resin and insert anchors. Remove excess resin from the concrete substrate.

(Delete the following subsection .47 if no Anodes are used on the project. Do not re-number subsequent subsections.)

00542.47 Anode Installation - Install galvanic zinc Anodes in Damaged Concrete repair locations that have scaled or pitted reinforcement bar with a high probability of recurring corrosion. Place an Anode in the edge of the patch area within the vicinity of the corroded reinforcement. Securely fasten the Anode to clean reinforcing steel using a suitable wire twisting tool to eliminate free movement, and to ensure electrical continuity. Confirm continuity using an ohmmeter. Electrical resistance between the Anode wire and adjacent reinforcement shall be 2.0 ohms or less. Install Anodes in a 24 inch grid, on center. Adjust spacing where intersecting reinforcement does not allow for 24 inches and maintain 14 inches minimum and 24 inches maximum spacing. Install a single Anode in directions where less than 30 inches of reinforcement is exposed. Install Anodes according to the Anode manufacturer’s recommendations and cover with patch Material within 24 hours after removing the Anode from its original packaging. Provide a minimum of 3/4 inch coverage over Anodes.

00542.48 Patch Installation:

(a) Forms - Provide smooth-surfaced form Materials. Provide adequate support and bracing of forms to prevent deflection under the weight and pressure of new mortar, and to prevent vibration damage to mortar during setting and curing. Leave forms in place for a minimum of 3 Days after mortar placement.

Provide watertight form Materials and a watertight form system to prevent loss of water during presoaking and repair mortar placement. Incorporate enough pumping ports to ensure consistent placement and enough vent holes or vent tubes to allow air to escape extreme surface irregularities and remote cavities. Limit port spacing to prevent mortar segregation.

Provide forms that can readily be removed and reinstalled for presoaking, flushing, blowdown, and for verification of Surface Saturated Dry Condition.

(b) Pre-soak - Saturate the substrate concrete for at least 24 hours before application of repair mortar. Use either a watertight form kept full of water; saturated burlap or foam Material packed inside the forms, in contact with the entire existing concrete surface,

and soaked frequently; or any other method demonstrated to produce Saturated Surface Dry Condition.

After the substrate has been saturated, temporarily remove the form and, immediately before placing mortar, remove all dust, dirt, and other debris by flushing the surface with water pressurized to at least 60 psi, followed by blasting with clean compressed air to remove excess water. Provide a damp surface free of standing water and free of contaminants when applying repair mortar. Light surface rust that appears during the pre-soak stage does not need to be removed. When the concrete surface is in Saturated Surface Dry Condition and free of contaminants, and reinforcement is clean or has only light surface rust, immediately reinstall the forms and place mortar.

(c) Mixing - When a package of prepackaged repair mortar is opened, mix the entire contents of the package.

Mix repair mortar according to the manufacturer's instructions including, but not limited to, mixing speed, mixing time, and mixing Equipment.

(d) Placing Repair Mortar - Pump repair mortar and achieve thorough and uniform hydration without the use of excess water.

Do not place mortar before acceptance of Saturated Surface Dry Condition by the Engineer.

Do not place mortar during freezing weather or if temperatures are likely to drop below freezing during the cure period for the mortar. Do not apply mortar to frosted surfaces. Follow the manufacturer's recommendations regarding temperature and weather conditions during mortar placement.

Provide adequate pumping pressure into each port to ensure mortar completely fills the cavity and mortar is observed at all vents. Vibrate only if approved by the Engineer in advance.

(e) Adjacent Surface Protection - Protect surfaces outside the repair area from mortar overshoot and drip. Remove the excess Material from these areas after the application has been completed.

(f) Mix Records - Record proportion (by weight) of Sand to portland cement and the quantity of any additives for all mortar mixed on-site at the start of each mortar placement operation and every time proportions or additives are changed. Keep a record of which mix is used for each repair area.

00542.49 Curing - Take care to avoid cracks in the new mortar due to excessive surface evaporation. Continuously cure all newly applied mortar according to the manufacturer's recommended curing schedule.

00542.50 Finish - Finish all exposed surfaces and surface defects to straight and true lines as shown. Provide a Class 2 surface finish according to 00540.53 on all exposed surfaces and a general surface finish according to 00540.53 on all other surfaces, with no coating on any surface unless otherwise directed.

00542.51 Delamination Survey - After mortar repair Work has cured, conduct a delamination survey of all repaired areas with the Engineer according to the following:

- Sound all repaired areas with a 1-pound masonry hammer or by other approved technique.
- Mark boundaries of all delaminations in the repaired areas.
- Identify the marked delamination that needs patching.

Make repairs when delamination repair areas do not meet the acceptance criteria of 00542.52.

Upon completion of the survey, prepare and sign a survey report that identifies all areas to be patched. Submit the survey report for review and acceptance by the Engineer. Repair the identified areas in a manner satisfactory to the Engineer.

After patching the identified areas, repeat the delamination survey. Repeat the delamination survey and repair procedure until all areas of unsound concrete have been repaired and accepted.

Following the bond strength test of cores according to 00542.52(b), the Engineer will visually inspect the cores for sand pockets and voids. If sand pockets or voids are found, the area from which the core was taken will be marked by the Engineer to aid in the Contractor's delamination survey.

00542.52 Production Quality Control Testing - Acceptance of Work performed under this Section will be according to the following tests:

(Fill in the blank in the first sentence below. For small estimated repair work area projects use an area value that will provide desired number of test samples. For single-span bridges, use the default value of 100 SF. For medium to large structures, proportion the estimated repair work area to result in a minimum of three samples taken on each primary bridge segment, such as approach span or main span.)

(a) Compressive Test - For each _____ square feet of mortar placed on the Bridge, but not less than once per production Work shift, cast at the same time and under the same conditions three 4 by 8 inch cylinders for testing. Cast the cylinders in single-use plastic molds. Cast and cure strength specimens according to AASHTO T 23 or AASHTO R 39. Test the cylinders for compressive strength according to AASHTO T 22 following a 28-Day cure.

(Fill in blank in the sentence below. At a minimum, use the design compressive strength of concrete in the existing structure (if available) or the value determined for load rating. If field testing on an existing structure determines a higher concrete strength, use that value.)

The minimum acceptable 28-Day compressive strength of cylinders is _____ psi.

(Fill in the blank in the sentence below. For small estimated area projects use an area that will provide desired number of test samples. For single-span bridges,

use the default value of 100 SF. For medium to large structures, proportion the estimated repair work area to result in three samples being taken on each primary bridge segment, such as approach span or main span.)

(b) Pull-off Test - Following a 7-Day cure of the mortar patch, core one test specimen from each _____ square feet of newly applied mortar placed on the Bridge surface, at locations designated by the Engineer. Locate cores to avoid damaging reinforcing bar. Core approximately 1/2 inch into the original concrete. Do not break cores free before testing. Perform pull-off tests of the cores 14 to 24 Calendar Days after placement and in the presence of the Engineer.

Measure the core bond strength according to ASTM C1583. Use pull-test dollies with the same diameter as the cores. Conduct the test until failure.

The minimum acceptable bond strength between the new and original concrete is 175 psi.

If the test shows failure at less than 100 psi, retest after checking Equipment and verifying core angle is perpendicular to the surface. If the patch area is too small for another test, use alternate patch location. If the retest shows failure at less than 100 psi, then a pull-off test may be performed on in situ concrete substrate in the vicinity of the patch area to determine the existing concrete substrate tensile strength. If in situ concrete substrate fails at 100 psi or less, the Engineer will re-evaluate the original concrete substrate.

Individually seal the cores taken from the Bridge in plastic bags and tag them for identification.

If any quality control test fails to meet the minimum requirements, any or all repair mortar represented by that test may be rejected by the Engineer.

00542.53 Deficient Repair Mortar - Repair, at no additional cost to the Agency, all mortar patches that show an alligator cracking in the surface or uncontrolled cracks visible without magnification. Perform additional testing as directed to determine the extent of deficient mortar in the production test area represented. If additional patches are found to be deficient, repair the production test area represented according to the Specifications at no additional cost to the Agency. Repairs include, but are not limited to, removal and replacement of patches found to be substandard.

Repair small crevices a maximum of 0.4 inch deep and 0.1 inch wide at the edge of a patch with non-conductive resin mixed with abrasive blasting Material or other approved patch Material, at no additional cost to the Agency. Cut out pockets or other defects and replace with new repair mortar according to this Section.

Measurement

00542.80 Measurement - The quantities of Work performed under this Section will be measured according to the following:

(Delete the items not used on project. Re-alphabetize the remaining items as needed after deletion. In paragraph (a), insert the estimated quantity provided by the Designer.)

(a) Locate ~~Damaged~~ Concrete Repair - No measurement of quantities will be made for locating ~~Damaged Concrete~~concrete repairs. The estimated quantity of locat~~ing~~ ~~Damaged Concrete~~concrete repairs is _____ square feet.

(b) Reinforcing Bar Repair ~~Damaged Reinforcing Bar~~ - Repair of damaged reinforcing bar will be measured on the unit basis, per each.

(c) Concrete Repair ~~Damaged Concrete~~ - Concrete r~~R~~epair of ~~Damaged Concrete~~ will be measured on the area basis. Measurement will be the outside measurement of the area of Work marked for concrete repair, not including areas marked for mortar buildup ~~on~~ over Shallow Rebar, after locating ~~Damaged~~ c~~C~~oncrete repair and before concrete removal Work. The area of Work marked for concrete repair does not include initially sound concrete that is damaged or micro-fractured by the Contractor's operations.

(d) Mortar Buildup ~~on~~ over Shallow Rebar - Mortar buildup ~~on~~ over Shallow Rebar will be measured on the area basis. Measurement will be the outside measurement of the area of Work marked for mortar buildup after locating ~~Damaged~~ c~~C~~oncrete repair and before concrete removal Work. The area of Work marked for mortar buildup does not include initially sound concrete that is damaged or micro-fractured by the Contractor's operations.

(e) Resin Buildup ~~on~~ over Shallow Rebar - Resin buildup ~~on~~ over Shallow Rebar will be measured on the area basis. Measurement will be the outside measurement of the area of resin in place.

(f) ~~Install~~ Zinc Anode Installation~~s~~ - Installation~~ing~~ of zinc Anodes will be measured on the unit basis, per each.

Payment

00542.90 Payment - The accepted quantities of Work performed under this Section will be paid for at the Contract unit price per unit of measurement for the following item(s):

(Delete Pay Items not used on the Project. Re-alphabetize as needed after deletion.)

Pay Item	Unit of Measurement
(a) Locate ~~Damaged~~ Concrete Repair	Lump Sum
(b) ~~Repair Damaged~~ Reinforcing Bar Repair	Each
(c) ~~Repair Damaged~~ Concrete Repair	Square Yard
(d) Mortar Buildup ~~on~~ over Shallow Rebar	Square Yard
(e) Resin Buildup ~~on~~ over Shallow Rebar	Square Yard
(f) ~~Install~~ Zinc Anodes Installation	Each

Payment will be payment in full for furnishing and placing all Materials, and for furnishing all Equipment, labor, and Incidentals necessary to complete the Work as specified.

No separate or additional payment will be made for providing mix proportion or mix design records.

No payment will be made for repair of initially sound concrete that is micro-fractured or otherwise damaged by the Contractor's operations.