PART 1 GENERAL

1.1 REFERENCES

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

2. ASTM International (ASTM):

1.2 DEFINITIONS

A. Large Cracks: Wider than 0.015 inch.
B. Small Cracks: Width equal to 0.015 inch or less.

1.3 SUBMITTALS

A. Shop Drawings:

1. Physical and chemical properties for epoxy adhesives.
2. Technical data for metering, mixing, and injection equipment.

B. Information Submittals:

1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy adhesives.
2. Installation instructions for repairing core holes with epoxy grout.
3. Manufacturer's Certificate of Compliance: Certified test results for each batch of epoxy adhesive.
4. Statements of Qualification for Epoxy Adhesive:
   a. Manufacturer's site representative.
b. Injection applicator.
c. Injection pump operating technician.

5. Epoxy adhesive two component ratio and injection pressure test records for concrete crack repair work.

1.4 QUALITY ASSURANCE

A. Qualifications for Epoxy Injection Staff:

1. Manufacturer's Site Representative:
   a. Capable of instructing successful methods for restoring concrete structures utilizing epoxy injection process.
   b. Understands and is capable of explaining technical aspects of correct material selection and use.
   c. Experienced in the operation, maintenance, and troubleshooting of application equipment.

2. Injection crew and job foreman shall provide written and verifiable evidence showing compliance with the following requirements:
   a. Licensed and certified by epoxy manufacturer.
   b. Minimum 3 years' experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection including 2,000 linear feet of wet crack injection to stop water leakage.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Package adhesive material in new sealed containers and label with following information:

   1. Manufacturer's name.
   2. Product name and lot number.
   3. ANSI Hazard Classification (formerly SPI Classification).
   4. ANSI recommended precautions for handling.
   5. Mix ratio by volume.

B. Storage and Protection: Store adhesive containers at ambient temperatures below 120 degrees F and above 32 degrees F.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Epoxy Manufacturers:

   1. Contech Group, Portland, OR, Seattle, WA.
2. Sika Corp., Lyndhurst, NJ.
3. Euclid Chemical Co., Cleveland, OH.

2.2 EPOXY ADHESIVE

A. Two-component A and B structural epoxy adhesive for injection into cracks or other voids in concrete structures for bonding or grouting.

B. Component A Properties: Blend of modified epoxy resins as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Test Method</th>
<th>Large Cracks</th>
<th>Small Cracks*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Visual</td>
<td>Clear Amber</td>
<td>Light Amber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>Viscosity @ 40, plus or minus 3 deg F</td>
<td>Brookfield RVT Spindle No. 4 @ 200 rpm</td>
<td>8,000 cps, max.</td>
<td>850 cps, max.</td>
</tr>
<tr>
<td>Viscosity @ 77, plus or minus 3 deg F</td>
<td>Brookfield RVT Spindle No. 2 @ 20 rpm</td>
<td>700 cps, max.</td>
<td>375 cps max. @ 50 rpm</td>
</tr>
</tbody>
</table>

*Small crack epoxy blend shall meet requirements for Large Cracks except as shown.

C. Component B Properties: Modified amine curing agent as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Test Method</th>
<th>Large Cracks</th>
<th>Small Cracks*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Visual</td>
<td>Black Liquid</td>
<td>Black Liquid</td>
</tr>
<tr>
<td>Viscosity @ 40, plus or minus 3 deg F, cps</td>
<td>Brookfield RVT Spindle No. 2 @ 20 rpm</td>
<td>1,400 cps, max.</td>
<td>550 cps, max.</td>
</tr>
<tr>
<td>Viscosity @ 77, plus or minus 3 deg F, cps</td>
<td>Brookfield RVT Spindle No. 2 @ 20 rpm</td>
<td>240 cps, max.</td>
<td>150 cps max. Using Spindle No. 1 @ 50 rpm</td>
</tr>
</tbody>
</table>

*Small crack epoxy blend shall meet requirements for Large Cracks except as shown.

D. Uncured Adhesive Properties: When mixed in ratio specified on adhesive container label:

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Large Cracks</th>
<th>Small Cracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pot Life (60-gram mass) @ plus or minus 4 deg F</td>
<td>As specified in Article SOURCE QUALITY CONTROL</td>
<td>13 to 25 minutes</td>
</tr>
<tr>
<td>Test Method</td>
<td>Large Cracks</td>
<td>Small Cracks</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Pot Life (60-gram mass) @ 100, plus or minus 3 deg F</td>
<td>As specified in Article</td>
<td>3 to 10 minutes</td>
</tr>
<tr>
<td>Viscosity @ 40, plus or minus 3 deg F</td>
<td>Brookfield RVT Spindle</td>
<td>4,400 cps</td>
</tr>
<tr>
<td>Viscosity @ 75 to 77 deg F</td>
<td>Brookfield RVT Spindle No. 2 @ 20 rpm</td>
<td>375 to 350 cps</td>
</tr>
</tbody>
</table>

E. Adhesive Properties: When cured for 7 days at 77, plus or minus 3 degrees F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Large Cracks</th>
<th>Small Cracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate Tensile Strength, psi</td>
<td>ASTM D638</td>
<td>8,000 min.</td>
</tr>
<tr>
<td>Tensile Elongation @ Break, percent</td>
<td>ASTM D638</td>
<td>4.2 max.</td>
</tr>
<tr>
<td>Flexural Strength, psi</td>
<td>ASTM D790</td>
<td>10,000 min.</td>
</tr>
<tr>
<td>Flexural Modulus, psi</td>
<td>ASTM D790</td>
<td>5.5x10^5 min.</td>
</tr>
<tr>
<td>Compressive Yield Strength, psi</td>
<td>ASTM D695*</td>
<td>15,000 min.</td>
</tr>
<tr>
<td>Compressive Modulus, psi</td>
<td>ASTM D695*</td>
<td>4.0x10^5 min.</td>
</tr>
<tr>
<td>Heat Deflection Temperature</td>
<td>ASTM D648*</td>
<td>130 deg F min.</td>
</tr>
<tr>
<td>Slant Shear Strength: (5,000 psi Compressive Strength Conc.)</td>
<td>AASHTO T 237**</td>
<td></td>
</tr>
<tr>
<td>Cured 3 days @ 40 deg F-Wet Concrete</td>
<td></td>
<td>3,500 psi min.</td>
</tr>
<tr>
<td>Cured 1 day @ 77 deg F-Dry Concrete</td>
<td></td>
<td>5,000 psi min.</td>
</tr>
<tr>
<td>Cured 3 days @ 77 deg plus or minus 3 deg F</td>
<td></td>
<td>5,000 psi min.</td>
</tr>
</tbody>
</table>

*Cure test specimens so that peak exothermic temperature of adhesive does not exceed 100 degrees F

**See referenced specifications for preparation method of test specimens
2.3 SURFACE SEAL

A. Sufficient strength and adhesion for holding injection fittings firmly in-place, and to resist pressures preventing leakage during injection.

B. Capable of removal after injection adhesive has cured.

2.4 SOURCE QUALITY CONTROL

A. Test Requirements: Perform tests for each batch of adhesive.

B. Pot Life Test:

1. Condition Components A and B to required temperature.
2. Measure components in ratio of Component B as stated on manufacturer's label into an 8-fluid-ounce paper cup.
3. Start stopwatch immediately and mix components for 60 seconds using wooden tongue depressor, take care to scrape sides and bottom of cup periodically.
4. Probe mixture once with tongue depressor every 30 seconds, starting 2 minutes prior to minimum specified pot life.
5. Pot Life Definition: Time at which a soft stringy mass forms in center of cup.

C. Fabrication of Slant Shear Specimens for Testing Bond of Injectable Adhesives to Wet Concrete at 40 Degrees F:

1. Scope: Test method for preparation of diagonal concrete mortar blocks used in determining slant shear strength of low viscosity injectable adhesives in accordance with AASHTO T 237 when concrete is wet.
2. Materials:
   a. Diagonal concrete mortar blocks prepared in accordance with AASHTO Test Method T 237 and cured to produce a mortar with compressive strength of 5,000 psi or greater.
   b. Paraffin wax.
   d. Suitable 20-mil thick shim stock.
3. Preparation:
   a. Place a 20-mil shim between diagonal faces of two blocks and align so ends and sides are square.
   b. Bind block with masking tape covering gap between blocks.
   c. Leave a gap between blocks on one face uncovered for removal of shim and application of adhesive.
   d. Paint melted paraffin wax over masking tape.
e. Shallow dam may be built up around opening using paraffin wax or modeling clay to help retain adhesive.

f. Apply suitable capping compound to each end of specimen producing smooth surfaces perpendicular to longitudinal axis of block.

g. Remove shim stock from gap opening.

h. Soak specimen in water at 40 degrees F, plus or minus 3 degrees F for at least 24 hours.

i. After soaking, remove specimen, shake free water from surface and gap opening.

j. Prepare liquid adhesive.

k. Within 5 minutes after removing specimen from water, start flowing adhesive into crack without entrap air bubbles.

l. Place specimen in 40 degrees F, plus or minus 3 degrees F ambient for curing within 15 minutes after removing specimen from water for bonding. Do not expose specimen to temperatures beyond 77 degrees F during the 15 minute period.

m. Cure specimen for 72 hours, plus or minus 4 hours at 40 degrees F, plus or minus 3 degrees F.

### PART 3 EXECUTION

#### 3.1 GENERAL

A. Structurally repair cracks in structures as specified in Section 03300, CAST-IN-PLACE CONCRETE.

B. Cracks:

1. Repair by injection of epoxy adhesive.
2. Repair cracks specified or as shown.

#### 3.2 PREPARATION

A. Free cracks from loose matter, dirt, laitance, oil, grease, salt, and other contaminants.

B. Clean cracks in accordance with epoxy adhesive manufacturer's instructions.

C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system.

D. Do not use acids and corrosives for cleaning, unless neutralized prior to injecting epoxy.
3.3 APPLICATION

A. Sealing: Apply surface seal in accordance with manufacturer's instructions to designated crack face prior to injection. Seal surface of crack to prevent escape of injection epoxy.

B. Entry Ports:
   1. Establish openings for epoxy entry in surface seal along crack.
   2. Determine space between entry ports equal to thickness of concrete member to allow epoxy to penetrate to the full thickness of the wall.
   3. Provide a means to prevent concrete dusts and fines from contaminating the crack or ports when drilling.
   4. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
      a. Cracks extend entirely through wall.
      b. Backfill of walls on one side.
      c. Difficult to excavate behind wall to seal both crack surfaces.
   5. Core drill to verify epoxy depth where only one side of wall is exposed.

C. Epoxy Injection:
   1. Store epoxy at minimum of 70 degrees F.
   2. Start injection into each crack at lowest elevation entry port.
   3. Continue injection at first port until adhesive begins to flow out of port at next highest elevation.
   4. Plug first port and start injection at second port until adhesive flows from next port.
   5. Inject entire crack with same sequence.

D. Finishing:
   1. Cure epoxy adhesive after cracks have been completely filled to allow surface seal removal without draining or runback of epoxy material from cracks.
   2. Remove surface seal from cured injection adhesive.
   3. Finish crack face flush with adjacent concrete.
   4. Indentations or protrusions caused by placement of entry ports are not acceptable.
   5. Remove surface seal material and injection adhesive runs and spills from concrete surfaces.
3.4 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter and mix two adhesive components, and inject mixture into crack.

B. Pumps:
   1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
   2. Primary injection pump for each material of different mix ratio, including a standby backup pump of similar ratio.
   3. Capable of immediate compensation for changes in resins.
   4. Do not use batch mix pumps.

C. Discharge Pressure: Automatic pressure controls capable of discharging mixed adhesive at pressures up to 200 psi, plus or minus 5 percent, and able to maintain pressure.

D. Automatic Shutoff Control: Provide sensors on both Component A and B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

E. Proportioning Ratio Tolerance: Maintain epoxy adhesive manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 psi.

F. Ratio/Pressure Check Device:
   1. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
   2. Pressure gauge capable of sensing pressure behind each valve.

3.5 FIELD QUALITY CONTROL

A. Epoxy Adhesive Two Component Ratio Tests:
   1. Disconnect mixing head and pump two adhesive components simultaneously through ratio check device.
   2. Adjust discharge pressure to 160 psi for both adhesive components.
   3. Simultaneously discharge both adhesive components into separate calibrated containers.
   4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work stops for more than 1-hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:
   1. Disconnect mixing head of injection equipment and connect two adhesive component delivery lines to pressure check device.
   2. Pressure Check Device:
      a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
      b. Pressure gauge capable of sensing pressure buildup behind each valve.
   3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
   4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
   5. Run pressure test for each injection equipment unit:
      a. Beginning and end of each injection work day.
      b. When injection work stops for more than 45 minutes.
   6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Crack Injection Tests:
   1. Initial Cores:
      a. 4-inch diameter for full crack depth taken from CONSTRUCTION MANAGER selected locations.
      b. Take three cores in first 100 lineal feet of crack repaired and one core sample for each 500 lineal feet thereafter.
   2. Provide suitable containers for storage, curing, and transportation of test specimens.
   3. Methods of Testing Cores:
      b. Bond Strength/Compression Test: Concrete failure prior to adhesive failure.
   4. Test Requirements:
      a. Penetration: Minimum of 90 percent of crack shall be full of epoxy adhesive.
b. Bond Strength/Compression Test: Concrete failure before adhesive failure, or 6,500 psi with no failure of either concrete or adhesive.

5. Evaluation and Acceptance of Tests:
   a. If initial cores pass tests as specified, epoxy adhesive injection Work at area represented by cores will be accepted.
   b. If initial cores fail either by lack of penetration or bond strength, crack repair Work shall not proceed further until areas represented by cores are reinjected or repaired and retested for acceptance.
   c. Obtain verifying core samples, number and location as selected by Construction Manager, after rework of areas represented by failed initial cores is complete.

6. Core Hole Repair:
   a. Correct Work as result of testing upon notification from Construction Manager.
   b. Refill initial and verifying core holes with an epoxy grout tamped and rodded in-place to form a dense fill.
   c. Finish surface to blend with adjacent concrete.

END OF SECTION