REPAIR APPLICATION PROCEDURES

ICRI's mission is that " ICRI provides education, certification, networks, and leadership to improve the quality of repair, restoration, and protection/preservation of concrete and other material systems." One aspect of providing education is searching out material on concrete repair and making this information, or at least a path to the information, available to our members.

In the spirit of our mission, ICRI has published several Repair Application Procedures (RAP) Bulletins developed by Committee E706 of the American Concrete Institute (ACI). Most of the members of this committee are active ICRI members as well. These bulletins are "how-to" documents for commonly used concrete repairs. ACI is allowing us to publish them in the *CRB*, as we feel that they are of great benefit to our members. These documents are also available free of charge on ACI's website at **https://www.concrete.org/store/storeresults.aspx?DocumentType=Education+Publications&Keyword=RAP**.

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, concrete repair contractors, and others involved in the concrete repair industry.

Readers are encouraged to tear out these pages for handy reference or, if they prefer, download these documents from ACI's website, make copies for distribution to field personnel, and file them for future reference.

LEVELING AND REPROFILING OF VERTICAL AND OVERHEAD SURFACES

Reported by ACI Committee E706

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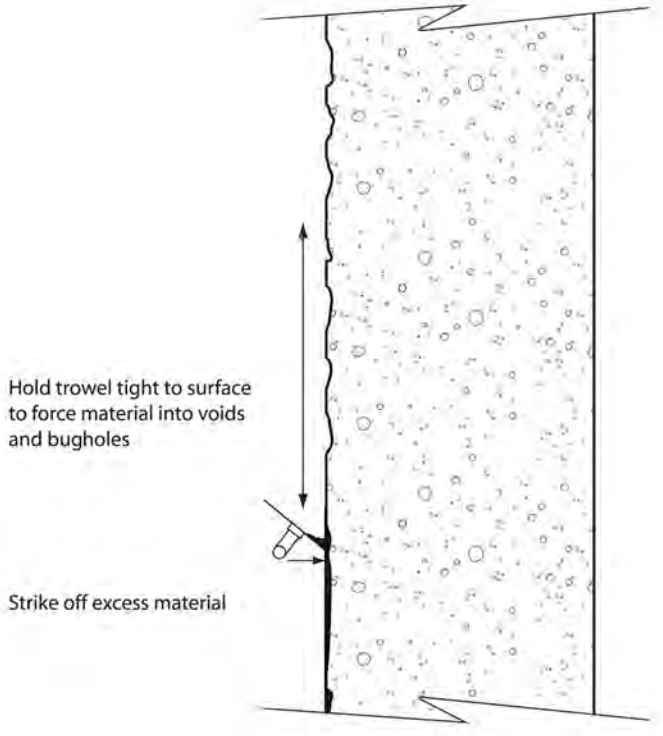
ACI RAP Bulletin 10

FIELD GUIDE TO CONCRETE REPAIR APPLICATION PROCEDURES

Leveling and Reprofiling of Vertical and Overhead Surfaces



Introduction

Leveling and reprofiling is a topical application for filling surface air voids ("bugholes") and establishing an acceptable profile using specially formulated materials or site-mixed materials such as sand, cement, and latex admixtures. The areas in question are typically limited to 10 ft^2 (0.9 m^2) with overall depths up to 1/4 in. (6 mm). If larger areas or greater depths are required, refer to stucco or overlay guidelines/applications.

Many leveling and reprofiling materials are available, depending on the type of cementitious material to be repaired, its condition, and the required degree of protection. Products are acrylic-based, cement-based, polymer-modified and cement-based, or polymer resin-based. The service requirements of the structure dictate which products are best.

Before any surface can be leveled or reprofiled, the reason for any deterioration of concrete must first be determined. This determination should consider the purpose of the structure, its service conditions and exposure, the composition of the substrate to be profiled, and the building practices originally used.

Once this determination is complete, an acceptable solution can be identified to provide the structure with the necessary protection for reinforcement and concrete, and the necessary durability. Solutions should include the appropriate material and construction method for leveling and reprofiling the cementitious surface, and also the appropriate coating or finish to provide aesthetics and protection to that surface (Fig. 1).

When do I use leveling or reprofiling?

Leveling or reprofiling is indicated whenever concrete with an unacceptable finish is exposed to the elements or in contact with aggressive chemicals. Leveling or reprofiling can be used on exterior or interior façades, foundations, beams, columns and soffits found in buildings, parking structures, retaining walls, bridges, storage tanks, and tunnels. It can also be used on interior façades and soffits of process tanks, water treatment tanks, and secondary containment with different chemical exposures. Usually, leveling or reprofiling is used to improve the aesthetic appearance or prepare the surface for subsequent coating or application.

What is the purpose of leveling and reprofiling?

The primary function of leveling and reprofiling is to correct surface deficiencies and provide the intended design surface. These deficiencies include nonmoving hairline or plastic shrinkage cracks, small or shallow surface air voids, honeycombs, or rock pockets. The crack repair solution selected, such as epoxy injection or rout and seal, will vary depending on the cause of the cracking and the degree of protection required. In some instances, the deficiency may be so great that the proper method of repair is removal and replacement.

The primary purpose of leveling and reprofiling is to provide an acceptable surface in preparation for aesthetic or protective coatings. For hotels or restaurants, aesthetics may be more important. For highways or water-treatment structures, structural integrity and protection of the concrete may be more important. In either case, the purpose is to achieve a uniform surface while providing enough cover for the embedded reinforcement.

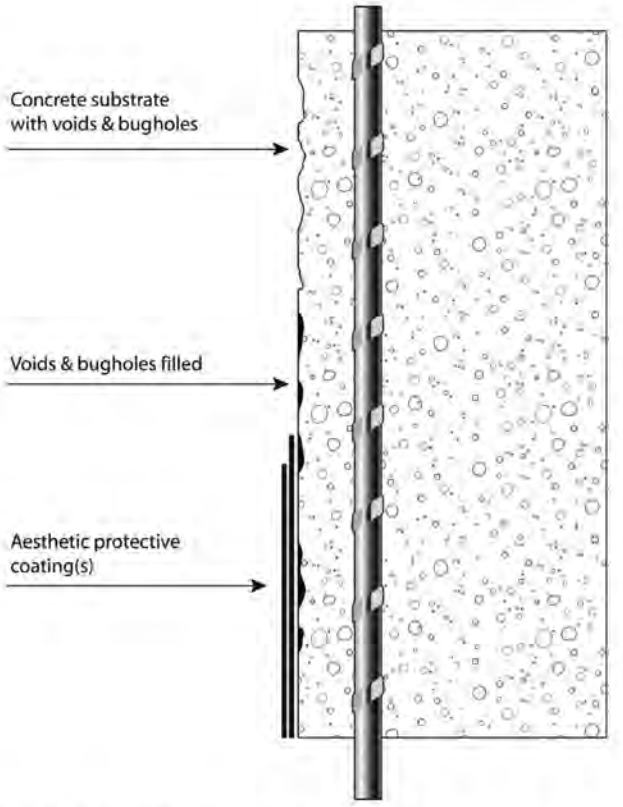


Fig. 1—Through-wall section of a typical concrete surface to be leveled or profiled.

If deteriorated surface concrete is not repaired, several undesirable consequences can result:

- Surface voids may allow a path for moisture to enter into interior surfaces, allowing for mold to grow on organic materials;
- Water can saturate the concrete, fill the voids, and lead to freezing-and-thawing damage; and
- Water can combine with chloride ions, acid rain, or aggressive gases to accelerate corrosion of the reinforcement, as in Fig. 2.

How do I prepare the concrete surface for leveling and reprofiling?

Several methods can be used to prepare the concrete surface for leveling and reprofiling. To ensure proper bond between the original concrete and the leveling and reprofiling material, the concrete surface must first be cleaned; it must have an open profile; it must be sound; and it must be free of bond-inhibiting materials, such as dust and laitance. Depending on the material, it must be abraded with a 60- to 100-grit sandpaper, high-pressure water-blasting, sand-blasting, diamond cup grinding, hand-held shot-blasting, hand-held scarification, or bush hammering (Fig. 3). Local building codes and municipalities may limit how the concrete surface is prepared.

How do I select the correct material?

Many times, the repair intent will limit the material selection. Field mixture proportioning, although sometimes successful,

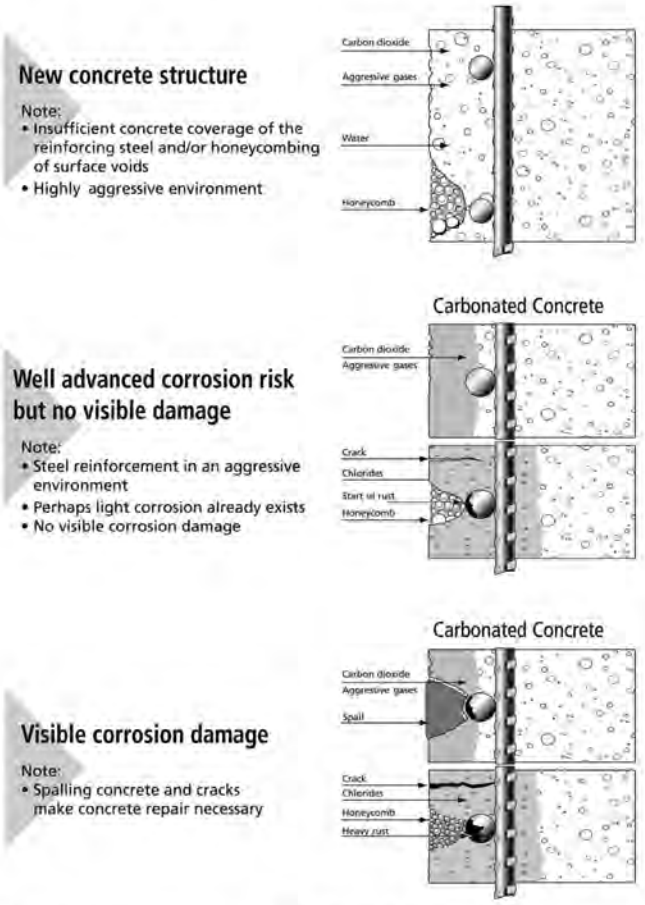


Fig. 2—Concrete with chloride and CO_2 penetration and corrosion.

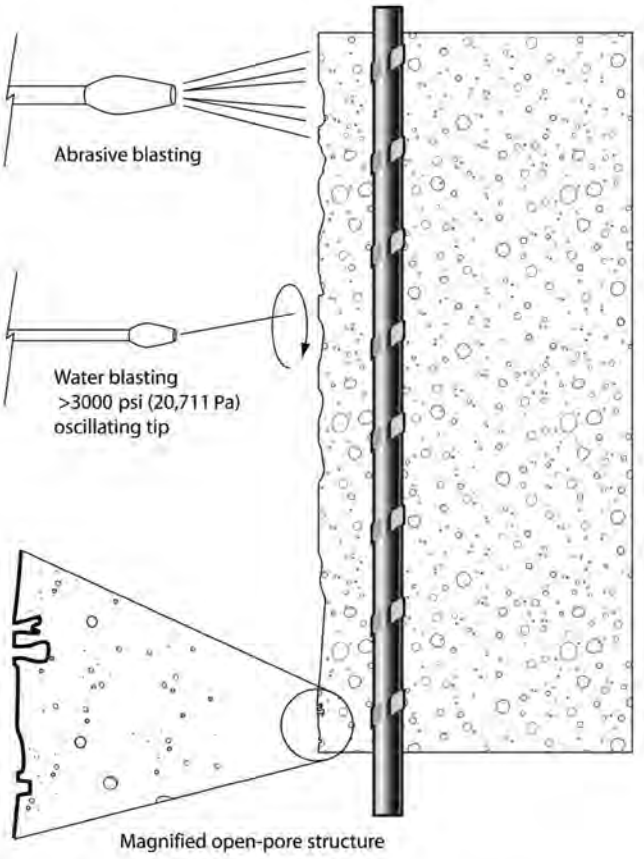


Fig. 3—Surface preparation.

Table 1—Material and condition/application grid

Applications	Materials			
	Acrylic-based ready-to-use	Cement-based mortar	Polymer-modified cement-based mortar	Polymer-resin-based mortar
Building façades c/o nonstructural elements	X	X	X	
Curtain walls	X	X	X	
Beams and columns		X	X	X
Bridge wall/parapet		X	X	X
Tunnels			X	X
Water, wastewater, and process tanks			X	X

rarely provides the consistent performance and reliability required for the structure. Preproportioned, factory-prepared materials are typically specified and used on leveling and reprofiling substrates. This allows the design professional to select the appropriate material based on project-specific needs such as compatibility, bond, weather durability, abrasion resistance, chemical resistance, color, and texture. Useful general guidelines are summarized in Table 1.

Curtain walls and nonstructural elements will generally use an acrylic-based material. These are typically sold in ready-to-use form. In some instances, the design engineer may dictate repair material that is similar to the original concrete, in which case cement-based or polymer-modified cement-based materials should be used. Polymer-modified cement-based materials have a latex or acrylic additive to provide additional bond and adhesion to the original concrete.

Parking structures and building structural elements generally require a repair material similar to the original concrete, typically cement-based and polymer-modified cement-based materials. For small voids, an acrylic-based material may be used.

Bridge walls, parapets, and tunnels require a repair material with durability and compatibility with the original concrete. The materials most likely to be selected are cement-based or polymer-modified cement-based products. For severe exposure conditions, polymer-modified cement-based material will provide greater protection and durability.

Water-treatment tanks, storage or process tanks, and secondary containments require a repair material that offers durability and exposure protection. Polymer-modified cement-based materials are typically selected, along with a protective coating such as epoxy, urethane, or polyurea. When turnaround time is critical, polymer resin-based materials are used so the protective coating can be applied the same day or the next.

Prior to selecting any repair system, the user should ensure that the materials selected are compatible with one another and are suitable for the intended use of the structure and any coatings that will be applied to the surface. The repair material chosen should at least have the same physical properties of the surface being repaired and should be compatible with the surface coating or treatment. The user should contact the proposed manufacturer(s) or the local

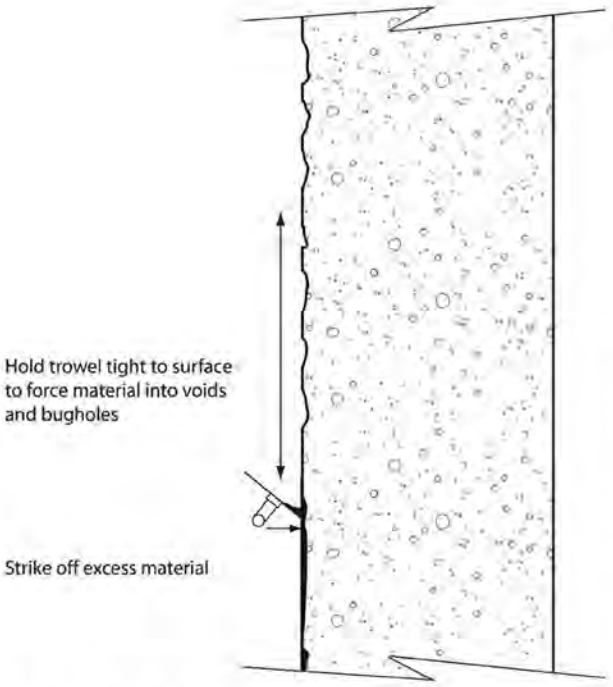


Fig. 4—Troweling material.

representative(s) to discuss the intended use, limitations of the product(s), and any compatibility issues.

What tools do I need?

Required tools include the following:

- Surface preparation equipment;
- Heavy-duty mixing drill;
- Mixing paddle (jiffy or box);
- Clean buckets;
- Mortar hawk; and
- Pool and margin trowels.

Optional spray equipment can include a hopper gun. Wet-spray mortar equipment usually consists of a grout pump and wet-spray handle. Both will require sufficient oil-free compressed air.

How do I apply leveling and reprofiling materials?

Leveling and reprofiling materials are typically troweled into place. This allows adequate pressure to be applied to the surface so as to push the material into the void, surface air void, or deficiency, while achieving sufficient bond (Fig. 4). For larger areas, the material can be spray-applied and then back-troweled and leveled by hand. This can significantly lower the installed cost. For large areas, refer to stucco or overlay guidelines.

Depending on the size of the void and the material selected, a second coating of material may be required to provide adequate smoothness. Application must be followed by curing in accordance with the instructions of the manufacturer of the repair material. Proper curing of cement-based materials is the key to the success and longevity of the repair.

How do I clean up afterward?

Before they have cured, acrylic-based, cement-based, and polymer-modified cement-based materials can be cleaned up using water. Polymer resin-based materials can be cleaned up using a citrus cleaner or manufacturer-approved solvent.

After they have cured, materials must be mechanically removed.

What safety precautions should be used with leveling and reprofiling materials?

When working with leveling and reprofiling materials, precautions are similar to those used with concrete. As a minimum, long-sleeved shirts and goggles should be worn at all times. When polymer-modified materials are used, workers should wear protective gloves and sometimes should use respirators. Some polymers can cause skin sensitization. Users should read and follow each product's Material Safety Data Sheet (MSDS) for hazards, protective gear requirements, and emergency contacts. Finally, refer to, and follow, local, state, and federal regulations that may apply.

How do I check the repair?

Once leveling and reprofiling has been completed, the user should allow sufficient time for material to cure (typically 7 to 14 days, depending on materials and curing conditions). After that time, several qualitative and quantitative tests are available, both nondestructive and destructive.

Nondestructive testing, as its name implies, does not disturb the finished concrete. Examples include a simple sounding of the repair with a hammer to verify adhesion, or impact-echo testing, which uses sound waves and computer software to verify bond and soundness of the underlying concrete.

Destructive testing allows one to truly determine the bond strength of the leveling and reprofiling material to the substrate. The ideal mode of failure is within the substrate. An example is a direct tensile bond test described in ASTM C1583.

In either case, the owner of the repaired element should use the services of a professional testing company to obtain an objective opinion on the quality of the repair.

References

ASTM C1583-04/C1583M-04^{e1}, 2004, "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)," ASTM International, West Conshohocken, PA, 5 pp.

Sources for additional information

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