*ACI RAP Bulletin 7*

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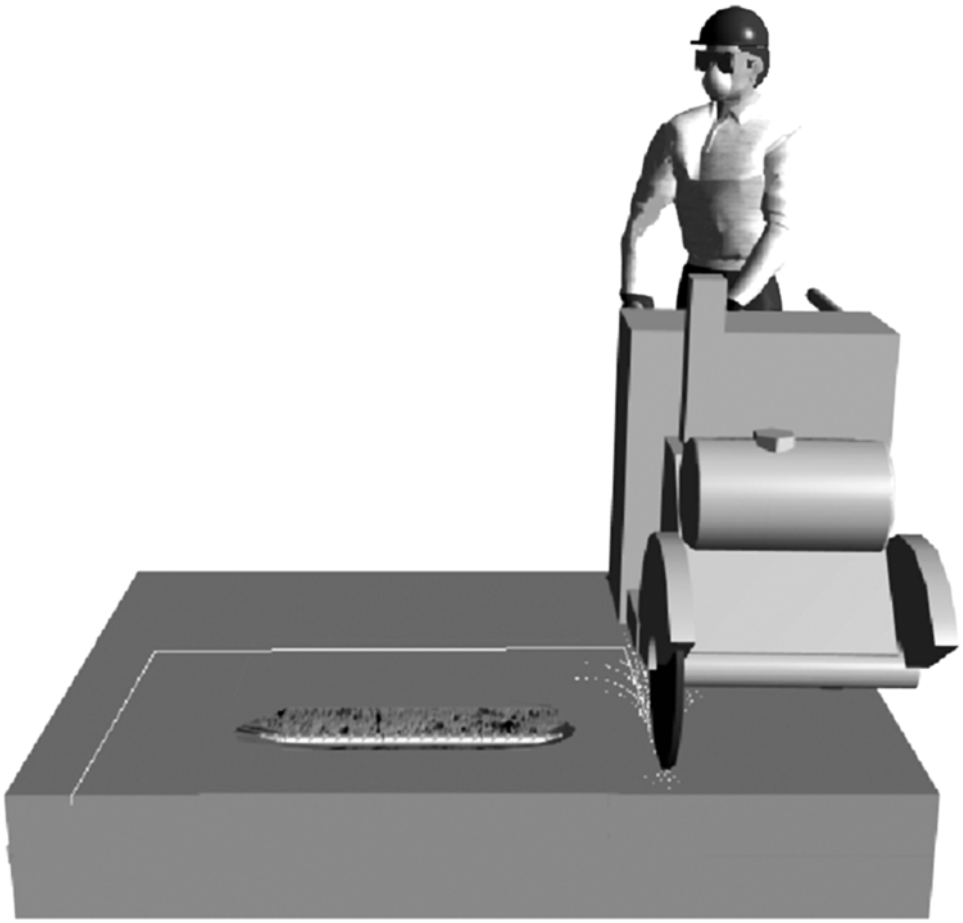
FIELD GUIDE TO
CONCRETE REPAIR
APPLICATION PROCEDURES

# Spall Repair of Horizontal Concrete Surfaces



# ACI RAP Bulletin 7

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## Field Guide to Concrete Repair Application Procedures

# Spall Repair of Horizontal Concrete Surfaces

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ACI Repair Application Procedure 7.




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## Introduction

Horizontal surface repair is common on slabs either elevated or on grade. Deterioration may be caused by corrosion of embedded reinforcement resulting in delamination and spalling. Other common causes include freezing-and-thawing deterioration and chemical attack. After an evaluation of the deterioration by an engineer, a plan should be developed including objectives and specifications for the repair. Steps for repairs that include layout, removals, edge preparation, mixing, bonding, placement, and curing have been included below as a step-by-step guide for use by field personnel.

## What is the purpose of this repair?

The purpose of spall repair is to repair deteriorated concrete, repair damaged reinforcing steel, and replace the lost concrete section.

## When do I use this method?

This method should be used for repairing spalls on horizontal surfaces such as structural slabs, exterior slabs on ground, balconies, and interior floors.

## How do I prepare the surface?

Regardless of the repair method, surface preparation is essentially the same. Unsound concrete is removed. Exposed bars are undercut and surfaces are cleaned with high-pressure water (3000 psi minimum) or are abrasively blasted. Follow the steps outlined below:

## Surface preparation

*Step 1*—Sound the concrete surfaces to locate delaminated areas. This may be done as described in ASTM D4580-03(2007), "Standard Practice for Measuring Delamination in Concrete Bridge Decks by Sounding."

*Step 2*—Mark the perimeter of the repair area. Preferable layout will result in simple geometric shapes with few re-entrant corners.

*Step 3*—Sawcut the perimeter of the repair. To avoid damaging reinforcement, the sawcut should not be deeper than the cover over the reinforcement. If the delamination is caused by corrosion, but the area of corroded reinforcing isn't apparent, use chipping hammers to expose the reinforcement until areas of uncorroded bars are found. Then sawcut an area that encompasses the boundaries of corrosion that have been established.

*Step 4*—Perform initial concrete removal with either 15-lb or 30-lb jackhammers. Jackhammers larger than 30 lb may cause damage to reinforcement, reinforcement bond to surrounding concrete, and remaining concrete. Use 15-lb jackhammers for final removal and detailing around the reinforcing steel.

*Step 5*—If exposed bars are corroded, concrete surrounding the bar should be fully removed to expose the corroded bar, regardless of how much of the bar is corroded. Removals around the bar should allow the hand to pass under the bar. Clearance around the bar should be approximately 3/4 in. (20 mm).

*Step 6*—If corroded bars are found and the bars have loss of cross section, a structural engineer should be consulted.

*Step 7*—Final cleaning of the exposed reinforcement and concrete is required. Use of high-pressure water or abrasive

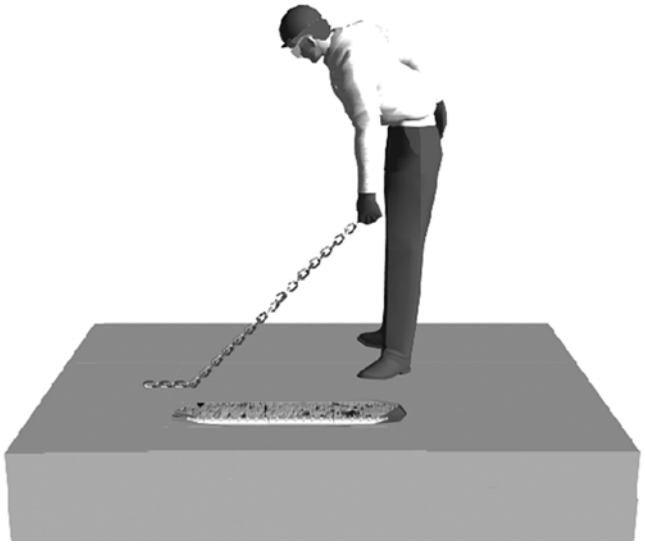

*Fig. 1—Sound the concrete surface to locate delaminated areas. Chain drags can be used for sounding.*

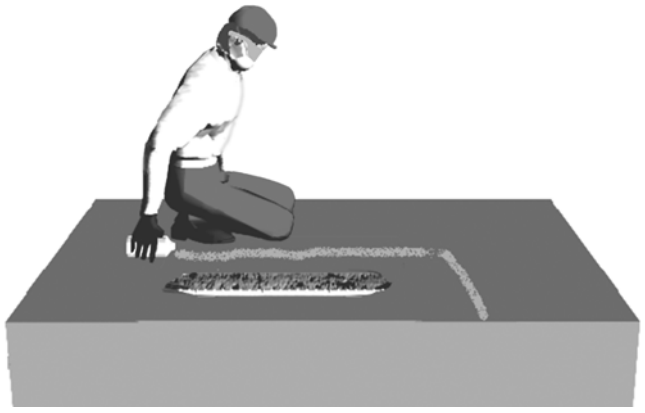

*Fig. 2—Mark the perimeter of the repair area using simple geometric shapes and minimizing re-entrant corners.*

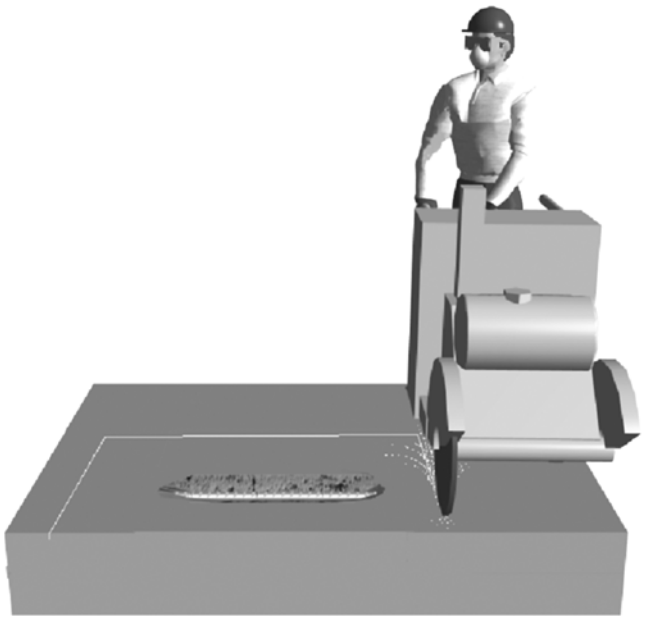

*Fig. 3—Sawcut the repair perimeter, but no deeper than the thickness of the concrete cover over the reinforcement.*

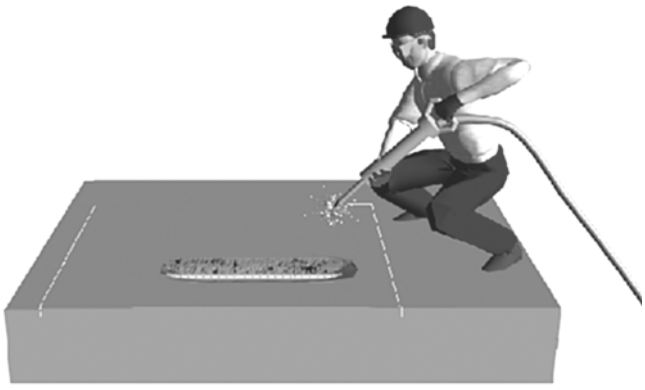

*Fig. 4—Initial concrete removal within the sawcut area, using a 15- or 30-lb jackhammer. Use 15-lb jackhammer for final removal.*

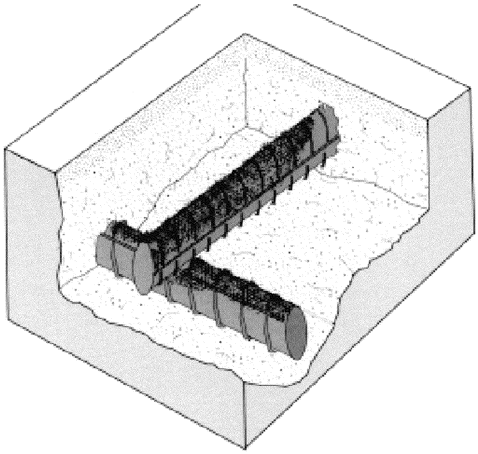

*Fig. 5—If corrosion is present, remove enough concrete to fully expose the corroded bar.*

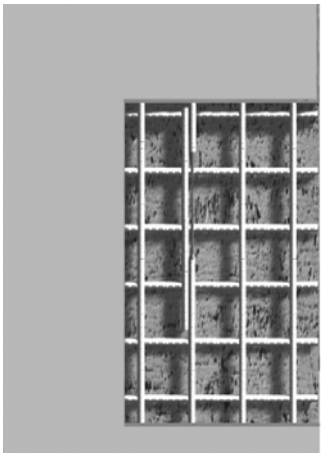

*Fig. 6—Remove enough concrete so clearance beneath bars is about 3/4 in.*

blasting is required to remove loose and bond-inhibiting materials.

### Placement procedures

*Step 8*—Pre-wet concrete surfaces before placing repair materials. Concrete surfaces receiving repair materials should be saturated surface-dry (SSD). An SSD condition is

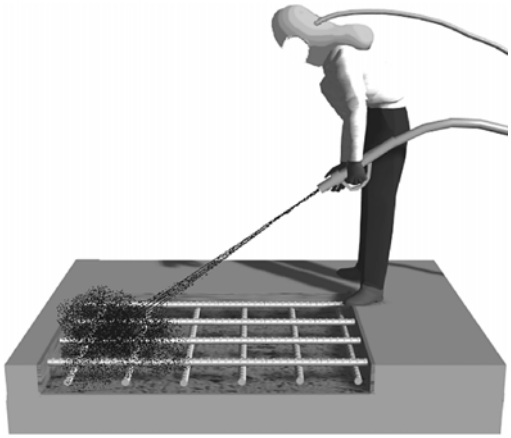

*Fig. 7—Clean the exposed concrete and reinforcing bars with high-pressure water or abrasive blasting.*

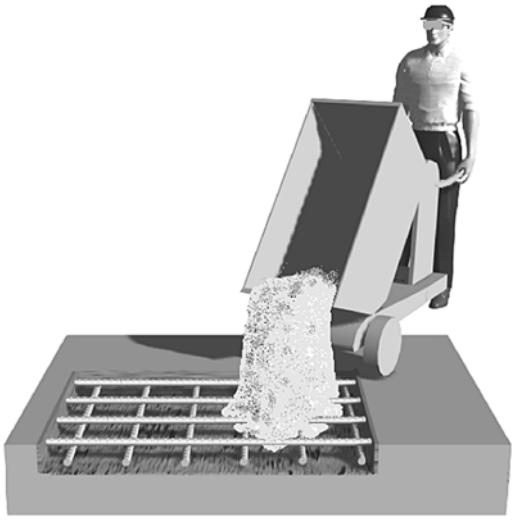

*Fig. 8—Place repair material into the prepared cavity by buggy, pump, or other conveying method.*

achieved when the body of the concrete is saturated and free surface water and puddles have been removed from the surface of the concrete. Wetting the surface immediately before placing material may result in standing water and water-filled surface pores. This condition will result in poor bond between the repair material and the concrete substrate.

*Step 9*—Use of bonding agents is optional. The most common bonding agents are composed of cement and water mixed together to form a broomable slurry. When a cement slurry is used, care should be exercised so the slurry doesn't dry prior to placement of the repair material. Manufactured bonding agents can also be used. Follow manufacturer instructions for use of these materials. Certain repair material mixture proportions and placement conditions may not require a separate bonding agent. If a manufactured (bagged) product is used, follow the manufacturer's instructions. Follow the procedures outlined in the preceding section of this document. This will ensure that the placement methods and materials will result in adequate bond.

*Step 10*—Mix bagged repair material in accordance with the manufacturer's instructions. If using ready mixed

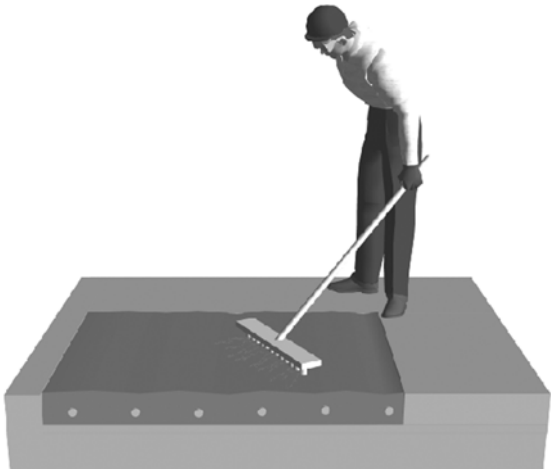

*Fig. 9—Strike off, then float the repaired surface.*

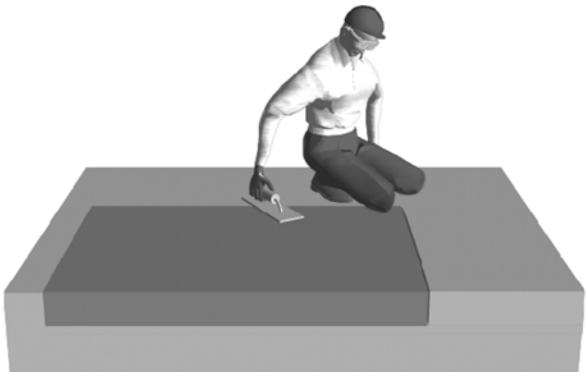

*Fig. 10—After floating, trowel or broom the surface.*

concrete, follow project specifications for mixing and transport requirements.

*Step 11*—Place repair material into the prepared cavity by buggy, pumpline, or other acceptable method.

*Step 12*—Consolidate the repair material into the cavity using either a vibrating screed or internal vibrator. Vibration allows the repair material to flow around the reinforcing steel and also come into intimate contact with the existing concrete substrate. This will promote maximum bond between the new material and the substrate. Entrapped air will also be removed in this step.

*Step 13*—Screed the repair material.

*Step 14*—Float the repair material.

*Step 15*—Trowel the repair material or broom the surface for texture.

*Step 16*—Cure the repair in accordance with the manufacturer's recommendations (if the material is bagged). If the repair uses ready-mixed or site-mixed concrete, place wet burlap and a polyethylene sheet over the repair for a minimum of 7 days. An alternative to wet burlap is the use of a spray-applied curing compound.

## How do I select the right material?

If ready mixed concrete is used for the repairs, a water-cementitious material ratio (*w/cm*) of not more than 0.40

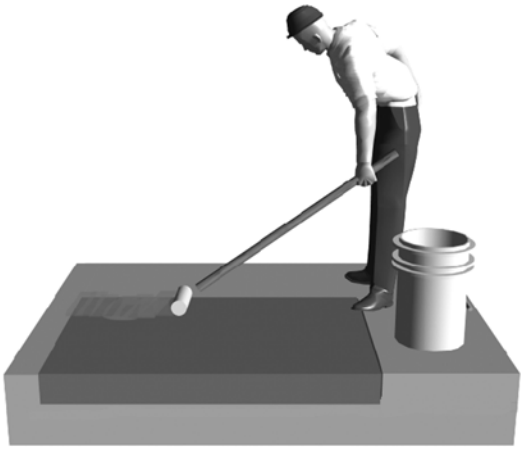

*Fig. 11—Cure with wet coverings, or use a spray- or roller-applied curing compound as shown here.*

should be used. Compressive strength should be greater than the original concrete and should not be less than 4000 psi. Other properties such as low shrinkage may be desirable and should be specified by the owner's representative. Prepackaged materials specially designed for the repair of concrete surfaces can also be used. Selection should be based on meeting the specified properties outlined by the owner's representative. Refer to ACI 546.3R-06, "Guide for the Selection of Materials for the Repair of Concrete," for more information.

## What equipment do I need?

- Sawcutting equipment and blades
- Chipping hammers
- Air compressor
- Abrasive blast equipment
- Concrete mixing and placing equipment
- Concrete finishing tools

## What are the safety considerations?

- Eye protection is required for demolition and cleaning operations.
- Hearing protection must reduce sound levels reaching the inner ear to limits on these levels that are specified by OSHA.
- Respiratory protection is required when airborne dust or vapors are produced.
- Skin should be protected from chemicals and cement.
- Material Safety Data Sheets (MSDS) should be available for materials on the job site.

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## Preconstruction meeting

Prior to proceeding with the repair, a preconstruction meeting is recommended. The meeting should include representatives from participating parties (owner, engineer, contractor, materials manufacturer), and specifically address the parameters, means, methods, and materials necessary to achieve the repair objectives.

## How do I check the repair?

- Check surface preparation in two ways. First, the surface should be free of dust or other bond-inhibiting materials. A visual check is the first thing to do. The visual check should observe the surface for signs of dust or anything that may cause the repair material not to bond to the visible surface. The second check is to sound the area with a hammer to locate any delaminations that may still exist beneath the prepared surface.
- Test the repair-material properties to ensure the material meets the desired or specified properties. Compressive strength is the most common test. Samples of the material should be placed into the standard cylinder molds used for concrete testing and sent to a lab for testing.
- Check bond using a pull-off test. This test requires core drilling through the repair into the substrate approximately 1/2 in. (12 mm); the concrete core should remain attached to the substrate. Minimum core diameter is 2 in. (50 mm). After core drilling, a steel plate is glued to the top of the core. A specially designed pulling device is attached to the steel plate and is used to pull the plate until failure of the concrete occurs with the core. The force required to break the core is divided by the area of the core resulting in a value expressed in psi (pounds per square inch) or MPa (megaPascals). A target value above 150 psi (1 MPa) is recommended. In some cases, however, values below 150 psi (1 MPa) and above 100 psi (0.7 MPa) are acceptable. If the test results are below 100 psi (0.7 MPa), critically review materials and procedures to develop a plan for improving the bond strength of the repair. More information regarding this procedure is given in ICRI Technical Guideline No. 03739, "Guide to Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials," published by the International Concrete Repair Institute.

## References


ACI Committee 201, 2008, "Guide for Conducting a Visual Inspection of Concrete in Service (ACI 201.1R-08), American Concrete Institute, Farmington Hills, MI, 15 pp.

ACI Committee 308, 1992, "Standard Specification for Curing Concrete (ACI 308-92)," American Concrete Institute, Farmington Hills, MI, 11 pp.

ACI Committee 364, 2007, "Guide for Evaluation of Concrete Structures before Rehabilitation (ACI 364.1R-07)," American Concrete Institute, Farmington Hills, MI, 18 pp.

ACI Committee 515, 1985, "A Guide to the Use of Waterproofing, Damproofing, Protective, and Decorative Barriers for Concrete (ACI 515.1R-79 (Revised 1985))," American Concrete Institute, Farmington Hills, Mich., 44 pp.

ACI Committee 546, 2004, "Concrete Repair Guide (ACI 546R-04)," American Concrete Institute, Farmington Hills, Mich., 53 pp.

ACI Committee 546, 2006, "Guide for the Selection of Materials for the Repair of Concrete (ACI 546.3R-06)," American Concrete Institute, Farmington Hills, MI 34 pp.

ASTM D4580-03(2007), 2007, "Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding," ASTM International, West Conshohocken, PA, 4 pp.

International Concrete Repair Institute, 1997, "Selecting and Specifying Concrete Surface Preparation for Coatings, Sealers, and Polymer Overlays," *ICRI Technical Guideline* No. 310.2-1997, 41 pp.

International Concrete Repair Institute, 2004, "Guide to Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials," *ICRI Technical Guideline* No. 310.3-2004, 16 pp.

International Concrete Repair Institute, 2008, "Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion," *ICRI Technical Guideline* No. 310.1R-2008, 12 pp.

International Concrete Repair Institute, 2009, "Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces," *ICRI Technical Guideline* No. 320.2R-2009, 36 pp.