ITEM #0601954A – EPOXY INJECTION CRACK REPAIR

Description: This item shall consist of surveying the existing areas, locating all cracks to be repaired under this item, and rebonding the cracked concrete structures with a two component modified epoxy resin system injected into the cracked structure under low pressure using continuous positive displacement metering and mixing equipment as directed in accordance with these specifications.

Work under this item is limited to crack widths greater than 1/16" and less than 1/4". The Contractor shall not perform any repair work without prior approval by the Engineer for locations, limits, and type of repairs.

Materials: The modified epoxy resin shall be a pre-qualified epoxy resin (see Appendix A). A Materials Certificate and a Certificate of Compliance in according with Article 1.06.07 shall accompany each batch or lot of the material delivered to the job site, to verify the epoxy resins conformance with the manufacturers supplied infrared spectroscopy test results. A sample of liquid epoxy resin component A and B shall be taken and shall consist of one pint of each batch of each component represented in each shipment. The samples shall be presented to the Laboratory a minimum of 14 calendar days before incorporation of any of the batch into the work. The Laboratory shall conduct an Infrared Spectroscopy Test on the samples (see Appendix A, attached). Each test result shall be compared to the test results on file with the Laboratory from the "Prequalification Procedures". Two materials are considered to be identical if all of the absorption points agree as to wavelength and relative magnitude of the peaks in comparison with the other points of absorption.

A batch of each component will be defined as that quantity of material that has been subjected to the same unit chemical or physical mixing process intended to make the final product substantially uniform.

Each component shall be packaged in steel containers not larger than 5 gallons in volume. The containers shall have lug type crimp lids with ring seals, shall be new, not less than 0.024-inch nominal thickness, and shall be well sealed to prevent leakage. If a lining is used in the containers it shall be of such character as to resist any action by the components. Each container shall be clearly labeled with the designation (component A or B), manufacturer's name, and date of manufacturer, batch number and the following warning:

CAUTION: This material will cause severe dermatitis if it is allowed to come in contact with the skin or eyes. Use gloves and protective creams on the hands. Should this material contact the skin, wash thoroughly with soap and water. Do not attempt to remove this material from the skin with solvents. If any gets in the eyes, flush for 10 minutes with water and secure immediate medical attention.

Any material, which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments that cannot be readily redispersed with a paddle, shall not be used.

Construction Methods: A survey shall be undertaken by the Contractor on the area designated to be repaired, under the direction and to the satisfaction of the Engineer, to determine the exact limits and location of the area to be repaired under this item.

At the time of mixing, components A and B and the substrate temperature shall be between 50° and 85° Fahrenheit, unless the material has been pre-qualified at a temperature less than 75° Fahrenheit, in which case this lesser temperature shall govern the use of the material. Any heating of the adhesive components shall be done by application of indirect heat. Immediately prior to filling the tanks of the mixing equipment, each component shall be thoroughly stirred with a paddle. Separate paddles shall be used to stir each component.

Injection ports shall be inserted in the cracks at intervals not less than the thickness of the concrete being injected. At the end of a crack or at a point where the thickness of the crack becomes less than .005 inches, the first port shall be half the distance from this point. The Contractor may use either surface injection ports or insertable injection ports as recommended by the manufacturer of the epoxy.

Drilling of the injection ports shall be done with a hollow drill bit to which vacuum is applied with an industrial vacuum cleaner (such as Black and Decker No. 95 Vackar or equivalent). The drill shall not contact any steel reinforcing or pre-stressing strands or ducts. A pachometer shall be used to locate the embedded steel.

Spacing of the ports shall be such that the injected adhesive will substantially fill the crack without excessive waste. If necessary to meet this requirement, the spacing of the ports shall be revised as approved by the Engineer as the injection process progresses.

The surface of the crack between ports shall be sealed with tape or other temporary surface sealant, which is capable of retaining the epoxy adhesive in the crack during pressure injection, and shall remain in places until the epoxy has hardened. Sealant tape and/or temporary surface sealant shall also be removed and any spillage of epoxy shall also be removed. No clean up on surfaces not generally viewed by the public will be required unless the surface sealant will interfere with subsequent surface treatments.

Epoxy adhesive shall be pumped into the cracks through the injection ports. The pump, hose, injection gun and appurtenances shall properly proportion and mix the epoxy and shall be capable of injecting the epoxy at a sufficient rate and pressure to completely fill all designated cracks. A suitable gasket shall be used on the head of the injection gun to prevent the adhesive from running down the face of the concrete. Pumping pressure shall be kept as low as practicable.

The temperature of the concrete shall not be less than 50° Fahrenheit at the time epoxy is injected, unless the epoxy has been pre-qualified at a lower temperature as hereinbefore provided, in which case the lower temperature shall govern.

For a crack with uniform thickness, the epoxy adhesive shall be forced into the first port at one end of the crack until adhesive runs in substantial quantity from the next adjacent port. The first port shall then be sealed and injection started at the next port. Injection shall then continue from port to port in this manner until the crack is fully injected.

Cracks with non-uniform thickness shall have the epoxy adhesive forced into the port at the widest separation in the crack until adhesive runs in substantial quantity from the two adjacent ports. The first port shall then be sealed and injection started at the adjacent port corresponding to the shortest length of the crack. Injection shall then continue from port to port in this manner until the short side of the crack is fully injected. Then, beginning with the port that is filled with epoxy adhesive but not sealed, injection shall continue from port to port until the crack is fully injected.

For slanting or vertical cracks, pumping shall start at the lower end of the crack. Where approximately vertical and horizontal cracks intersect, the vertical crack below the intersection shall be injected first. The ports shall be sealed by removing the fitting, filling the void with epoxy and covering with tape or surface sealant.

Before starting injection work and at 2-hour intervals during injection work when requested by the Engineer, a 3-fluid ounce sample of mixed epoxy shall be taken from the injection gun. Should these samples show any evidence of improper proportioning or mixing, injection work shall be suspended until the equipment or procedures are corrected.

Samples obtained above shall be used directly, without further stirring, to make test pieces for the Slant Shear Strength on Dry Concrete. One test piece shall be made at the beginning, middle and end of daily operations. The samples shall be allowed to cure for 7 days in the "Concrete Cylinder Curing Box". On the 7th day the samples shall be removed to the laboratory and tested in accordance with the requirements for Slant Shear Strength (see Appendix A, attached).

Each sample shall be numbered consecutively and dated (with a waterproof marker) and it shall be noted which sample represents which part of the structure.

Technical Advisor: The Contractor shall provide the Engineer with a notarized statement showing a specific record of epoxy injection repairs actually made by the Contractor and/or a specific record of training of his employees in epoxy injection repairs as taught by the manufacturer of the epoxy product. If the statement is not produced or is deemed insufficient by the Engineer, the Contractor shall obtain the services of a Technical Advisor who is employed by the manufacturer of the epoxy resin. The Technical Advisor shall assist the Engineer and the Contractor in the correct use of the injection resin. The Advisor shall be a qualified representative approved by the Engineer, and shall be at the site of the work when the work begins in connection with the epoxy injection and at such other times as the Engineer may request until completion of this item.

Method of Measurement: This work will be measured for payment by the number of linear feet, which have been designated by the Engineer to be injected and which were subsequently filled with epoxy, shall be measured.

Where cracks are designated for injection on opposite sides of a concrete member and the epoxy adhesive injected on one side penetrates through the members to completely fill the crack on the opposite side, payment will be made for the cracks in both sides as though injection had been performed on both sides, except that no payment will be made for such cracks on the opposite side that were not designated by the Engineer for injection.

Where a crack designated for injection extends around the corner of a concrete member, the length of crack on both faces will be measured for payment.

Basis of Payment: This work will be paid for at the contract unit price per linear foot for "Epoxy Injection Crack Repair", complete in place, which price shall include all work and services called for herein including all preparation, materials, equipment, tools, labor and cleanup incidental thereto.

Pay Item	Pay Unit
Epoxy Injection Crack Repair	L.F.

APPENDIX A

Prequalification Procedure

The Prequalification Procedure shall consist of the following test procedure on the mixed epoxy resin at a temperature of 77°F, unless the Contractor desires to use the material at a lower temperature than 50°F, in which case the lower temperature shall be used to condition the material and test pieces.

TEST: **VISCOSITY**

Requirements: 900 centipoise max. @20°F (±2°)
4,000 centipoise max. @any test temperature

Test Method: ASTM D 2393

TEST: **GEL TIME (POT LIFE)**

Requirement: 4 to 60 minutes

Test Method:

A. Apparatus

1. Unwaxed paper cups, 8 oz., 2¼ inches at base (Dixie Cup No. 4338 or equivalent).
2. Wooden tongue depressor with ends cut square (Puritan No. 705 or equivalent).
3. Stainless steel spatula with blade 6” x 1” and with end cut square.
4. Stopwatch, 1 second or smaller divisions.
5. Balance, 0.1 gram divisions.

B. Test Procedure

1. Condition both A and B components to required temperature (±2°F).
2. Measure proper volumes of well-mixed components A and B into an 8-oz. unwaxed cup to yield total mass of 60 (±2.0 grams).
3. Start stopwatch immediately and mix components for 60 seconds, stirring with a wooden tongue decompressor taking care to scrape the sides and bottom of the cup periodically.
4. Place the sample at the required temperature (±2°F) on a wooden bench top, which is free of excessive drafts.
5. Probe the mixture once with the tongue depressor every 30 seconds starting 4 minutes from the time of mixing.
6. The time at which a soft stringy mass forms in the cup is the gel time.

TEST: **SLANT SHEAR STRENGTH ON WET CONCRETE**

Requirements: 1700 psi min. after 7 days of cure in air at the required temperature (±2°F)

TEST: **SLANT SHEAR STRENGTH ON DRY CONCRETE**

Requirements: 4500 psi min. after 7 days of cure in air at the required temperature (±2°F)

TEST: **SLANT SHEAR STRENGTH**

A. Materials

1. Ottawa sand, ASTM C109
2. Portland cement, Type II
3. Water

B. Apparatus

1. Suitable mold to make diagonal concrete mortar blocks with a square base with 2-inch sides and having one diagonal face 2” x 4” starting about ¾-inch above the base. The diagonal faces of two such blocks are bonded together producing a block of dimensions 2” x 2” x 5”.
2. Block made from the following composition:
   - Ottawa sand, ASTM C109 30.1 lbs.
   - Portland cement, Type II 12.1 lbs.
   - Water 4.8 lbs.

   Cure blocks 28 days in a fog room. Dry and lightly sandblast diagonal faces.

3. Suitable test press.

B. Test Procedure

Condition the components for 4 hours at the required temperature (±2°F). Without entrapping air, stir the separate components for 30 seconds and place the proper volumes of each component on a plate and mix with a spatula for 60 + 5 seconds. Apply a coat approximately 0.010-inch thick to each diagonal surface. Place four ⅛-inch square pieces of shim stock 0.012-inch thick on one block to control final film thickness. Before pressing the coated surface together, leave the blocks so that the coated surfaces are horizontal until the epoxy reacts slightly to prevent excessive flow. Press diagonal surfaces of each block together by hand and remove excess epoxy adhesive.

Align the blocks so that the ends and sides are square and form a block 2” x 2” x 5”. Use blocks of wood or metal against each 2” x 2” end, to keep diagonal faces from slipping until epoxy hardens.

After the required cure time, apply a suitable capping compound to each of the 2” x 2” bases, and test by applying a compression load with a Universal Test Machine or other suitable testing apparatus at the rate of 5000 lbs./min, until failure.

Report results in pounds per square inch

$$= \frac{\text{Load in Pounds}}{4}$$

For wet shear strength, soak another set of blocks in water for 24 hours at the required temperature (±2°F). Remove and wipe off excess water. Prepare, cure, and test sample according to above test procedure.

TEST: **TENSILE STRENGTH**

Requirements: 4500 psi Min.

TEST: **ELONGATION**

Requirements: 15% Max.

Test Method: TENSILE STRENGTH AND ELOGATION

A. Apparatus

1. Leveling table about 12” x 8” with removable rim ¼-inch thick by ½-inch wide.
2. Mylar or similar plastic sheeting 0.004-inches thick.
3. Air circulation oven capable of maintaining 158°F (±3°F).
4. Cutting die, Figure I
5. Thickness gauge, ⅛-inch.
6. Release agent, non-silicone type.

B. Procedure

1. Place Mylar sheet on leveling table.
2. Coat inside edge and bottom of rim with the release agent and secure to table with screws.
3. Level the table.
4. Mix sufficient volume of well-mixed component A and well mixed component B in the proper volumes so as to be able to form a layer ⅛-inch deep when placed inside the ring on the leveling table.
5. Introduce as few bubbles as possible during mixing.

6. Flush surface of epoxy with a heat gun or Bunsen burner to remove air bubbles on surface. Repeat if necessary.
7. Allow the specimen to cure for 18 hours at the required temperature (±2°F).
8. Remove specimen from table and strip off Mylar sheet. Cure specimen for 5 hours at 158°F (±3°F).
9. Allow specimen to cool to the required temperature and cut specimens using cutting die shown in Figure I.
10. Proceed as specified in ASTM D 638, using 0.2-inches/minute test rate and 1-inch gauge length.

TEST: **INFRARED SPECTROSCOPY**

Requirement: Infrared Spectroscopy Tests shall be obtained of Components A and B

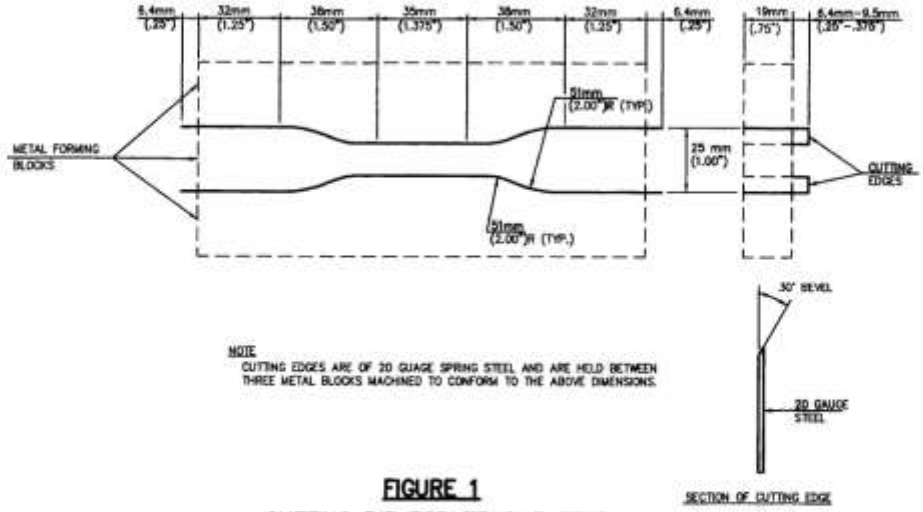
Test Method: RECORDING SPECTROPHOTOMETER

A. Apparatus

1. Perkin–Elmer Model 137-B Infracord Spectrophotometer, automatic recording system from 2.5 microns to 15 microns with a two-speed recorder. Comparable results can be obtained with similar resolution.
2. Disk holder for a one-inch diameter disk.
3. Two sodium chloride crystal disks one-inch in diameter.
4. Sorvall SS-3 Automatic Superspeed Centrifuge, or comparable centrifuge, which is able to separate the liquid and solid phases of the epoxy components without previous dilution with solvents.

B. Procedure

1. Place about 15 grams of component A into a stainless steel centrifuge table.
2. Counterbalance with component B in a second centrifuge tube.
3. Centrifuge the two components at 17000 rpm until there is a supernatant liquid layer present in each tube. This takes 20 to 30 minutes.
4. Place a drop of component A liquid layer on a sodium chloride disk.
5. Place another sodium chloride disk over the drop, rotate, and press down until the liquid has flowed into a uniform layer of proper thickness between the two sodium chloride disks.
6. Place the disks in the holder and run an absorption curve with the infrared spectrophotometer.
7. More or less liquid may be used between the disks so as to produce a maximum absorption of 0.7 to 1.0 for the strongest absorption point on the curve.
8. Clean the disks with toluene and dry.
9. Repeat steps 4 through 8 with the liquid layer from component B.
10. Record each curve in order that they may be used for comparison purposes with lots of material delivered to the job site.



NOTE
CUTTING EDGES ARE OF 20 GUAGE SPRING STEEL AND ARE HELD BETWEEN THREE METAL BLOCKS MACHINED TO CONFORM TO THE ABOVE DIMENSIONS.

FIGURE 1
CUTTING DIE FOR TENSILE TEST
N.T.S.