ACI RAP 1
STRUCTURAL CRACK REPAIR BY EPOXY INJECTION
OCTOBER 16, 2018
SCOTT DISTEFANO
AGENDA

- Introduction
- Purpose of Repair
- When to Use
- Proper Preparation
- Selecting Materials
- Equipment
- Safety
- Repair Procedure
- Evaluation
INTRODUCTION

- Life, Death, Taxes and Cracks!
INTRODUCTION

- Causes may include:
  - Drying shrinkage;
  - Thermal contraction or expansion;
  - Settlement;
  - Lack of appropriate control joints;
  - Overload conditions that produce flexural, tensile, or shear cracks in concrete
  - Restraint of movement
PURPOSE OF REPAIR

- Restore structural integrity
- Resist moisture penetration (0.002 in. width and greater)
WHEN TO USE INJECTION METHOD

- Horizontal, Vertical & Overhead
- Must determine:
  - Cause
  - Need

Vertical Cracks

Horizontal Cracks
PROPER SURFACE PREPARATION

- ½” wide on each side
- Wire brush
  - Grinders may fill crack with dust
- Pressure washer
  - Allow to dry
  - Moisture tolerant epoxy
- Compressed Air (oil free)
- Power Vacuums

- “V” groove or notch
PROPER SURFACE PREPARATION
SELECTING THE CORRECT MATERIALS

- Viscosity is very important
  - Width 0.010” or smaller = 500 cps or less
    - Water = 1 cps
    - Syrup = 3000 cps
  - Larger cracks may use higher medium to gel viscosity
SELECTING THE CORRECT MATERIALS

- ASTM C881 identifies basic criteria
- Concrete >12” may require
  - Increased working time
  - Lower viscosity
  - Depending on width
- Other considerations include:
  - Modulus of elasticity (rigidity);
  - Working life;
  - Moisture tolerance;
  - Color
  - Compressive, flexural, and tensile strengths.

Table 1—ASTM C 881 requirements for epoxy resins that are used to bond hardened concrete to hardened concrete

<table>
<thead>
<tr>
<th></th>
<th>Type I(^a)</th>
<th>Type IV(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viscosity, centipoise</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 1 (low-viscosity), maximum</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>Grade 2 (medium-viscosity), minimum</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>Maximum</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td><strong>Consistency, in.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 3 (non-sagging), maximum</td>
<td>1/4</td>
<td>1/4</td>
</tr>
<tr>
<td>Gel time, min.</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><strong>Bond strength, minimum, psi</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 days, moist cure(^c)</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>14 days, moist cure</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>Absorption, 24 h maximum, %</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Heat deflection temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 days minimum, °F</td>
<td>—</td>
<td>120</td>
</tr>
<tr>
<td><strong>Linear coefficient of shrinkage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On cure, maximum</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Compressive yield strength</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 days minimum, psi</td>
<td>8000</td>
<td>10,000</td>
</tr>
<tr>
<td>Compression modulus, minimum, psi</td>
<td>150,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Tensile strength, 7 days minimum, psi</td>
<td>5000</td>
<td>7000</td>
</tr>
<tr>
<td>Elongation at break, minimum, %</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^a\)Type I: for use in non-load-bearing applications.
\(^b\)Type IV: for use in load-bearing applications.
\(^c\)Moist-cured systems should be tested by assembling the sections to be bonded before immersing in water.
PROPER EQUIPMENT

- High & Low pressure is acceptable
  - Injection ports
  - Wire brush
  - Air guns;
  - Hand-actuated delivery systems;
  - Spring-actuated capsules
  - Balloon-actuated capsules.
SAFETY CONSIDERATION

- User must document safety practices:
  - Having Material Safety Data Sheets (MSDS) available on site;
  - Wearing protective clothing and protective eyewear
  - Wearing rubber gloves or barrier creams for hand protection
  - Having eye wash facilities available;
  - Wearing respirators where needed;
  - Providing ventilation of closed spaces;
  - Secured storage of hazardous materials;
  - Having necessary cleaning materials on hand; and
  - Notifying occupants of pending repair procedures.
REPAIR PROCEDURE

1. Port Installation
   - Surface mounter or Socket
   - May be connected with manifold

   How far apart do we space ports?
REPAIR PROCEDURE

1. Port Installation
   - Surface mounter or Socket
   - May be connected with manifold

How far apart do we space ports?

As far apart as possible
but no closer than 6”
(we can assume a 3” travel of resin in direction).

On Average 8”
Thinned slabs may allow for 12”
REPAIR PROCEDURE

1. Port Installation
2. Install the Capsel

- Must install on both sides of crack
- “More is better”
- Material Selection Criteria:
  - Non-sag consistency (for vertical or overhead)
  - Moisture-tolerance
  - Working life
  - Rigidity (modulus of elasticity).
REPAIR PROCEDURE

2. Install the Capseal

- Mark largest portion of crack
- Pay close attention to:
  - Use only materials that haven’t exceeded their shelf life;
  - Accurate batching of components
  - Small batches to keep material fresh and dissipate heat;
  - Port spacing
  - Consistent application of the material (1 in. wide x 3/16 in. thick [25 x 5 mm]) over the length of the crack.
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REPAIR PROCEDURE

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REPAIR PROCEDURE

3. Inject the Epoxy
   - Double check cap seal and ports
   - Mix epoxy according to manufacturer
   - For horizontal – start at widest point
   - For vertical – start from bottom
   - Continue until refusal, cap immediately
REPAIR PROCEDURE

3. Inject the Epoxy

- Double check cap seal and ports
- Mix epoxy according to manufacturer
- For horizontal – start at widest point
- For vertical – start from bottom
- Continue until refusal, cap immediately
- If hairline crack, try increasing pressure to 200 psi for 5 min. (must be managed to prevent blowout)
4. Remove Ports & Caps seal

- Optional step
- May use:
  - Heat
  - Chipping
  - Grinding
  - Other mechanical means
REPAIR PROCEDURE

4. Remove Ports & Capseal
1. Test cores
   - Engineer should determine location to avoid high stress areas
   - ASTM C42 – compressive & split tensile
   - Visual evaluation for penetration depth
   - Must patch with expansive high strength grout (epoxy or cement based)
HOW TO CHECK THE REPAIR

1. Test cores
HOW TO CHECK THE REPAIR

2. Nondestructive evaluation
   - Impact Echo
   - Ultrasonic pulse velocity
   - Spectral analysis of surface waves
SOURCES

THANK YOU FOR YOUR ATTENTION!

QUESTIONS?