

REPAIR APPLICATION PROCEDURES

ICRI's mission is: "...to be a leading resource for education and information to improve the quality of repair, restoration, and protection of concrete and other structures." Part of being the leading resource is to know what information other organizations have developed on the topic of concrete repair and whether to make this information available to our members.

In this spirit of cooperation, ICRI has published several Repair Application Procedures (RAP) Bulletins, developed by Committee E706 of the American Concrete Institute (ACI). These bulletins are "how-to" documents for commonly used concrete repairs. ACI is allowing ICRI to publish them in the *CRB*, as they are of great benefit to our members.

These documents are also available, free of charge, on ACI's Web site: www.concrete.org.

Each bulletin gives a concise description of the repair method, including the purpose of the repair, when it should be used, needed surface preparation, material and equipment selection, and safety considerations. The bulletins are useful reference documents for facility owners, design professionals, and concrete repair contractors.

Readers are encouraged to tear out these pages for handy reference or, if you prefer, download these documents from ACI's Web site (www.concrete.org/members/freedownloads.asp#E706), make copies for distribution to field personnel, and file them for future reference.

CONCRETE REPAIR BY SHOTCRETE APPLICATION

Reported by ACI Committee E706

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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 12.

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FIELD GUIDE TO
CONCRETE REPAIR
APPLICATION PROCEDURES

**Concrete Repair
by Shotcrete
Application**



Introduction

One of the most economical and effective methods of concrete repair is by the shotcrete process. This is particularly true for repairs that would otherwise require forming, such as vertical and overhead repairs. Repair materials, comprised of cementitious products with aggregates, are placed pneumatically onto prepared substrates, finished, and cured with no additional steps required. The use of bonding agents is not required or advised because consolidation and bonding of the material occurs during proper shotcrete application. As with all repair techniques, proper surface preparation is paramount in attaining a permanent repair solution.

When do I use this method?

This technique is most economical on vertical surfaces, such as columns, walls, beam sides, pier caps, and overhead horizontal surfaces such as ceilings, beam bottoms, slab soffits, and deck overhangs.

What is the purpose of this repair?

The shotcrete process is typically used to restore structural integrity, increase concrete cover over reinforcement, or both. It's typically used when forming requirements are difficult or prohibitively expensive or as another repair tool in the designer's and contractor's tool kits.

How do I prepare the surface?

The most important requirement for successful concrete repair is surface preparation. Deteriorated or spalled concrete should be removed back to sound concrete. If reinforcing bars are exposed, they must be undercut to provide mechanical bond for the shotcrete. Corrosion products on reinforcing bars should be removed by abrasive or high-pressure water blasting. The repair boundaries should be left at an out-sloping 45 degree angle to facilitate air and rebound escape. The outer edge of the repair area should be sawcut to a depth of about 3/4 in. (20 mm) to prevent the formation of feathered edges (Fig. 1).

Step-by-step procedures for surface preparation are:

- Observe or sound the concrete to determine areas of delamination or deficiency;
- Remove unsound concrete with a hand-held chipping hammer or ultra-high-pressure water blaster so as not to unnecessarily damage substrate concrete and reinforcing bar. Remove any resulting loose or fractured material;
- Replace or supplement damaged reinforcement as necessary. Consult the designer for required sizes and spacing. Separate lap splices by one bar diameter to facilitate placement of repair material. Do not place new reinforcing steel directly behind or in front of existing reinforcing steel (Fig. 2);
- Abrasive blast or water blast the reinforcing steel and the surface of the area to be repaired to remove any contaminants; and
- Spray the surface with water and allow to dry back to a saturated surface-dry (SSD) condition.

How do I select the correct materials?

Shotcrete can be placed by two processes: wet-mix and dry-mix. In most repair operations, the choice is left to the

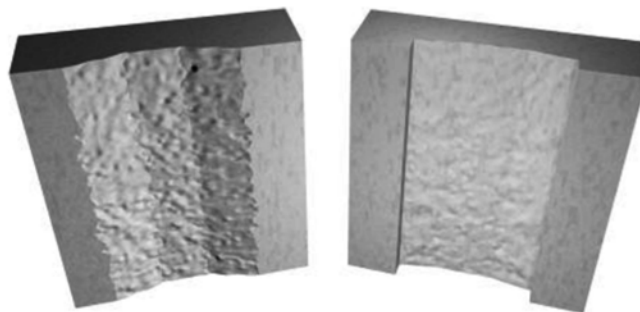


Fig. 1—Repair areas with feathered edges (left) should be avoided by making sawcuts along the edges.

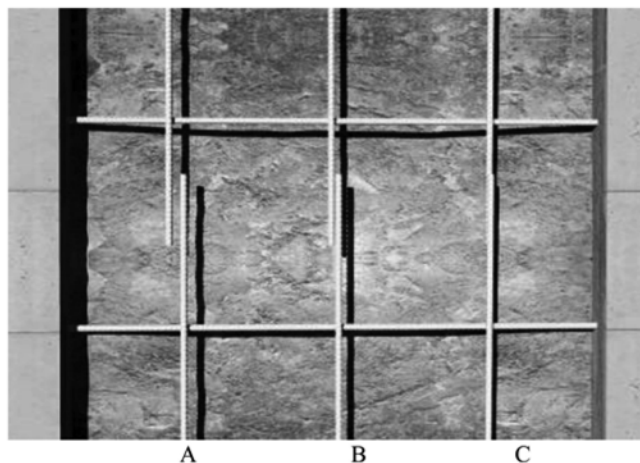


Fig. 2—Separate lap splices of reinforcing bars by one bar diameter to facilitate placing of repair material between the bars: A—Correct; B—Incorrect; and C—Incorrect.

contractors, who often select the process they are most comfortable with and have the right equipment for. Maximum aggregate size will generally be less than 1/2 in. (13 mm), and the grading of the total aggregate constituent should conform to ACI 506R, "Guide to Shotcrete," or ASTM C1436, "Standard Specification for Materials for Shotcrete," requirements. The materials can be ready mixed, prepackaged, or site batched. They can include fibers, silica fume, or other additives for enhancing physical properties and performance. Bonding agents are not recommended as they may act as bond breakers. Potential drying shrinkage problems can usually be minimized with the addition of fibers and proper curing conditions. An attempt should be made to generally match the substrate concrete and the repair material in strength characteristics unless the substrate concrete is very weak.

Ready mixed shotcrete should be batched and delivered in accordance with ASTM C94/C94M, "Standard Specification for Ready-Mixed Concrete," or ASTM C1116/C1116M, "Standard Specification for Fiber-Reinforced Concrete." Materials for shotcrete mixtures should meet the requirements of ASTM C1436. Prepackaged product should meet the requirements of ASTM C1480/C1480M, "Standard Specification for Packaged, Pre-Blended, Dry, Combined Materials for Use in Wet or Dry Shotcrete Application."

What equipment do I need?

An extensive discussion of the equipment requirements for shotcrete application is contained in ACI 506R.

Equipment necessary for wet-mix shotcrete includes:

- A concrete pump;
- An air compressor;
- Concrete hoses;
- Air hoses; and
- Shotcrete nozzles with air rings.

Equipment necessary for dry-mix shotcrete includes:

- A cement gun;
- A mixer/elevator;
- An air compressor;
- Shotcrete hoses;
- A water pressure booster pump;
- Water hoses; and
- Shotcrete nozzles with water rings.

Equipment common to both processes includes:

- Finishing tools and screeds;
- Air lances for blowing away rebound/overspray;
- Abrasive blast equipment or water blaster; and
- Chipping hammers.

What are the safety considerations?

Shotcrete operations have multiple hazards, and job-site safety practices should include, but are not limited to, the following, where applicable:

- Material safety data sheets (MSDS);
- Protective clothing or skin barriers;
- Protective eye wear, hearing protection, and dust masks; and
- Forced-air respirators during abrasive blasting.

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Preconstruction meetings

Prior to proceeding with the repair, a preconstruction meeting is recommended. The meeting should include representatives for the owner, engineer, contractor, and any other parties involved to explain the means, methods, and materials necessary to achieve the repair objectives.

Repair procedure

Prepare material—Receive transit, site-batched, or prepackaged mixture.

Material placement—Thoroughly wet the prepared surface and bring it to an SSD condition. Begin material placement, filling the corners first and continuously moving the nozzle to encapsulate reinforcing steel and avoid buildup of shotcrete at any one spot. A bond coat of neat cement will automatically be placed due to the initial aggregate rebound.

Use a blow pipe to remove any overspray and rebound that accumulates in corners or on reinforcing steel. Repair thicknesses are not limited by the thickness that can be placed in a single layer. Additional layers can be placed as necessary. Preparation of the immediately preceding layer is crucial to obtaining a successful bond. Single layer thicknesses can be increased by the use of additives. Continue bringing the material out to just past the desired plane and allow it to stiffen. When the shotcrete can be worked without disturbing the bond, use a sharp-edged trowel or cutting instrument to trim the plastic material back to the desired plane. Do not overwork the material because this could create delaminations and spalls.

Finish and cure—Excessive finishing is discouraged, although rodding to straight lines is not a problem. Proper curing procedures will enhance the physical properties of the shotcrete and reduce shrinkage cracking. These procedures include moist curing and use of curing compounds as outlined in ACI 308R, “Guide to Curing Concrete.”

How do I check the repair?

One of the many benefits of the shotcrete repair process is that it can be observed during placement because there are no forms hiding what is going on in the cavity. Inspectors and applicators can both observe the corners being filled and reinforcing steel being encapsulated. The possibility of honeycombing is largely eliminated if care is taken to prevent voids and unconsolidated overspray and rebound is removed as it accumulates. Once the shotcrete has set, the bond can be verified by sounding for voids with a hammer. If additional bond information is desired, the test methods described in ASTM C1583/C1583M, “Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method),” can be followed. A good repair should typically fail in the substrate and, in most cases, have a tensile strength exceeding 150 psi (1 MPa).

References and additional reading

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American Association of State Highway and Transportation Officials (AASHTO):
www.transportation.org

American Shotcrete Association (ASA): www.shotcrete.org

ASTM International (ASTM): www.astm.org

International Concrete Repair Institute (ICRI): www.icri.org