



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



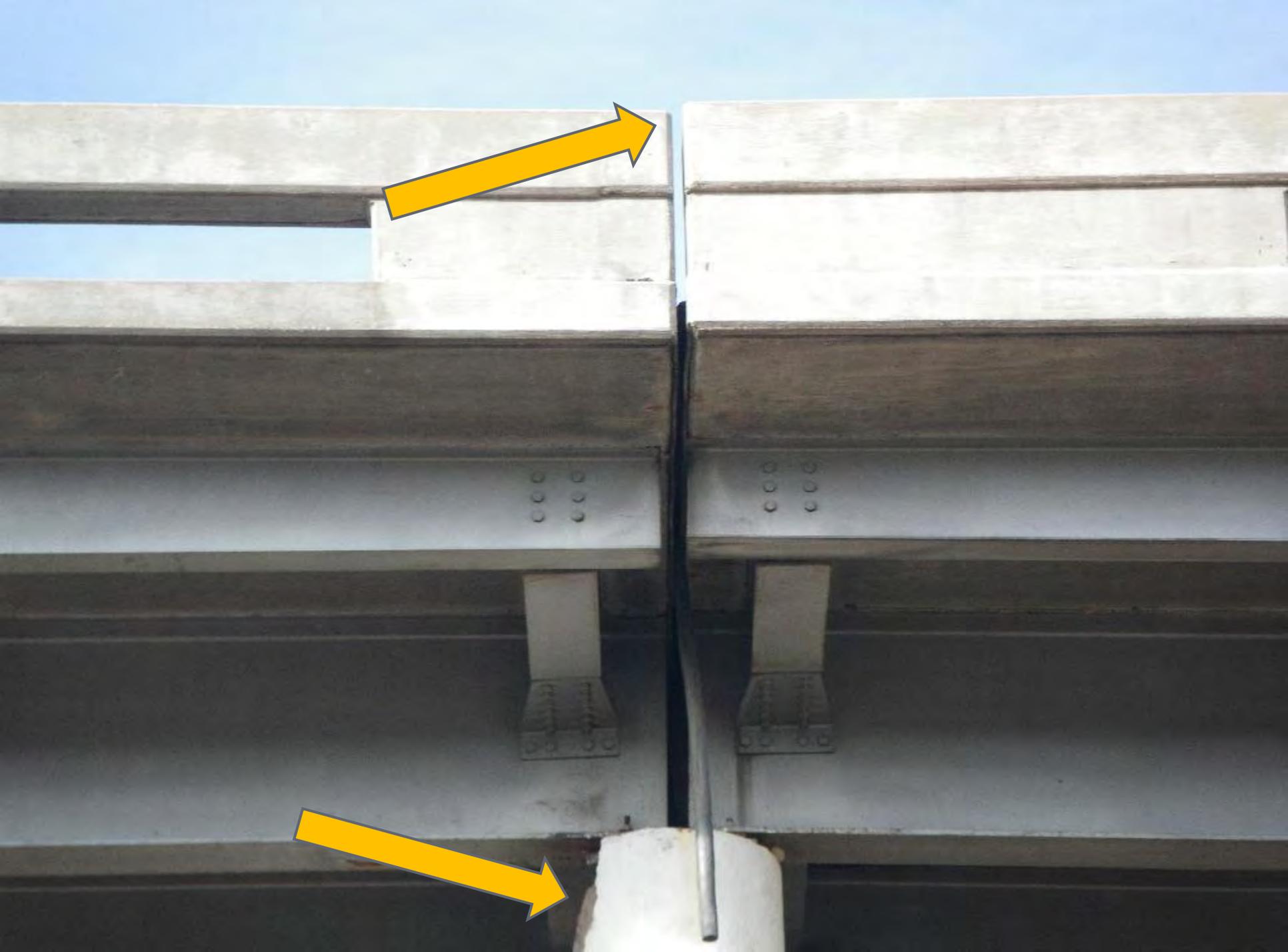


Design Considerations

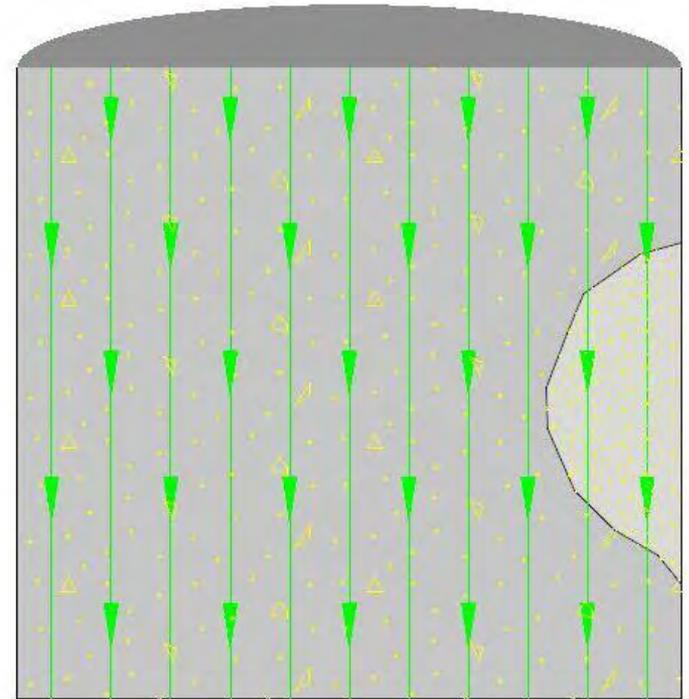
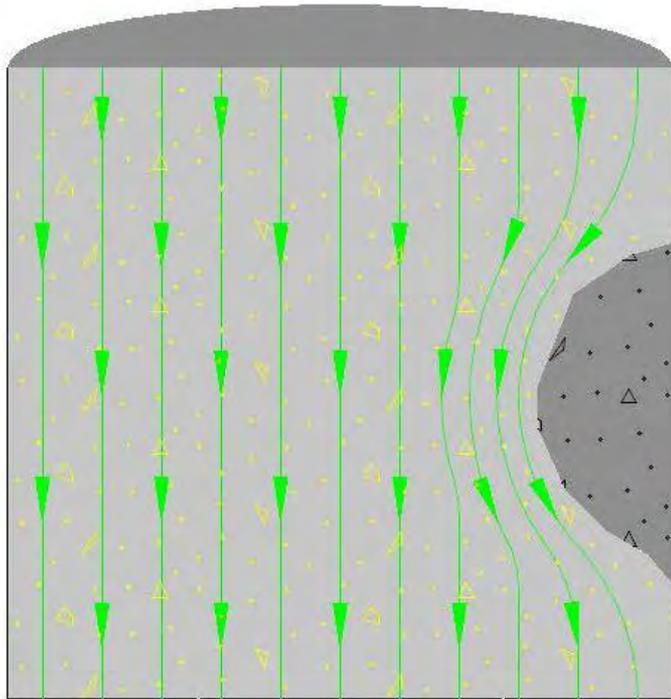
- What is the goal of the repair?
- Structural or Cosmetic?
 - Most repairs are cosmetic whether we want them to be or not.
 - Loads have already re-distributed.
- Structural Patches
 - Must Temporarily Remove Load
 - Matching Material Properties



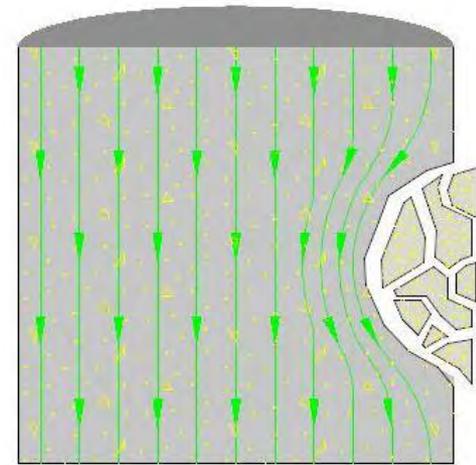
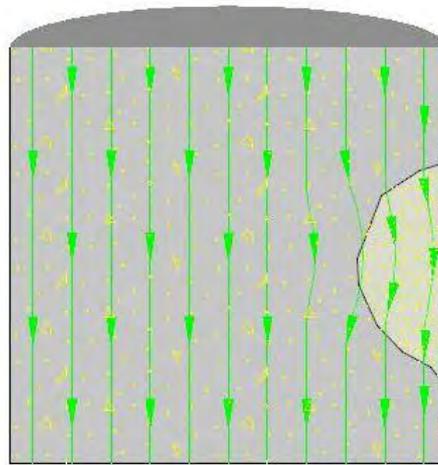
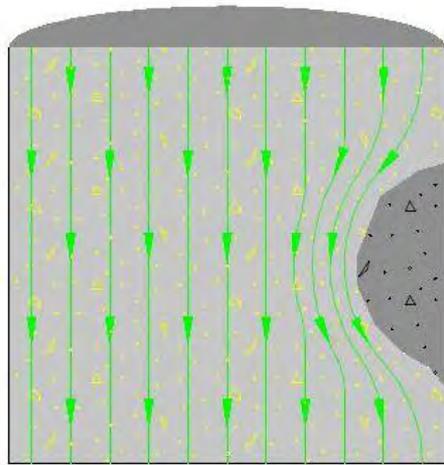




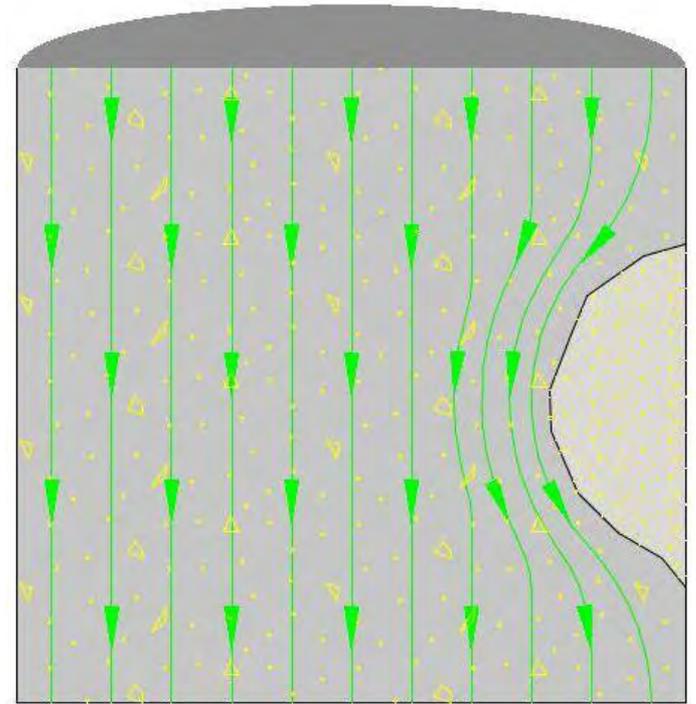
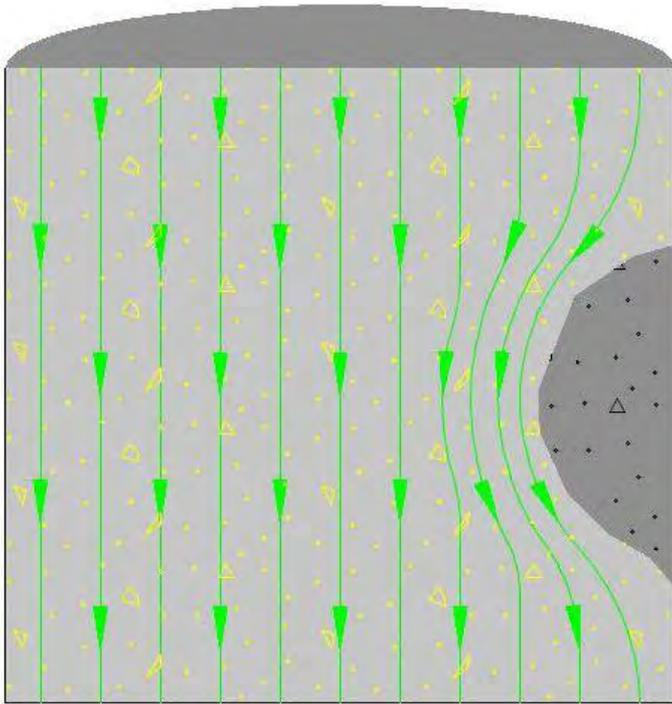
Structural Patch – The Goal



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



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- Regional Mobility Authorities
- SB 792 Report on Private Participation in Toll Projects

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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&P) 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.

DMS - 6100
EPOXIES AND ADHESIVES

EFFECTIVE DATE: OCTOBER 2007

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

TxDOT MOE Reqt's

D. Type D—Standard Repairs (Non-Rapid)

Table 7
Standard Repairs (Non-Rapid)

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

Keep it Slow

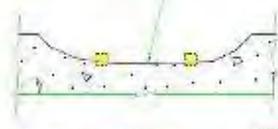
- Slow Strength Gain
 - Adequate Diffusion
 - Tighter Pore Structure
 - Less Tendency to Crack
- Rapid Repair Material
 - Use Only When Necessary
 - Less Durable (Open Pore Structure)
 - Unhydrated Cement
 - Greater Potential for Shrinkage and Cracking
 - Currently Researching

Stand-Alone Repair Docs



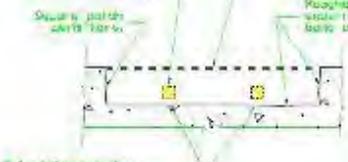
- Minimize References to Standards
- Include Prescriptive Requirements
- Create Stand-Alone Repair Documents
 - Makes It Easier for Field Use
 - Increases Likelihood that Someone will Actually Read the Plans
 - Don't Rely Too Much on Manufacturer Requirements

Remove existing concrete that is damaged or delaminated and existing repair material that was installed previously.



Damaged Condition

Remove 1/4" minimum dense exposed reinforcement.



Remove 1/4" minimum dense exposed reinforcement.

Step 1
Excavation and Preparation

For vertical repairs, leave the control joint at bottom of repair area.

Remove concrete adjacent to prepare base of patch material.

Apply spray seal to expose sub substrate.

Push a thin layer of repair material against existing concrete.

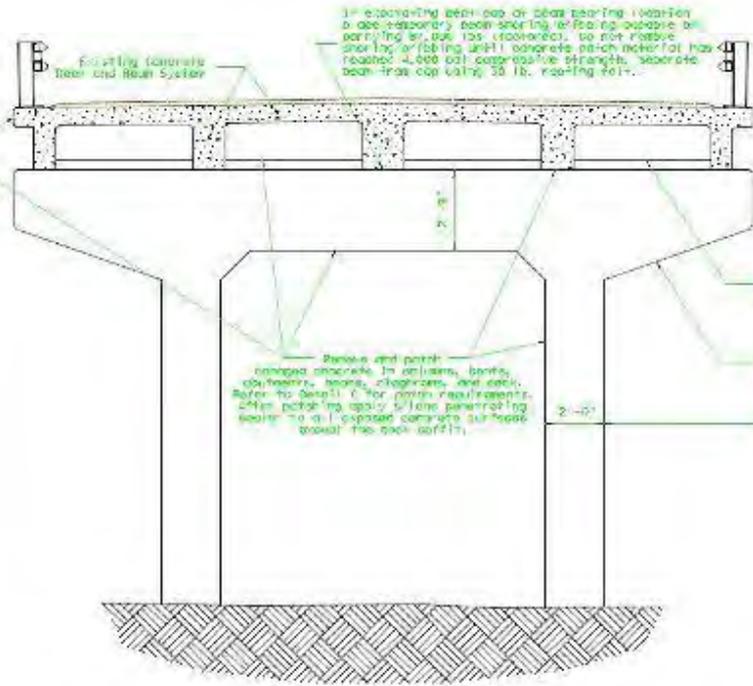
Apply repair material until repair area is full.

Contain patch material in intended repair area so not reach joints and adjacent concrete surfaces.

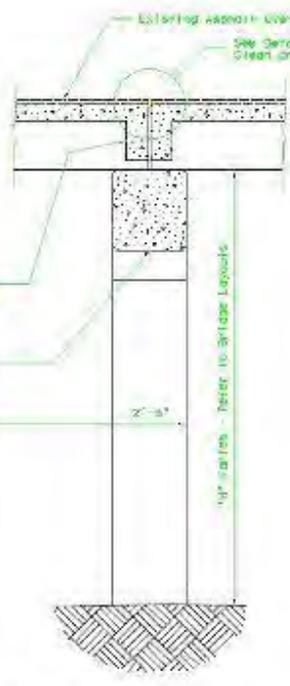
Extend repair surface with coarse aggregate.

Step 2
Repair Damaged Area

DETAIL C
Concrete Patch Procedure

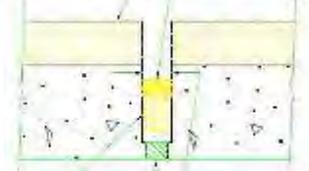


A - A
Bent Cap Elevation



B - B
Bent Cap Cross Section

Existing asphalt overlay. Remove as necessary to permit sealant installation.



Clean and seal expansion joints. Install sealant in pargeless areas such that depth (1/2") is approximately half the width (1/2").

Sealer not set under final paving.

Seal out concrete deck to achieve minimum 3" expansion joint width.

Grading to expansion form with precision joint seal.

DETAIL D
Clean and Seal Joint

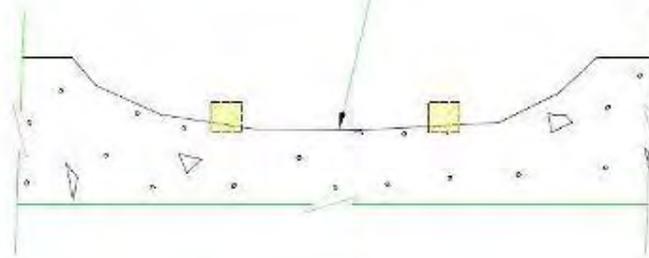
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REPAIR DETAILS
NOTES, & QUANTITIES

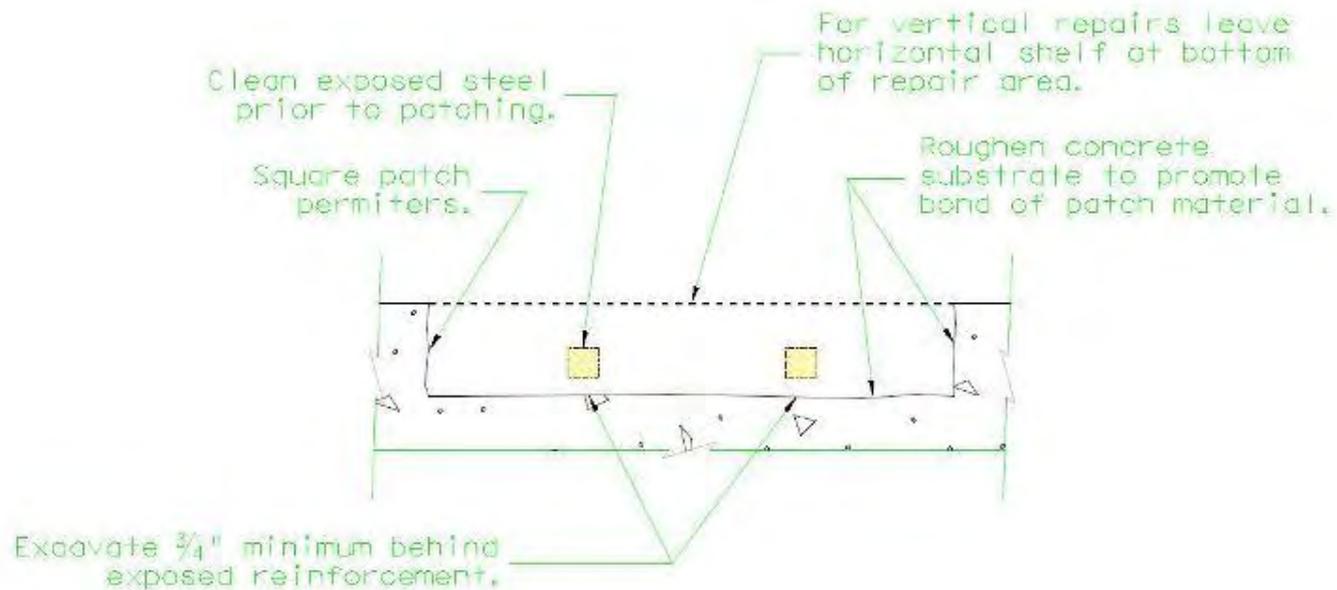
RM 2398 Howard Draw

PLAN SHEET NO.	NO.	REV.	DATE	BY	CHK.	APP.
2398	1					
2398	2					
2398	3					
2398	4					
2398	5					
2398	6					
2398	7					
2398	8					
2398	9					
2398	10					

Remove existing concrete that is damaged or delaminated and existing repair material that was installed previously.

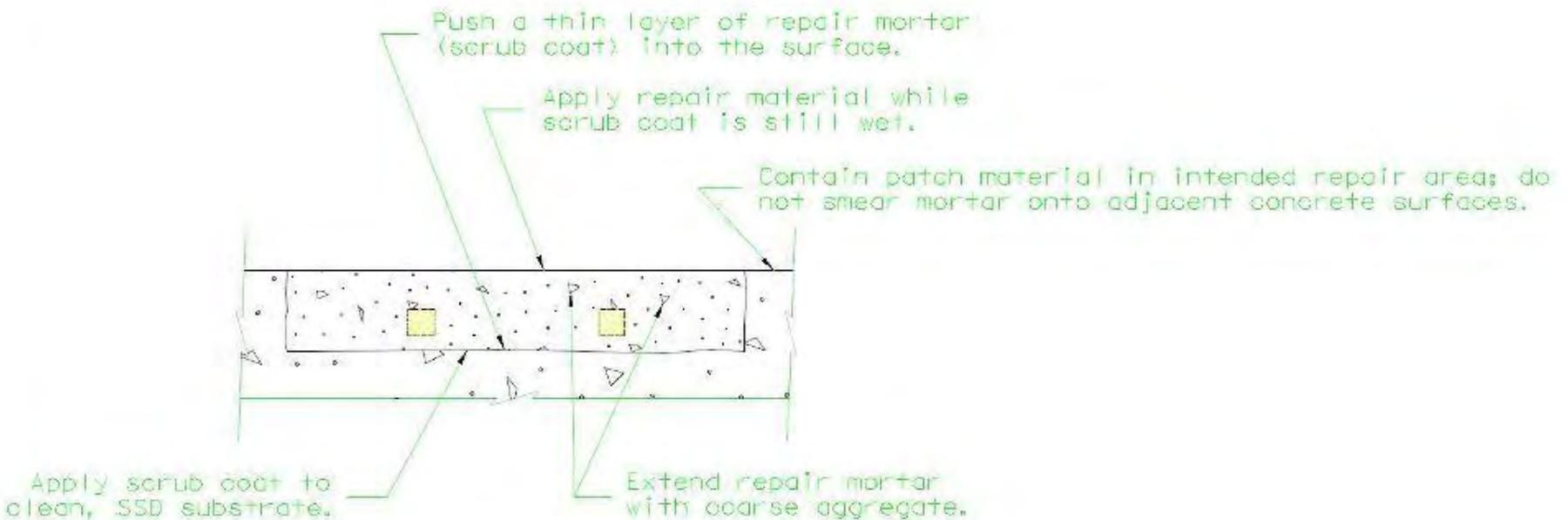


Damaged Condition



Step 1

Excavation and Preparation



Step 2

Patch Damaged Area

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 beams 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 DMS 4655, "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 chipping hammers (15-lb. class maximum) to remove concrete. Square the patch perimeters using handheld grinders or saws; do not over-cut patch perimeters at the corners of the repair areas. 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 filters 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 scrub coat 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.

Submit Repair
Procedures

Material
Selection

Surface Prep

Mixing

Application

Curing

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



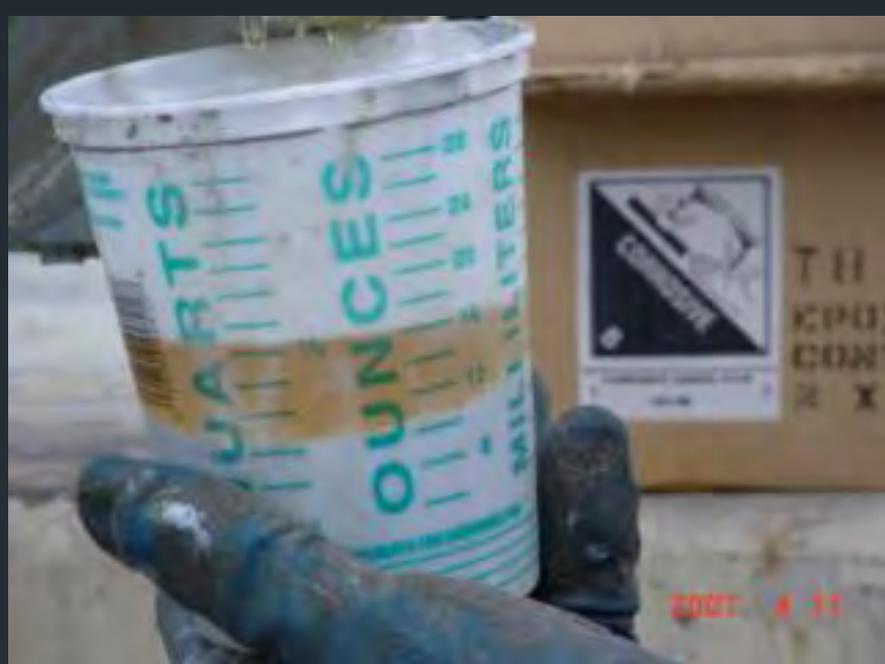
Repair Procedures

- Surface Prep
- Proportioning
- Mixing
- Application
- Curing









Curing

- Form Cure is Ideal
- Moist Cure is Good
- Membrane Cure is Okay



Polymer-Modified Repair

Anchor



SSD



Mixing Scrub Coat with Paddle





Scrub Coat



Installing Form



Sieved
Aggregate



Mixing Extended Mortar



Placing Material



Form Cure

Batched Concrete Repair

SSD



Removing Large Aggregate



Tamping





Bracing Forms



Moist Cure



Finished Product

TxDOT Standard Repairs for Precast Concrete



Precast Concrete Repair Manual 2nd Edition

TxDOT Construction Division
Materials & Pavements Section
Precast Concrete Group

Aesthetics







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