

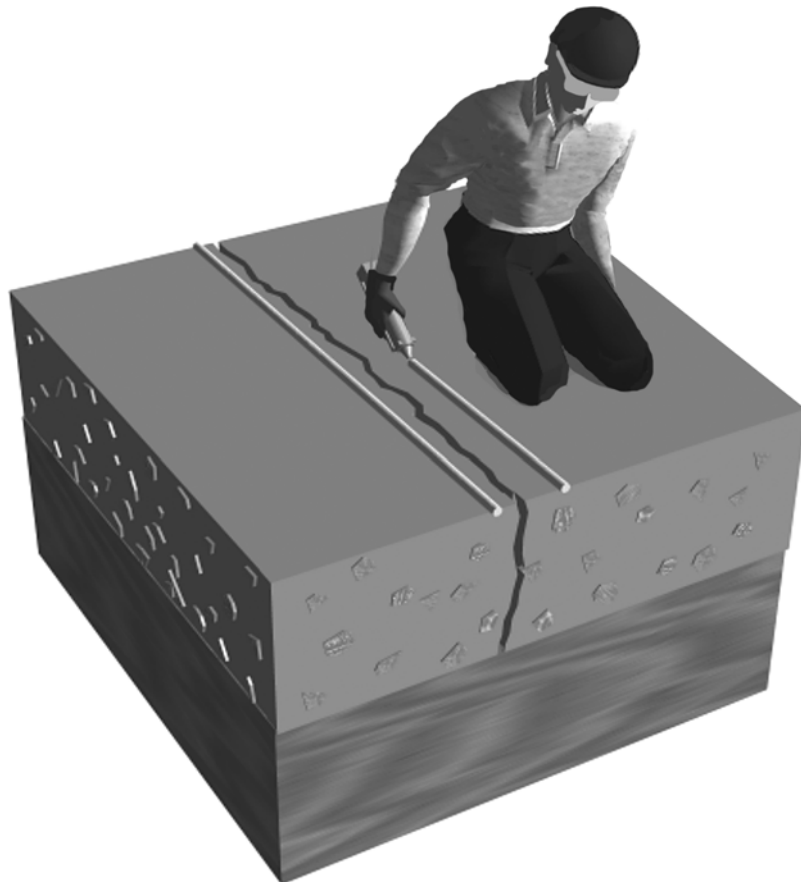


American Concrete Institute®  
Advancing concrete knowledge

ACI RAP Bulletin 2

FIELD GUIDE TO  
CONCRETE REPAIR  
APPLICATION PROCEDURES

# Crack Repair by Gravity Feed with Resin





# Field Guide to Concrete Repair Application Procedures

## Crack Repair by Gravity Feed with Resin

Reported by ACI Committee E706

Brian F. Keane  
Chair

J. Christopher Ball  
Floyd E. Dimmick, Sr.  
Peter H. Emmons  
Timothy R. W. Gillespie

H. Peter Golter  
Bob Joyce  
Kenneth M. Lozen

John S. Lund  
Richard Montani\*  
Jay H. Paul

George I. Taylor  
Patrick M. Watson  
David W. Whitmore

\*Primary author.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

### Structural Disclaimer

This document is intended as a voluntary field guide for the Owner, design professional, and concrete repair contractor. It is not intended to relieve the user of this guide of responsibility for a proper condition assessment and structural evaluation of existing conditions, and for the specification of concrete repair methods, materials, or practices by an experienced engineer/designer.

ACI Repair Application Procedure 2.

Copyright © 2003, American Concrete Institute.

All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by electronic or mechanical device, printed, written, or oral, or recording for sound or visual reproduction or for use in any knowledge retrieval system or device, unless permission in writing is obtained from the copyright proprietors. Printed in the United States of America.

The Institute is not responsible for the statements or opinions in its publications. Institute publications are not able nor intended to supplant individual training, responsibility or judgment of the user, or the supplier of the information provided.

## Introduction

This topical application for crack repair uses a thin polymer resin to fill the crack. Penetrating by gravity alone, the resin fills the crack and forms a polymer plug that seals out water, salts, and other aggressive elements. In some cases, a structural repair of the crack can be achieved.

Before any concrete is repaired, the cause of the damage must be assessed and the objective of the repair must be understood.

Typical causes of concrete cracking include steel corrosion, freezing and thawing, sulfate attack, and alkali-aggregate reaction (AAR). Poor practices during the original construction can cause excessive shrinkage or settlement in the structure. Improper joint spacing and load imbalances also contribute to cracking.

## What is the purpose of this repair?

The primary objective of this repair is to fill the crack and structurally bond the concrete on both sides of the crack. This repair is to seal cracks that are not moving—for example, shrinkage cracks, and settlement cracks that have stabilized. By penetrating and filling the cracks, the resin is able to form a polymer plug that seals the crack, keeping out water, chlorides, carbon dioxide, sulfates, and other aggressive liquids and gases.

This repair method is, therefore, a way to reduce possible future deterioration caused by freeze-thaw cycles, steel corrosion, and chemical attack of the concrete.

A common secondary objective of this repair is the protection of the entire deck or floor with a penetrating sealer. Instead of gravity feeding individual cracks, a flood coat on the entire deck or floor is often done to seal the concrete surface, in addition to “healing” the cracks. This is why the term sealer/healer is often associated with this application and material.

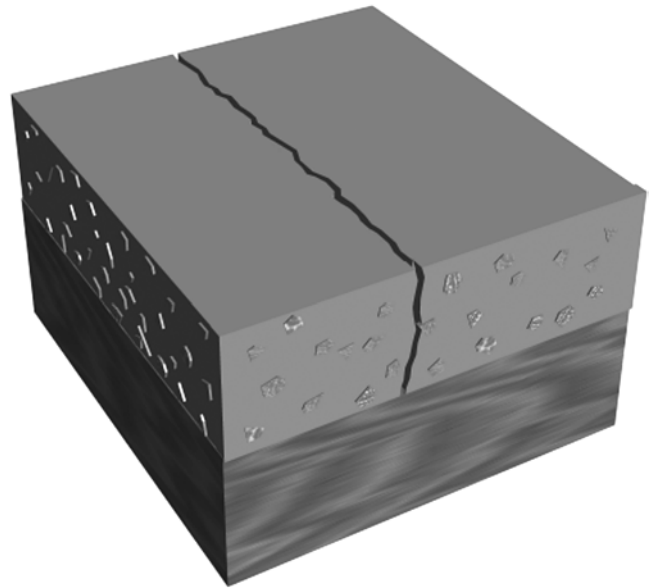
Finally, it is occasionally an objective to achieve a structural repair of the cracks using this method. Consult a qualified structural engineer if it is determined that a structural repair is needed. While many of these resin materials exceed the strength of the concrete, ensuring a structural repair with full depth penetration by gravity is difficult. Special care must be taken in these instances to ensure the cracks are open, clean, and not contaminated with any bond-inhibiting materials such as oil and grease, which can often be the case on horizontal decks and floors exposed to traffic. If a structural repair of the crack is critical, pressure injection may be a preferred option (see RAP 1).

## When do I use this method?

This repair can only be applied to horizontal concrete elements such as bridge and parking decks, floor slabs, plaza decks, and similar surfaces.

Gravity feed of resin is not effective for repairing moving cracks. This is because the materials are unable to act as a flexible joint material. In these cases it is most often necessary to rout and seal the crack to create a joint capable of movement.

Likewise, gravity feed of resin should not be viewed as a long-term solution to cracking caused by corrosion, sulfate attack, or AAR. At best, this repair will keep out water, chlorides, and sulfates, which may slow the progress of



*Fig. 1—Cracks must be clean and free of debris.*

future damage around the crack, but it certainly will not stop it indefinitely. In these situations, a complete repair and protection approach is required to address the entire area affected, not just the cracks.

## How do I prepare the surface?

Proper preparation of the cracks for gravity feed of resin is essential to a successful repair. All potential barriers to penetration must be removed. Clean away all dirt, oil, grease, paints, striping, curing compounds, and sealers. To prepare large areas for flood treatments, consider dry sand- or shot-blasting.

For cleaning individual cracks, begin with wire brushes and wheels, followed by high pressure, oil-free compressed air to remove dust from the surface of the crack.

If the crack surface is packed solid with dirt and/or debris, remove it prior to applying the resin. In this case, remove the debris by routing the crack surface with crack-chasers or grinders and follow up with compressed air to remove fines. This routing of the crack has the advantage of producing a wider surface opening. Vacuum cleaning of cracks can prevent dust from getting packed into the crack, which can hamper resin penetration.

Allow the repair area to dry for at least 24 hours before applying the resin. Moisture within the cracks and the concrete pores can prevent penetration because the resin materials are very thin and are not able to easily displace water.

## How do I select the right material?

The two most common polymer materials used for gravity feed crack repairs are epoxies and high molecular weight methacrylates (HMWM). Both must be formulated to have a very thin consistency (low viscosity) and low surface tension to enable them to easily penetrate fine cracks by gravity alone. Viscosities below 200 centipoise (cps) should be a minimum requirement. Many epoxies are available with viscosities below 100 cps. Most HMWMs have viscosities below 50 cps.

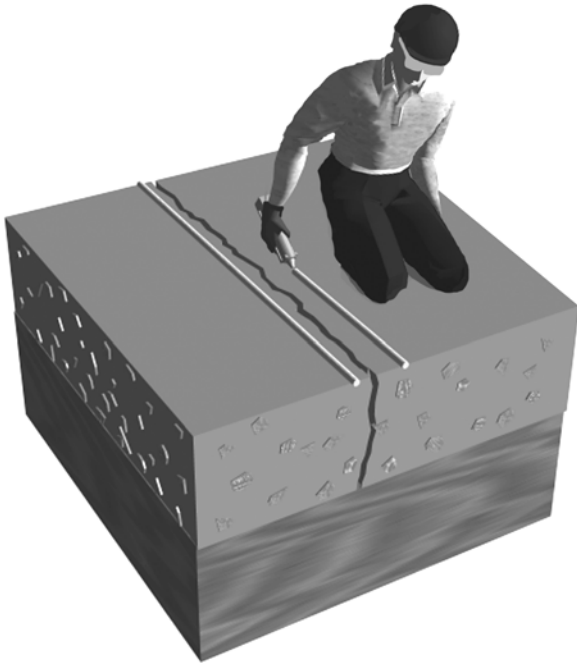


Fig. 2—On individual cracks, a sealant can be used to create a reservoir.

While both resin types are able to form the desirable polymer plug within the crack, they do have their differences. The epoxies tend to bond better when moisture is present within the concrete pores and they are easier and can be safer to mix and apply. HMWMs are generally lower in viscosity and surface tension and have less critical mixture ratios than epoxies. They can also be formulated to set faster. Successful applications of both polymer types have been documented in concrete cracks less than 0.006 in. (0.15 mm) wide.

#### What equipment do I need?

For small to midsize projects (up to 10,000 ft<sup>2</sup> [930 m<sup>2</sup>]):

- Mixing buckets, drills, mixing paddles;
- Flat rubber squeegees, brooms, or rollers;
- Small cans or squeeze bottles for pouring into individual cracks; and
- Grinder and air compressor.

For large projects (over 10,000 ft<sup>2</sup> [930 m<sup>2</sup>]):

- Mixing buckets, drills, mixing paddles;
- Mixing tanks with spray bar (low pressure pumps, no atomization);
- Flat rubber squeegees, brooms, or rollers;
- Sand spreaders or blowers; and
- Grinder and air compressor.

#### What are the safety considerations?

Epoxies and HMWMs are hazardous materials and should be treated as such. Job-site safety practices should include, but are not limited to, the following where applicable:

- Material Safety Data Sheets (MSDS). Adhere to all manufacturer recommendations for special safety equipment and requirements;
- Protective clothing. Cover the body fully and use adequate footwear;

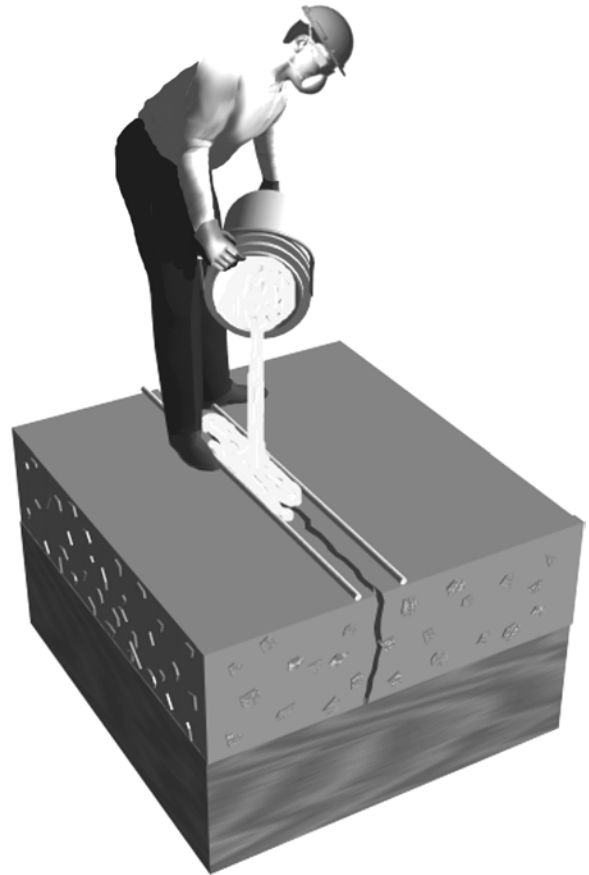


Fig. 3—Continue to gravity-feed the resin and “top off” until crack is completely filled.

- Protective eyewear. Face shields are recommended as a minimum;
- Wear rubber gloves for hand protection;
- Have eye wash facilities available;
- Take special precautions with flammable or combustible materials;
- Ventilate closed spaces. Wear appropriate masks to protect against fumes;
- Store hazardous materials in a secured area;
- Have necessary cleaning materials on hand; and
- Notify occupants within the structure being repaired prior to beginning work.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations including, but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

**Special note regarding HMWM mixing:** These polymers utilize a two-part catalyst usually consisting of an initiator (such as a peroxide) and a promoter (such as cobalt naphthate). These two materials must never come into direct contact with one another or a violent reaction may occur. It is important that the promoter first be added to the

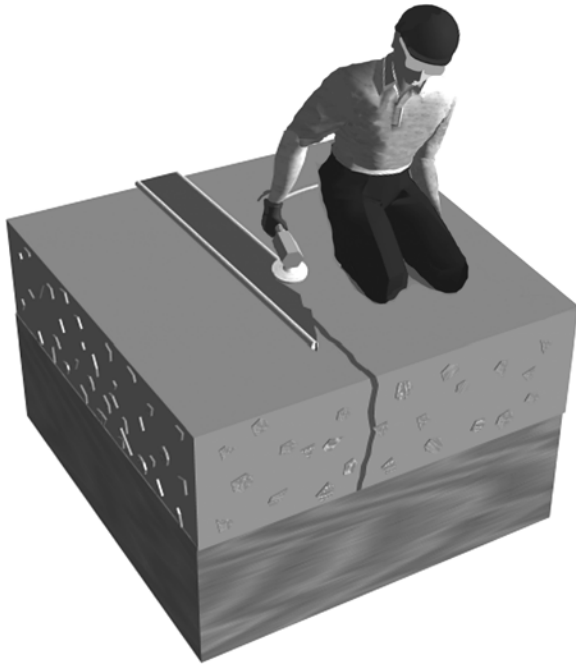


Fig. 4—Removal of sealant and grinding of excess resin.

HMWM monomer and mixed uniformly throughout before adding the initiator. Some formulations are available as a two-component system (pre-promoted) to avoid this potentially dangerous situation. Always refer to the material manufacturer's instructions.

### Preconstruction meeting

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

### Repair procedure

#### 1. Mix the resin.

After preparing the surface, mix the resin according to the manufacturer's instructions. If cracks run all the way through and the underside of the deck or slab is accessible, seal the underside of cracks at least temporarily to prevent resin loss (see RAP 1).

#### 2. Pour the resin.

Pour the mixed material (within the pot life of the resin) over the top of the cracks and allow it to penetrate. Keep filling the cracks until they will no longer accept resin.

For flood coat applications, distribute the resin evenly over the deck initially and then puddle the resin over the cracks. On smooth surfaces, use flat rubber squeegees; on tined or irregular surfaces, use brooms or rollers.

#### 3. Inspect the filling.

Look for signs of penetration such as air bubbles escaping from the cracks as the resin displaces the air.

**ALLOW TIME FOR PENETRATION.** Twenty to 30 minutes should be a minimum. Also, be aware that several

minutes may pass before resin has fully penetrated tight cracks and more resin may still be required.

#### 4. Remove excess resin.

Once all cracks have been filled to refusal, remove the excess surface resin with a flat rubber squeegee.

#### 5. Apply sand.

For safety purposes, lightly broadcast sand into the remaining resin to produce a skid-resistant surface. Apply about 1 to 2 lb/yd<sup>2</sup> (0.5 to 1.0 kg/m<sup>2</sup>) of an ordinary 8/20 blasting sand (or similar) within 20 to 30 minutes after the last application.

#### 6. Finish smooth (if desirable).

After the polymer has fully cured, remove sealant and grind smooth. Be careful not to inhale vapors during the grinding of the polymers.

### How do I check the repair?

Quality control tests should be taken on site to verify:

- Resin properties—taken in the form of cured prisms (ASTM D 495 type) to be checked for compressive strength as an indicator of proper mixture ratio and cure;
- Penetration depths—verified by cores taken at regular intervals. For very fine cracks, the cores may be analyzed under “black light” to highlight resin penetration depth within the cracks; and
- For structural repair checks, take cores and follow ASTM C 496, “Splitting Tensile Test.”

### Sources for additional information

California Department of Transportation, “Specifications and Special Provisions for Use of High Molecular Weight Methacrylate Monomers to Seal Bridge Decks,” Contract No. 04-001754.

Jerzak, H. P., 1991, “High Molecular Weight Methacrylate Resins in California,” State of California Department of Transportation, Jan.

Krauss, P. D., 1991, “Bridge Deck Repair Using Polymers,” paper presented at International Congress on Polymers in Concrete, San Francisco, Calif. Sept. 24-27.

Murray, M. A., and Eisenhut, W. O., 1995, “A Concrete Healer and Sealer,” *Concrete Repair Digest*, V. 6, No. 3, June-July.

Pfeifer, D. W., and Perenchio, W. F., 1982, “Coating, Penetrants, and Specialty Concrete Overlays for Concrete Surfaces,” paper presented at NACE seminar, Chicago, Sept. 27-29.

Rodler, D. J.; Whitney, D. P.; Fowler, D. W.; and Wheat, D. L., 1989, “Repair of Cracked Concrete with High Molecular Weight Methacrylate Monomers,” *Polymers in Concrete: Advances and Applications*, SP-116, P. Mendis and C. McClaskey, eds., American Concrete Institute, Farmington Hills, Mich., pp. 113-128.

Sprinkel, M. M., “Use of High Molecular Weight Methacrylate Monomers to Seal Cracks in Bridge Decks, Retard Alkali-Silica Aggregate Reactions, and Prime Bridge Surfaces for Overlays,” Virginia Department of Transportation Research Council.

Wiss Janney Elstner Associates, 1986, “Corrosion Protection Tests on Reinforced Concrete Treated with Sikaguard 70 and SikaPronto 19 Crack Healer for Sika Corporation, Lyndhurst, N.J.,” *Report No. 831298*, Sept.