Proper Design and Implementation of Concrete Repairs

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Concrete Repair Process

- Evaluate the Damage
- Diagnose the Problem
- Establish Course of Action
- Prepare Design Documents
- Implement the Repair
Concrete Repair Disconnect

- Cause vs. Solution
- Specific vs. Standard Requirements
- Prescriptive vs. Performance Specifications
- Design vs. Implementation
Cause vs. Solution
Diagnosis

- Defect
- Damage
- Deterioration

*This step is oftentimes skipped.*
Water is the Enemy
Design Documents

- Address Cause First
- Be Project Specific
  - Materials
  - Construction
- Don’t Rely Too Much on Standards
Concrete Repair Specifications: Guidance or Confusion

Concrete International, Dec. 2011

- Widespread Failure of Concrete Repairs
  - Incorrect Diagnosis
  - Incorrect Design
  - Inappropriate Repair Materials
  - Poor Workmanship
Concrete Repair Specifications: Guidance or Confusion

Concrete International, Dec. 2011

“Many repair specifications are mixtures of referenced standards, pay items, and cut-and-paste clauses recycled from previous projects with little thought about specifics. There is no such thing as a standard concrete repair.”
Inferior Repair Material
Design Considerations

- What is the goal of the repair?
- Structural or Cosmetic?
  - Most repairs are cosmetic whether we want them to be or not.
  - Loads have already re-distributed.
- Structural Patches
  - Must Temporarily Remove Load
  - Matching Material Properties
Structural Patch – The Goal
Structural Patch - High Strength / High Stiffness
Cosmetic Patch
Repair Material Options

- **Superficial Repairs:**
  - Neat Epoxy
  - Used to Address Minor Loss of Cover

- **Thin Repairs:**
  - Epoxy Mortar
  - Excellent Bond Strength
  - Minimal Surface Prep
  - Drastically Different Properties than Concrete
Repair Material Options

- **Intermediate Repairs:**
  - Proprietary Bagged Material
  - Extend Mortar with Coarse Aggregate
  - Proper Curing and Mechanical Ties to Substrate are Critical

- **Deep Repairs:**
  - Batched Concrete (Often Not Practical)
  - Proprietary Bagged Material
  - Other Options
Other Upcoming Projects
- Aviation Projects
- Freight Transportation
- Other Maintenance Projects
- Professional Services Projects
- Right of Way Acquisition
- Scientific Services
- Toll Plaza Operations

Contractors and Consultants
- Consultant Information
- Contractor Information
- Cost Control Measures
- CAD Standard Plans
- Specifications
- Plans Online
- Bridge Information
- Demographic Data Analysis Tool
- Materials Information
- Resources
- Forms

Environmental Information
- Environmental Process Flowchart
- Local Government Sponsor Projects
- Managing an Environmental Project

Government
- District and County Statistics (DISCOS)
- Airport Rules and Standards

Dealer Training Seminars
- Vehicle Shows
- Forms

Lienholders
- Electronic Lien and Title

Public-Private Partnerships
- Requests for Information
- Requests for Qualifications
- Comprehensive Development Agreements
- Design-Build Quality Assurance Program Implementation Guide
- Requests for Proposals
- Development/Exchange Agreements - Dallas District (RFP)
- Conflicts of Interest
- Metropolitan Planning Organizations
- Regional Mobility Authorities
- SB 792 Report on Private Participation in Toll Projects

Conferences & Meetings
- Americas 2020 International Trade & Transportation Summit
- 2012 Texas Aviation Conference
- 2012 Auto Burglary and Theft Prevention Conference
- 2012 Ports-to-Plains Alliance Conference

Training and Professional Development
Materials Information

TxDOT maintains the highest level of materials quality in construction projects to ensure long term safety and stability. The Department provides material specifications, guidelines and approves suppliers.

### Materials

- **Departmental Material Specifications**
- **Inspection and Testing Rates**
- **Material Producer List**
  - **Recycled Materials Producers**
  - **Test Procedures**

### Asphalt

- **Asphalt Materials and Uses**
- **Asphalt Emulsion**
- **Asphalt Binder Webinar**
- **Superpave Binder Materials Selection Procedures**
- **Superpave Binder Specification**

### General Information

- **Evaporation Rate Calculation for Concrete Worksheet**
- **Guide Schedule for Sampling and Testing**
- **Material Inspection Guide**
- **Materials Requirements**
- **Quality Assurance Program for Design-Build Projects**
- **Design Build Quality Assurance Program Implementation Guide**
- **SiteManager Materials Sourcing Letter**
DMS - 4655

CONCRETE REPAIR MATERIALS

EFFECTIVE DATE: MARCH 2011

4655.1. Description. This Specification governs the pre-qualification procedure, material properties, and packaging of inorganic cementing material for concrete repair. DMS-6170 covers polymeric materials, and Item 431 covers pneumatically placed materials.

4655.2. Units of Measurements. The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

4655.3. Material Producer List. The Materials and Pavements Section of the Construction Division (CST/M&K) maintains the Material Producer List (MPL) of all materials conforming to the requirements of this Specification. Materials appearing on the MPL, entitled “Concrete Repair Materials,” require no further testing unless deemed necessary by the Engineer.

4655.4. Pre-Qualification Procedure.

A. Pre-Qualification Request. Prospective producers interested in submitting their product for evaluation must submit a written request to the Texas Department of Transportation, Construction Division, Materials and Pavements Section (CP51), 125 E. 11th Street, Austin, TX 78701-2483.

Include the following information in the request:

- Company name
- Physical and mailing addresses
- Application classification(s) listed under Article 4655.6
- Contact person and telephone number

B. Pre-Qualification Sample. At no cost to the Department, submit a minimum of approximately 300 pounds of concrete repair material to the Texas Department of Transportation, Construction Division, Materials and Pavements Section (CP 51), 9500 North Lake Creek Parkway, Austin, Texas 78717.

Submit the following with the sample:

- Provide an independent laboratory test report from a laboratory audited and inspected by the Cement Concrete Research Laboratory containing test results and certifying compliance of the material to this Specification.
- Provide manufacturer’s certification and lot number for submitted sample.
- Provide manufacturer’s certification that repair material contains no added chlorides.
- Provide technical data sheets typically accompanying product with printed instructions for mixing and application and shelf life.
6100.1. Description. This Specification details requirements for various types of epoxy and adhesive materials suitable for highway use. These materials consist of a resin component and a hardener component or a catalyzing agent mixed to produce the finished product.

All epoxies and adhesives must be resistant to the action of weathering, moisture, acids, alkalis, and other environmental factors.

This Specification describes the following types of epoxies and adhesives:
- Type I (Classes A, B, and C)—precast concrete segment adhesive
- Type II—traffic marker adhesives
- Type III (Classes A, B, and C)—dowel and tie bars adhesives
- Type IV—bridge deck sealant and adhesive
- Types V and VII—concrete adhesives
- Type VIII (Classes A and B)—binder for producing grout or concrete
- Type IX—epoxy for crack injection
- Type X—epoxy coating for concrete
Repair Material Properties

- Modulus of Elasticity
- Slant Shear
- Drying Shrinkage
- Permeability
- Splitting Tensile Strength
- Compressive Strength
- Coefficient of Thermal Expansion
- Absorption
- Freeze/Thaw Resistance

ACI 546.3R-06 Guide for the Selection of Materials for the Repair of Concrete
Repair Material Properties

- Limit Modulus of Elasticity and Compressive Strength
- Corrosion Inhibitors
  - Use Only When Necessary
  - Corrosion Cells = Damage to Surrounding Concrete
### D. Type D—Standard Repairs (Non-Rapid)

#### Table 7

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
<th>Test Method</th>
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</thead>
<tbody>
<tr>
<td>28-day Permeability, Coulombs, max</td>
<td>1,500 at 28 days OR 0.09 % by mass in top 1 inch</td>
<td>ASTM C 1202 OR AASHTO T 259</td>
</tr>
<tr>
<td>Splitting Tensile Strength, psi, min.</td>
<td>500 at 28 days</td>
<td>ASTM C 496</td>
</tr>
<tr>
<td>Slant Shear, psi, min.</td>
<td>2,000 at 28 days</td>
<td>ASTM C 882&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Shrinkage, %, max.</td>
<td>0.04 at 28 days</td>
<td>ASTM C 157&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, micro strain /°F, max.</td>
<td>6.0&lt;sup&gt;c&lt;/sup&gt; at 28 days</td>
<td>Tex-428-A</td>
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<tr>
<td>Modulus of Elasticity, ksi, max.</td>
<td>5,000&lt;sup&gt;c&lt;/sup&gt; at 28 days</td>
<td>ASTM C 469</td>
</tr>
<tr>
<td>Absorption, %, max.</td>
<td>9.0 at 28 days</td>
<td>ASTM C 497 Section 7, Method A</td>
</tr>
<tr>
<td>Compressive Strength using 4&quot;x8&quot; cylinders, psi, min.</td>
<td>4,000 at 28 days&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ASTM C 39</td>
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</table>
Keep it Slow

- Slow Strength Gain
  - Adequate Diffusion
  - Tighter Pore Structure
  - Less Tendency to Crack
- Rapid Repair Material
  - Use Only When Necessary
  - Less Durable (Open Pore Structure)
  - Unhydrated Cement
  - Greater Potential for Shrinkage and Cracking
  - Currently Researching
Stand-Alone Repair Docs

- Minimize References to Standards
- Include Prescriptive Requirements
- Create Stand-Alone Repair Documents
  - Makes It Easier for Field Use
  - Increases Likelihood that Someone will Actually Read the Plans
  - Don’t Rely Too Much on Manufacturer Requirements
Remove existing concrete that is damaged or delaminated and existing repair material that was installed previously.

Damaged Condition
Clean exposed steel prior to patching.

Square patch permits.

For vertical repairs leave horizontal shelf at bottom of repair area.

Roughen concrete substrate to promote bond of patch material.

Excavate ¾" minimum behind exposed reinforcement.

**Step 1**

Excavation and Preparation
Step 2
Patch Damaged Area

Push a thin layer of repair mortar (scrub coat) into the surface.

Apply repair material while scrub coat is still wet.

Contain patch material in intended repair area; do not smear mortar onto adjacent concrete surfaces.

Apply scrub coat to clean, SSD substrate.

Extend repair mortar with coarse aggregate.
GENERAL NOTES:

Damage locations and quantities are based on July 2011 Bridge Damage Survey. Immediately notify TxDOT if any discrepancies are noted between the plans and actual conditions.

Submit detailed repair procedures, including proposed proprietary materials, for approval prior to commencing work.

Concrete repair quantities identified per bent on Bridge Layouts include exposed portions of concrete columns, bent caps, diaphragms and adjacent bents and deck. Do not exceed the square footage identified for any single bent until repairs have been made at each of the bent locations. Engineer will tally total square footage of repairs completed and determine if and where additional concrete repairs are necessary.

Work required to temporarily support beams using shoring or cribbing is subsidiary to Item 429.

CONCRETE REPAIR NOTES:

1) Perform work in accordance with Item 429, "Concrete Structure Repair." Use a Type A-4 repair material per TxDOT M 4635, "Concrete Repair Materials." Refer to the "Concrete Repair Materials" MPL for a list of pre-approved Type A-4 materials.

2) Surface Preparation: Remove any damaged or loose concrete or previously applied repair material. Unless otherwise approved by Engineer use only hand tools or power-driven shipping hammers (15-lb. class maximum) to remove concrete. Square the patch perimeter using handheld grinders or saws; do not over or cut patch perimeters at the corners of the repair area. Roughen the substrate to ensure there will be a mechanical bond between the patch material and parent concrete. Remove rust, oil, and other contaminants from exposed steel reinforcement. Just prior to patching, blast the repair area using a high-pressure air compressor equipped with filter to remove oil from the compressed air.

3) Mixing: Use measuring cups or buckets to determine the proper quantity of each component per the manufacturer's requirements, then dispense into a clean container. Do not "eyeball" or guess at the proper amounts while adding different components. Mix the components thoroughly until they are well-blended (3 minutes minimum using a low-speed electric drill and a clean "Jiffy" type mixing paddle). In no case will mixing by hand be permitted. Extend the repair mortar with coarse aggregate in accordance with the manufacturer's requirements. Do not attempt to make the material workable by over-mixing or adding additional liquid after it has begun to set.

4) Application: Obtain a Saturated Surface-Dry (SSD) substrate just prior to patching using a high-pressure water blast for a brief period (1 minute minimum) or other approved method. Surface may be damp but must be free of standing water. Apply a bonding coat consisting of a thin layer of non-extended repair mortar scrubbed into the substrate. Apply repair concrete while the substrate is still wet. Do not exceed the maximum lift depth permitted by the manufacturer. In multiple lift applications, roughen the surface of the preceding lift before it reaches initial set. Wet the surface just prior to applying the next lift.

5) Curing: Moist cure patch material for a minimum of 72 hours using wet mats, water spray, ponding, or other method approved by Engineer.
Repair Philosophy

- Don’t Complicate Things
  - Mechanical vs. Epoxy Anchors
  - SSD Substrate vs. Bonding Agents
  - Bagged Concrete vs. Mortar
Not Enough Epoxy
Too Much Epoxy
Too Much Epoxy
Bonding Agent Bond Breaker
Bonding Agent Bond Breaker
Repair Procedures

- Surface Prep
- Proportioning
- Mixing
- Application
- Curing
Curing

- Form Cure is Ideal
- Moist Cure is Good
- Membrane Cure is Okay
Polymer-Modified Repair

SSD

Anchor

Mixing Scrub Coat with Paddle
Mixing Extended Mortar

Placing Material

Form Cure
Batched Concrete Repair

Removing Large Aggregate

SSD

Tamping
Bracing Forms

Moist Cure

Finished Product
Aesthetics
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