Repair of Rigid Pavements Using Epoxy Resin Grouts, Mortars and Concretes

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Module 1: Repair of Rigid Pavements Using Epoxy Resin Grouts, Mortars, And Concretes

Learning Objectives

- Define the various components and mixtures of epoxy resin systems.
- Identify the correct ASTM C 881 types, grades, and classes for specific pavement repair applications.
- Outline the procedures for preparing, mixing, and placing epoxy materials under varying temperature conditions.
- Describe the specific repair methods for different pavement conditions, including cracks, spalls, and corner breaks.
- Recognize critical safety and health precautions when handling epoxy resins and solvents.

Executive Summary: This module provides comprehensive technical guidance on the expedient repair of uncontrolled cracks and spalls in rigid pavements using epoxy resin grouts, mortars, and concretes. It covers the essential definitions of thermosetting polymers and the classification of epoxy systems according to ASTM C 881 standards for bonding and viscosity. Detailed operational protocols are established for temperature conditioning of both resins and aggregates to ensure proper chemical reaction and bond strength. The chapter delineates specific repair procedures for seven distinct pavement conditions, ranging from random cracks to longitudinal failures. Furthermore, it emphasizes rigorous quality control through trial batches and strict adherence to safety measures to protect personnel from chemical sensitivity and fire hazards associated with cleaning solvents.

Purpose

This manual presents materials, criteria, and procedures for the rapid repair of uncontrolled cracks and spalls in rigid pavements by using epoxy resin grouts, mortars, and concretes. This guidance is applicable to the repair of rigid pavements on roads and airfields.

References

Appendix A contains a list of references used in this document.

Definitions

- **Epoxy resin:** The resin component of a thermosetting polymer containing epoxy groups responsible for polymerization.
- **Epoxy resin system:** The product resulting from the combination of all components supplied for use.
- **Binder:** The cementitious part of a grout, mortar, or concrete that binds the aggregate or filler into a cohesive mass.
- **Component:** A constituent intended to be combined with others to form the epoxy resin system.
- **Filler:** A finely divided solid (passing No. 200 sieve) used to improve properties or reduce cost.

- **Epoxy resin grout:** Product obtained by combining a filler with the epoxy resin system.
- **Epoxy resin mortar:** Product obtained by combining a fine aggregate with the epoxy resin system.
- **Epoxy resin concrete:** Product obtained by combining both fine and coarse aggregate with the epoxy resin system.

General

Expedient methods are required to minimize pavement closure time. Approved epoxy resins provide high bond strength in a short period, usually permitting traffic within 24 to 48 hours. Optimal air and surface temperatures range from 70°F to 100°F, though repairs can occur at 40°F if proper conditions are met. Repairs should not be initiated unless temperatures are above 40°F and rising, unless Class A epoxy is used.

Approved Epoxy Materials

Epoxy resins must conform to ASTM C 881, which designates types, grades, and classes:

- **Types:** Type I (hardened to hardened concrete), Type II (fresh to hardened concrete), Type III (skid-resistant materials and binder for mortars/concretes).
- **Type III Bond Strength:** 1,400 psi shall be used in lieu of the 300 psi shown in ASTM C 881 Table 1.
- **Grades (Viscosity):** Grade 1 (low), Grade 2 (medium), Grade 3 (non-sagging/high). Grade 3 is used for vertical faces.
- **Classes (Temperature):** Class A (below 40°F), Class B (40–60°F), Class C (above 60°F).

Applications

- **a. Type I:** Cementing dowels and pressure grouting of nonworking cracks; Grade 1 is required for pressure grouting.
- **b. Type II:** Adhesive for bonding fresh PCC to hardened PCC; Grade 2 is preferred.
- c. Type III: Binder in epoxy mortars or concretes for repairing spalls and filling nonworking joints.

Effective Temperature and Conditioning

- a. Pavements: If temperatures are 50–70°F, repairs can proceed without an artificial environment if longer cure times are acceptable. Below 50°F, use infrared heat lamps for 3 hours prior to placement. Above 90°F, schedule repairs in the early morning. Enclosure surface temperatures must not exceed 100°F.
- b. Conditioning of Aggregates: Aggregates must be dry (moisture $\leq$ 1.0%) and conditioned to 70–85°F.

- c. Conditioning of Epoxy Resin Components: Components should be conditioned to 60–100°F prior to mixing.
- d. "Triggering" Curing Chemical Reaction: To accelerate hardening in cold conditions, aggregates can be warmed, but temperatures must not exceed 120°F.

Aggregates for Epoxy Resin Concretes and Mortars

- a. Concretes: Clean, dry, washed gravel or crushed stone (3/8-inch or 1/2-inch max size) meeting ASTM C 33.
- b. Mortars: Fine aggregate meeting ASTM C 144 or ASTM C 33.
- **General Rule:** Max aggregate size should not exceed 1/3 of the layer thickness or 1/3 of the opening width.

Sampling and Testing Epoxy Resins

All resins must be tested for compliance; manufacturer certificates are not accepted for large jobs. Testing is conducted by US Army Engineer Waterways Experiment Station or South Pacific Division Laboratories.

Trial Batches

- a. Epoxy resin mortars and concretes: Small laboratory batches (min. 300g) are required. Use a polyethylene container with a hemispherical bottom.
- **Proportions:** * Concrete (weight): 6 to 10 parts aggregate to 1 part binder.
    - Concrete (volume): 4 to 7 parts aggregate to 1 part binder.
    - Mortar (weight): 4 to 7 parts aggregate to 1 part binder.
    - Aggregate mixture should contain 55 $\pm$ 5 percent fine aggregate by weight.
- b. Epoxy resin system and grout: Trial batches are not required for bonding or filling cracks/dowels.

Field Mixing and Batch Size

Small batches (0.1 cu ft) can be hand-mixed, but power-driven mixers are preferred for large batches. Maximum batch size is 200 to 300 pounds. Mix resin first, then add aggregates immediately; for concrete, add large aggregate first, then fine aggregate to prevent "balling". Clean tools with solvents like methyl-ethyl-ketone, toluene, or methylene chloride.

Procedures for Conditions 1 and 2

Random cracks must be widened with a rotary grooving tool. Faces must be clean of oil/grease via sandblasting and dried with air jets. Fill with a moderately rich epoxy resin mortar finished flush with the surface.

Procedure for Condition 3

Repair involves removing the area and replacing it with new PCC.

- a. Preparation: Saw cut at least 2 inches outside the crack to a depth of 2 inches; remove concrete using air hammers.
- b. Maintaining the joint: Use temporary inserts or sawing to prevent bonding to adjacent slabs.
- c. Placement of new concrete: Coat vertical faces with 20-mil epoxy film. Place concrete when epoxy is tacky (30–60 mins). Slump should not exceed 2 inches.

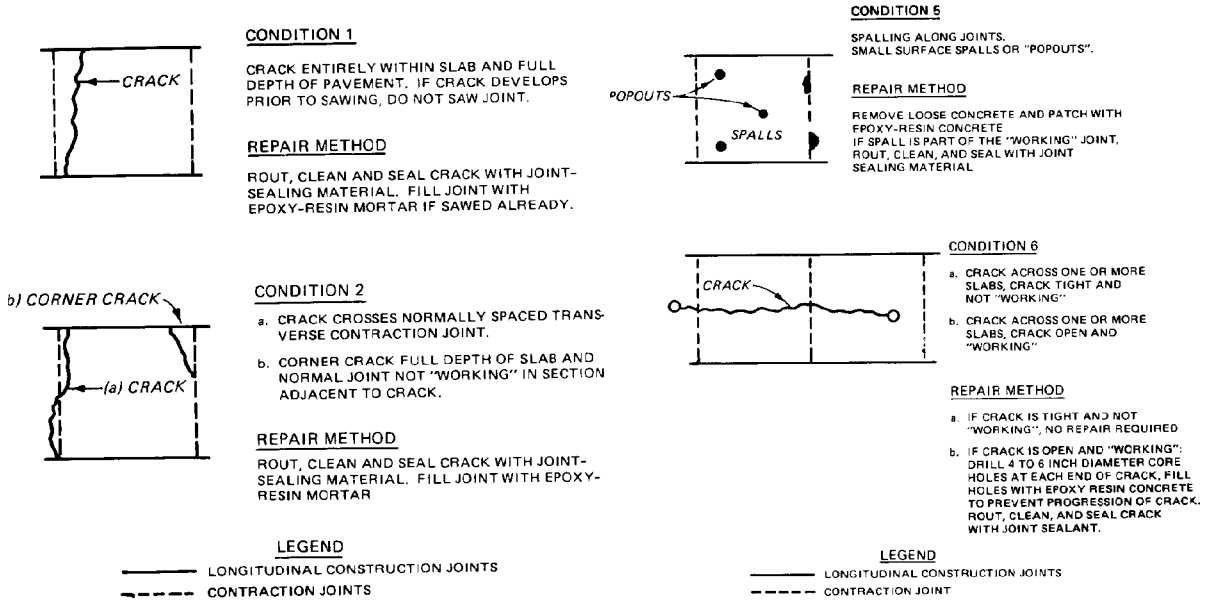

Figure 1. Approved methods for repair of uncontrolled cracks and spalls in rigid pavements.

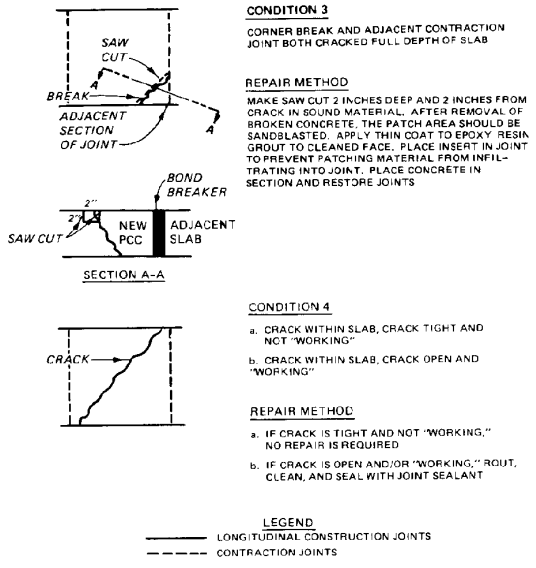

Figure 1. Approved methods for repair of uncontrolled cracks and spalls in rigid pavements—continued.

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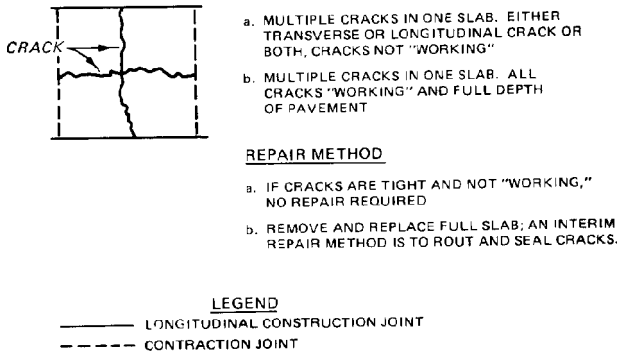

Figure 1. Approved methods for repair of uncontrolled cracks and spalls in rigid pavements—continued.

Procedure for Condition 4

These repairs do not use epoxy resin grouts, mortars, or concrete.

Procedure for Condition 5

Includes all spalls along joints and working cracks.

- a. Removing unsound concrete: Determine defective areas by tapping. Saw cut min. 1/2-inch for mortar and 2 inches for concrete repairs.
- b. Surface preparation: Clean by sandblasting.
- c. Maintaining working joint: Use fiberboard coated with polyethylene film or foam strips (min. 1/2-inch thick).
- d. Spalls along working cracks: Use bond-breaking mediums like grease or polyethylene foam to prevent further spalling.
- e. Repair of spalls within working cracks: Maintain the crack alignment using polyethylene foam sheets.
- f. Placement: Prime cavity with binder (15–20 mils) and place epoxy mixture immediately.
    - If depth > 2 inches, use multiple courses to avoid heat-induced cracking.
    - Ensure temperature does not exceed 140°F during hardening.

Procedure for Condition 6

Route the full length of the crack and drill 4–6 inch core holes at each end. Fill core holes with epoxy resin concrete in courses up to 6 inches thick.

Procedure for Condition 7

These repairs do not use epoxy resin grouts, mortars, or concretes.

Protection of Repaired Areas from Weather and Traffic

- a. Temperature: If ambient temp < 60°F, use tarpaulins or heated enclosures.
- b. Water: Protect from rain for 2–12 hours; do not apply to surfaces with excessive moisture (check with plastic film test).
- c. Traffic: Barricade until hardened (usually < 24 hours).

Cleaning of Equipment and Tools

Clean tools before epoxy sets using toluene or xylene. Workers must wear solvent-resistant gloves and aprons.

Safety and Health Precautions

- a. General: Handle in well-ventilated areas and prevent skin contact using neoprene gloves.
- b. Personal sensitivity: Amine-type curing agents are caustic and can cause tissue or eye damage.
- c. First aid: For eyes, flush for 15 minutes and see a physician. For skin, wash with soap and water.

Checkpoint Quiz

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1. **What is the maximum allowable moisture content for aggregates used in epoxy resin concrete or mortar?**
   a) 0.5 percent by weight
   b) 1.0 percent by weight
   c) 2.0 percent by weight
   d) 5.0 percent by weight

Answer: (b). Excessive moisture prevents the epoxy resin from bonding correctly to the aggregate surfaces, which compromises the stability and integrity of the final mixture.

2. **Which ASTM C 881 Grade is specifically recommended for use on vertical faces?**
   a) Grade 1
   b) Grade 2
   c) Grade 3
   d) Grade 4

Answer: (c). Grade 3 is defined as having a nonsagging consistency or high viscosity, which allows the material to stay in place on vertical surfaces without running or slumping during application.

3. **Why must epoxy resin concrete be placed in multiple courses if the repair depth exceeds 2 inches?**
   a) To ensure the aggregate stays well-graded
   b) To reduce the amount of epoxy resin required
   c) To prevent cracking due to excessive heat buildup
   d) To allow for easier hand-tamping

Answer: (c). The chemical reaction in epoxy systems is exothermic (releases heat); in layers thicker than 2 inches, the internal heat buildup can become sufficient to cause the material to crack.

Purchase this course to see the remainder of the technical materials.