

Building Name
The Description of the Project
P00000000 0000

SPECIFICATION DIVISION 3

NUMBER SECTION DESCRIPTION

DIVISION 03 CONCRETE

SECTION 037300 - TUNNEL CONCRETE RESTORATION

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DIVISION 03 CONCRETE

SECTION 037300 - TUNNEL CONCRETE RESTORATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Locate and remove delaminated, spalled and unsound concrete.
 - 2. Preparation of cavities created by removal to receive patching materials.
 - 3. Replacement of existing deteriorated concrete and reinforcement.
 - 4. Crack repair.
 - 5. Temperature, ventilation and humidity control per manufacturers recommendations for proper curing.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASTM:
 - a. A185 - Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
 - b. A615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - c. A775 - Epoxy-Coated Reinforcing Steel Bars.
 - d. C33 - Concrete Aggregates.
 - e. C94 - Ready-Mixed Concrete.
 - f. C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or Cube Specimens).
 - g. C136 - Sieve Analysis of Fine and Coarse Aggregates.
 - h. C150 or C595 - Cementitious material.
 - i. C260 - Air-Entraining Admixtures for Concrete.
 - j. C309 - Liquid Membrane Forming Compounds for Curing Concrete.
 - k. C494 - Chemical Admixtures for Concrete.
 - 2. ACI:
 - a. 301 - Specification for Structural Concrete for Buildings.
 - b. 302 - Guide for Concrete Floor and Slab Construction.
 - c. 308R - Guide to External Curing of Concrete.
 - d. 390R - Guide to Consolidation of Concrete.
 - e. 347R - Guide to Formwork for Concrete.
 - f. 503.2 - Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive.
 - g. 503R - Pull Off Test to Determine CFRP Adhesive to Concrete Substrate.

- h. 546.1 - Guide for Repair of Concrete Bridge Superstructures.
- 3. US Corps of Engineers:
 - a. EM - 1110-2-2002 - Corp of Engineers Manual.
- 4. International Concrete Repair Institute (ICRI).

1.4 DEFINITIONS

- A. Delaminations: Fracture planes or "internal cracks," within concrete. Typically these fractures are parallel to the member face and vary in depth.
- B. Spalls: Potholes, cavities or voids in floor slabs, beams, columns, and walls. Usually result of delamination migrating to face of concrete member. When fracture finally reaches surface, concrete encompassed by delamination breaks away, resulting in spall.
- C. Unsound Concrete: Concrete exhibiting one or more of the following:
 - 1. Incipient fractures present beneath existing delaminated or spalled surfaces.
 - 2. Honeycombing.
 - 3. Friable or punky areas.
 - 4. Deterioration from freeze-thaw action.
- D. Scaling: Deterioration which attacks mortar fraction (paste) of concrete mix. First appears as minor flaking and disintegration of concrete surface. Scaling eventually progresses deeper into concrete, exposing aggregate which breaks away. Concrete scaling is caused by freeze-thaw action. If concrete is frozen in saturated state, excess water freezing in concrete causes high internal stresses.
- E. Saturated Surface Dry (SSD): The condition where the concrete is saturated with water and cannot absorb more, but no free water is present on the surface and is in accordance with the ICRI recommendations.

1.5 SUBMITTALS

- A. Product Data:
 - 1. For manufactured materials and products including reinforcement and forming accessories, concrete materials, shot Crete materials, admixtures, and curing compounds.
 - 2. Shop drawings: for details of fabricating, bending, and placing reinforcement. Include support anchor details, number and location of splices, and special reinforcement required for openings.
 - 3. MSDS safety data sheets for each product
 - 4. Design mixes: For each concrete or shot Crete mix
 - 5. Material test reports: For concrete or shot Crete materials
 - 6. Material Certificates: for each material item, signed by manufacturers. Include specifications and recommended application procedures showing compliance with the project requirements.
 - 7. Provide MSDS material safety sheets for products used.

8. Provide either an approved ICBO Evaluation Report number in the name of the system and system's Manufacturer, or an evaluation by independent testing facility.
9. Product Suitability:
 - a. Submit signed letter from Product Manufacturer's technical representative stating that they have visited the Site, reviewed conditions and agree that the products specified are suitable for this application.
 - b. The letter shall certify that the Product Manufacturer's technical representative:
 - 1) Is familiar with the project, aware of job conditions and aware of associated products (i.e., sealants, concrete repair products and other proposed for the Project).
 - 2) Agrees with the intended application of their products as specified.
 - 3) Agrees with the surface preparation specified.
 - 4) Agrees with project specifications. If necessary, submit revisions to project specifications.
 - 5) Agrees that their product is compatible with associated products (i.e., sealants, concrete repair materials and other proposed for the Project).
 - 6) Agrees with the type and quantity of testing specified to ensure their product is adequately installed.
 - 7) Agrees that all components of concrete repair materials furnished comply with this Specification and are compatible.
 - 8) Agrees with proposed means to assure proper curing of the repair material.
- B. Surface Preparation Method: Submit details of preparation method to Engineer for review prior to commencing work.

1.6 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 1. Contractor shall have not less than 5 years of experience in the field of structural concrete restoration. The installer shall have completed concrete work similar in material, design, and whose work has resulted in construction with a record of successful in-service performance.
 2. Knowledgeable of the design and the reviewed Shop Drawings.
 3. Each component of a system or product shall be installed by Manufacturer trained personnel. Installers shall demonstrate knowledge of product and installation. Provide Manufacturer's certification of the applicator's training and experience with the systems to be installed.
- B. Manufacturer's Services:
 1. Provide 4 hours of product Manufacturer's technical representative for start-up of application for each repair product in each work site as defined in the documents. Review the work to be performed with the applicator and the Engineer's Site representative.

2. Manufacturer's technical representative shall certify in writing for each site or area of work, that the preparation and installation procedures are in accordance with the manufacturer's directions.
- C. Formwork: Design of the formwork is the responsibility of the Contractor. Proposed method of forming shall be submitted to Engineer for review prior to placement of concrete. Submitted method shall include materials and means of bracing and sealing formwork. Design shall provide adequate means of ensuring complete filling of forms with concrete through the use of birdmouths or other methods. Refer to ACI 347R for assistance with design of formwork.
- D. Testing:
1. Concrete and Prebagged Mixes:
 - a. The Owner will engage and pay for a testing laboratory approved by the Engineer and Owner.
 - b. Testing will be performed both by the Engineer, and by the testing agency selected and employed by the Owner.
 - c. Contractor shall cooperate fully with the Engineer and the testing agency while they perform testing.
 - d. Contractor shall include as incidental, the cost for additional material, time and expense; and repair cost to allow the testing to be performed.
 - e. The representative of the testing agency shall be at the Site for sampling, inspection and testing during concrete repair placement.
 - f. Concrete Repair:
 - 1) Compressive strength, slump and concrete temperature tests shall be performed at the point of placement for each batch of redi-mixed concrete and prebagged repair mixes used each day.
 - 2) 3 x 6 compressive strength test specimens shall be molded in accordance with ASTM C31 and tested in accordance with ASTM C39.
 - 3) Slump and temperature tests shall be performed in accordance with ASTM C143 and C1064, respectively.
 - 4) 2 cylinders minimum per set of specimens shall be tested for compressive strength at 7 days and 2 cylinders minimum shall be tested for compressive strength at 28 days.
 - 5) 2 reserve cylinders shall be molded for testing at later ages if required.
 - g. Trowel Applied Prebagged Mixes: 1 set of three 2-inch cubes shall be made from each prebagged mix placed each day and tested by the Owner's testing laboratory in accordance with ASTM C109 and Manufacturer's requirements.

1.7 QUALITY CONTROL

- A. Work Oversight:
1. Pre-Repair Area Preparation:
 - a. Perform demolition and repair preparation for review and approval by the Engineer and Project Representative:
 - 1) Sawcut and remove deteriorated concrete.
 - 2) Clean exposed reinforcing.

- 3) Splice reinforcing if needed.
- 4) Install crack injection ports.
- 5) Rout cracks.
- b. Notify Engineer and Project Representative when concrete repair cavities demolition and prep has been completed and ready for review, prior to patching. Provide a minimum of 48-hours' notice.
 - 1) Supplemental reinforcement shall be added where existing reinforcement as 15% or more section loss as directed by Engineer.
 - 2) Reinforcement damaged by Contractor's demolition operations shall be repaired at no additional cost.
 - 3) Correct items identified by Engineer prior to patching.
- 2. Final Repair Area Application
 - a. Perform repair and indicate ambient temperature at time of repair.
 - b. Notify Engineer and Project Representative when areas are ready for review.

1.8 AIR TEMPERATURE, HUMIDITY AND VENTILATION CONTROL

- A. The Installation Contractor or a Specialty Contractor shall provide temporary/mobile air temperature, humidity and ventilation control during the course of this project to meet manufacturer's installation requirements for performance.
- B. Provide additional equipment and fuel as required to condition the space for surface preparation, application of products, and curing of those products, in accordance with Manufacturer's requirements. This equipment may include, but not be limited to, dehumidification, heaters, fans for intake and exhaust air, and throw away filters. Discharge of work-related dust and debris outside of the tunnel is prohibited.

1.9 WARRANTY

- A. All material under this section shall be fully warranted for a period of five years against any defects in materials or workmanship commencing with the date of Substantial Completion.
- B. All required warranties shall be obtained by the Contractor as an agent for the Owner from all installation contractors, and the manufacturers. All such warranties shall inure to the benefit of the Owner without the necessity of separate transfer or assignment thereof.
- C. Submission: Within 7 days after the bid, a signed copy of the comprehensive 5-year warranty attached to this Section shall be submitted to the Owner. Failure to submit this signed warranty will result in rejection of the contractor's bid. Submit 1 warranty for each supplier of concrete repair materials.
- D. Responsibilities of Each Party
 - 1. Contractor: Shall act as the agent for the Owner in collecting and enforcing submission of the warranty requirements prior to Substantial Completion of the project.

2. Installation Contractor: Responsible for 100% of the labor to remove and replace the defective material if a failure occurs within the warranty period.
3. Manufacturer: Responsible for supplying 100% of replacement material in case of a failure during the warranty period unless stated otherwise in the warranty.

E. Specific Warranty Requirements

1. The five-year comprehensive warranty shall specifically cover the following:
 - a. A fully complete 100% warranty for all workmanship and material for the repairs.
 - b. Delamination of the coating or substrate.
 - c. Any damage to material or equipment caused by coating system failure.
 - d. Failures due to improper surface preparation, use of non-approved materials, insufficient thickness for any part of the system including primer(s), faulty workmanship, or non-approved deviations from current manufacturer's specifications and written instructions.
 - e. Material incompatibility with any existing coating.

F. Replacement Cost:

1. The warranty shall cover 100% of the replacement cost whether or not the Owner has benefitted from use of the product through part of its useful life.
2. When the work covered by the warranty has failed, the replacement work shall be warranted to cover the original remaining warranty period.

PART 2 - PRODUCTS

2.1 MATERIALS

A. VOC Compliance:

1. All individual coatings and coating systems shall have VOC levels at or below the EPS recommendations identified in 40 CFR Part 59.
2. VOC content shall be tested in accordance with EPA Method 24.

B. Vertical and Overhead (Walls, Floors and Ceilings) Trowelable Concrete Repairs(Prebagged products):

1. SikaQuick VOH.
2. EucoRepairV100 by Euclid Chemical Co.
3. MasterEmaco S488C1 by MaterBulders
4. Or preapproved equal.

C. Horizontal (Slabs) Cementitious Overlays:

1. Sikacrete 211 SCC+. 1 inch - 8 inch thick.

D. Structural Injection Resins:

1. Sikadur 31 and Sikadur 35 by Sika Corp.
2. Dural 452 Gel by Euclid Chemical.
3. ADH 327 RS by MasterBuilders
4. Or preapproved equal.

- E. Water Reactive Injection Polyurethane Sealants:
 - 1. Hydrophobic:
 - a. Sika Fix HH Plus.
 - b. DeNeef Flex LV.
 - c. Or preapproved equal.
- F. Hydraulic (Water Stop) Grouts:
 - 1. ThoRoc Plug by ThoRoc.
 - 2. Water Stop by Dayton-Superior.
 - 3. Sika Set Plug by Sika Corp.
 - 4. MasterSeal 500 by MasterBuilders
- G. Corrosion Inhibitor (Surface Applied On Reinforcing Bars Only):
 - 1. Sika Armatec 110 Epo Cem by Sika.
 - 2. Dural Prep AC by Euclid.
- H. Steel Reinforcing:
 - 1. Reinforcing Bars:
 - a. ASTM A615.
 - b. Yield Stress: $F_y = 60,000$ psi.
 - c. Epoxy coated, conforming to ASTM A775.
 - 2. Welded Wire Fabric:
 - a. ASTM A185.
 - b. Yield Stress: $F_y = 65,000$ psi.
- I. Corrosion Inhibiting Coating
 - 1. Ferroguard 903 by Sika Corp.
 - 2. Or preapproved equal.
- J. Water-Based Concrete Cure & Seal Compound
 - 1. VOCOMP-20 by W.R. Meadows, Inc.
 - 2. Cure & Seal 309 J18 by Dayton Superior Corporation.
- K. General: Provide primers as required in accordance with Manufacturer's recommendations.

PART 3 - EXECUTION

3.1 GENERAL

- A. Installation: Install products in strict accordance with Manufacturer's recommendations.
- B. For each type of repair, all repair products must be sourced from a single manufacturer's product line for single-source responsibility.
- C. Maintain ambient air temperature, temperature of concrete substrate and temperature of all products, components of mixing water within manufactures written limitations or between 40 deg F and 90 deg F (whichever is more stringent) for a minimum of 48 hours before repair products are placed and for a minimum of 48 hours after all placement is complete. Maintain daily temperature logs for all items above for inspection by Owner and for submittal upon completion of project work.

- D. For each area of and type of repair, maintain daily record of demolition and preparation work quantities (SF patching, LF crack injection, etc.) and notify Owner in advance of exceeding stipulated contract quantities, for evaluation and Owner direction on how to proceed. Contractor will not be reimbursed for overages which are not authorized in writing by Owner.
- E. Engineer's Inspection: Do not install patching or reinforcing material until Engineer has inspected the repair site.
- F. Inspection by Specialty Concrete Manufacturers Representative: For area of repair coordinate inspection by manufacturer's representative to review surface preparation and procedures for preparation and mixing of repair compounds and other components. Provide notice to Owner to allow attendance by Owner's representative. Manufacturer's representative shall prepare written certification that surface preparation and preparation of repair compounds is in strict accordance of the project specifications and the manufacturer's written directions.
- G. Acceptance of completed concrete Work will be according to provisions of ACI 301.
 - 1. Repair areas shall be sounded by Engineer and Contractor with hammer or rod after curing for 72 hours. Contractor shall repair all hollowness detected by removing and replacing patch or affected area at no extra cost to Owner.
 - 2. If shrinkage cracks appear in repair area when initial curing period is completed, repair shall be considered defective, and it shall be removed and replaced by Contractor at no extra cost.
- H. Waste Removal: Remove waste material from Site and dispose of legally.

3.2 CONCRETE REPAIRS

- A. General:
 - 1. Delaminated Areas:
 - a. Areas to be repaired have been identified on the drawings and marked with paint in the field.
 - b. Concrete shall be removed from within marked boundary to minimum depth of 3/4-inch using 15 pound maximum electric or pneumatic chipping hammers or hand tools.
 - c. If delaminations exist beyond minimum removal depth or beyond marked boundary, notify Engineer prior to proceeding.
 - d. Engineer will define and mark additional unsound concrete areas for removal, if required.
 - 2. Spalls:
 - a. Areas of spalling have been marked with paint after and identified on the drawings.
 - b. Engineer will define and mark additional unsound concrete areas for removal, if required.
 - 3. Embedments:
 - a. Locate and determine depth of embedded reinforcement and electrical conduit in repair area.

- b. Mark these locations for reference during concrete removal.
 - c. Where embedded reinforcement or electrical conduit is exposed by concrete removal, exercise extra caution to avoid damaging it during removal of unsound concrete.
 - d. Damage due to removal operations shall be repaired by Contractor in accordance with building code requirements at no cost to the Owner.
 - e. Embedded materials which are defective prior to construction may be repaired or replaced by Contractor or abandoned at Owner's option and cost.
4. Sawcut Edges:
- a. For vertical and overhead surfaces marked boundary must be sawcut to depth of 1/2-inch to 0.625-inch into existing concrete, measured from original surface. Sawcut boundary prior to any concrete removal to minimize overages.
 - b. Edges shall be straight and patch areas square or rectangular-shaped.
 - c. Diamond blade saw or grinder with abrasive disk suitable for cutting concrete is acceptable for performing work.
 - d. Edge cut at delamination boundary shall be dressed perpendicular to member face. It shall also be of uniform depth, for entire length of cut.
 - e. Exercise extra caution during sawcutting to avoid damaging existing reinforcement and electrical conduit and other embedded items near surface of concrete.
 - f. Damage to existing reinforcement or conduit during removals shall be repaired by Contractor with Engineer approved methods at no additional cost to Owner.
5. Clearance:
- a. Concrete shall be removed to provide minimum of 3/4-inch clearance on all sides of defective or damaged exposed embedded reinforcement that is left in place.
 - b. Minimum of 1-1/2-inch concrete cover shall be provided over new and existing reinforcement.
 - c. Concrete cover over reinforcement may be reduced to 1-inch with Engineer approval if coated with an approved epoxy resin.
6. Preparing Cavities:
- a. Cavities shall be sandblasted; waterblasting is prohibited.
 - b. Remove deleterious materials such as damaged concrete, corrosion, laitance, dirt and grease from concrete surfaces.
 - c. Roughen surface to CSP-7 as defined by the ICRI.
 - d. Airblasting is required as final step to remove sand.
 - e. Apply corrosion inhibitor on full circumference of reinforcing bars.
7. Rectangular Areas: Areas to be removed shall be as straight and rectangular as practical to encompass repair and provide neat patch. Avoid acute angles on patch.
8. Reinforcement Repair:
- a. Supplement defective or damaged embedded reinforcement by addition of reinforcement of equal diameter with Class "B" minimum splice in accordance with ACI 318 beyond damaged portion of reinforcement.

- b. Secure new reinforcement to existing reinforcement with wire ties or approved anchors into concrete, or both.
 - c. Supplemental reinforcement shall be installed in accordance with ACI 318 and ACI 301.
 - d. If rust is present on embedded reinforcement where it enters sound concrete, additional removal of concrete along and beneath reinforcement is required.
 - e. Additional removal shall continue until non-rusted reinforcement is exposed, or may be terminated as Engineer directs.
 - 1) If bond between exposed embedded reinforcement and adjacent concrete is impaired by removal operations, perform additional removal around and beyond perimeter of reinforcement for minimum of 3/4-inch along entire length affected at no cost to Owner.
 - 2) Remove rust from the full circumference of reinforcement.
 - f. Embedded reinforcement exposed during surface preparation that has lost more than 10% of original cross-section due to corrosion shall be considered defective.
 - g. Non-defective exposed reinforcement that has lost section to extent specified as direct result of Contractor's removal operations shall be considered damaged.
 - h. Exposed steel shall be cleaned of rust to bare metal by sandblasting; waterblasting is not allowed.
 - i. Cleaning shall be completed immediately before patch placement to ensure that base metal is not exposed to elements and further rusting for extended periods of time.
 - j. Loose reinforcement exposed during surface preparation shall be securely anchored prior to patch placement.
 - k. Drilled-in anchors shall be approved by the Engineer.
 - l. Engineer will determine adequacy of wire ties and approve other anchoring devices prior to their use.
 - m. Securing loose reinforcement is incidental to surface preparation and no additions to the Contract Sum will be allowed for this work.
9. Inspection of Repair Preparation:
- a. Inspection:
 - 1) After removals are complete, but prior to final cleaning, cavity and exposed reinforcement shall be inspected by Contractor and verified by Engineer for compliance with requirements of this Section.
 - 2) Where Engineer finds unsatisfactory cavity preparation, Engineer shall direct Contractor to perform additional removals. Engineer shall verify areas after additional removals.
 - b. Defects:
 - 1) Inspect embedded reinforcement and conduits exposed within cavity for defects due to corrosion or damage resulting from removal operations.
 - 2) Notify Engineer of defective and damaged reinforcement or conduits.
 - 3) Replace damaged or defective reinforcement or conduits according to this Section and as directed by Engineer.
10. Provide other surface treatment as required by the Manufacturer of the patching compounds.

11. Inform Engineer at least 2 days in advance of concrete repair placement to allow adequate time for Engineer to schedule inspection.
12. Predampen cavity surface with clean water. Cavity concrete surfaces shall be saturated surface dry (SSD) with no free water.
13. Apply bonding grout / slurry to existing concrete surfaces to have repair concrete bonded to. Bonding grout shall have the same makeup as the approved concrete mix and the consistency of pancake batter.
14. After placement of concrete repair material, wet concrete surface and allow surface water to dissipate, then immediately apply water-based concrete cure & seal compound to entire area of repair per Manufacturer's requirements.
15. Following Manufacturer's guidelines for application timeframe, apply corrosion inhibiting coating over entire area of concrete repair. Ambient air temperature must be held less than 90°F for a minimum of 48 hours following application of coating.

B. Crack Repair:

1. Refer to Drawings for specific criteria for crack repair.
2. Follow sealant Manufacturer's specific guidelines where more stringent than those referenced herein.
3. Cracks which are prepared shall be sealed the same day.
4. Routing of cracks shall be a dry process.

3.3 CRACK INJECTION

- A. Cracks identified for injection and adjacent substrate must be clean, sound and free of frost. Remove dust, laitance, grease, curing compounds, waxes, impregnations, foreign particles, efflorescence and other bond inhibiting materials from the surface by mechanical means, as recommended by the Manufacturer.
- B. Injection ports may be located directly on the crack or they may be drilled along the side of the crack at 45 degrees. Drill the hole to intersect the crack midway through the substrate. Install the injection packers (ports) in the holes.
- C. Install injection ports and grout ports as recommended by the product Manufacturer.
- D. Spacing of injection ports shall be accomplished as required to achieve the travel of the adhesive for the pressure injection grouting between ports and to completely fill the cracks. Stagger ports both sides of the crack.
- E. Injection products which are composed of individual components shall be thoroughly mixed in strict accordance with the Manufacturer's recommendations.
- F. Dispense the material for injection under constant pressure in accordance with procedures recommended by the equipment Manufacturer or as required to achieve maximum filling and penetration of the prepared cracks without the inclusion of air pockets or voids in the adhesive.

- G. Injection of the material into each crack shall begin at the entry port at the lowest elevation. Injection shall continue at the first port until the injection adhesive begins to flow out of the port at the next highest elevation or until the material is flowing out of the crack between these ports.
- H. Remove injection packers, clean ports and grout holes.

3.4 ENCLOSURE

- A. Construct an enclosure within the tunnel system at the project extents of the repair work. The enclosure shall be of such quality as to maintain optimal conditions for the repair work, as well as to prevent debris and dust from entering in to the tunnel system and adjacent buildings.
- B. The enclosures shall remain until the repair work is sufficiently cured.
- C. Provide additional equipment as required to condition the space for repair work. This equipment may include, but not be limited to, dehumidification and fans for intake and exhaust air. Coordinate opening and protection of access hatches with U-M Project Manager and Tunnel Utilities representative (Contact: Mike Rhodes (734) 323-8592 rhodey@umich.edu).

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Engineer: Check prep work and final repair work, each site.
- B. Promptly make corrections, changes, and additions required by Manufacturer's engineer.

3.6 CLEANING

- A. Clean materials installed under this Section in accordance with Division 01 Section 01500 requirements.

END OF SECTION 037300