Don't Just Patch It—Repair It!

by J. Chris Ball, Vector Corrosion Technologies

Reinforced concrete is a useful and economical building material that is commonly used in bridge construction. As they age, concrete structures—just like humans—require periodic maintenance and repairs. Instead of aching joints and reduced eyesight, the symptoms of concrete deterioration include spalling and delaminations, which should be repaired if the structure is to achieve a long service life.

Unfortunately, failed concrete "patches" have led some engineers and owners to believe that concrete repairs are just temporary fixes and cannot be expected to perform well over time (**Fig. 1**). Developing an understanding of the cause of the deterioration and implementing industry-accepted repair procedures are the initial steps toward improved performance of concrete repairs.

Stages in Concrete Rehabilitation

Concrete rehabilitation projects should adhere to a process with the following stages:

- Conduct a condition evaluation.
- Develop the repair strategy.
- Execute the repair design.
- Implement an on-site quality control program.

The life of a concrete structure can be affected by many factors, such as reinforcing steel corrosion, freeze-thaw cycling, alkali-silica reactivity, carbonation, poor original construction, or inappropriate design details. A condition evaluation that identifies these problems, and the contributing factors that caused them, is essential to better develop a repair strategy that meets the owner's expectations for service life and budget.

Surface Preparation

Concrete demolition and surface preparation techniques affect the longevity of concrete repairs. Lightweight (15-lb) chipping hammers are preferred to remove deteriorated concrete because they are less likely to damage the concrete substrate (**Fig. 2**). Hydrodemolition is another effective way to remove deteriorated concrete. Whichever procedure is used, concrete removal should continue until all unsound concrete is removed and all corroded reinforcement is exposed.

The full circumference of the exposed reinforcing steel should be sufficiently exposed to allow a gloved hand to fully wrap around the reinforcing bar, approximately ¾ in. between the bar and the existing sound concrete. All cement and corrosion products should be removed from the exposed reinforcing steel by abrasive blasting to enhance repair longevity and promote a good bond. Special attention should be given to cleaning the back side of the reinforcement.

Figure 1. Failed shotcrete repair on a bridge pier cap. Photo: Vector Corrosion Technologies.

Figure 2. Concrete is prepared for repair by removing deteriorated concrete using a small chipping hammer. Photo: American Concrete Institute Repair Application Procedure (RAP) Bulletin 6.

Figure 3. Concrete repair area ready for repair with square edge geometry, saw-cut edges, and properly cleaned and exposed reinforcement. Photo: Vector Construction.

The prepared concrete substrate should be roughened, by a ¼ in. amplitude or greater, which normally means some coarse aggregate will be exposed. Before the concrete repair material is placed, the prepared concrete should be cleaned with abrasives or high-pressure water to remove any loose or deleterious materials that could inhibit bonding of the concrete repair material to the existing sound concrete.

Another important consideration is the shape of concrete repairs. Rectangular and square shapes without re-entrant corners minimize cracking of the repair material. To define the edges and minimize the potential for thin repairs or feathered edges, an approximately ¾-in.-deep saw cut is used to provide square edges around the repair boundary (**Fig. 3**).

If there is no corrosion of the steel reinforcement, concrete repairs can be completed without additional steel treatment and the alkaline repair material will protect the steel encased within the repair. Reinforcing bar coatings can provide additional protection to the steel; this is useful if minimal concrete cover exists or if there is a concern about future intrusion of contaminants. If the parent concrete is chloride contaminated, cathodic protection (impressed current or galvanic) or electrochemical chloride extraction may extend the life of the rehabilitated structure. For localized protection, Type 1 embedded galvanic anodes are commonly used to extend the service life of concrete repairs by mitigating accelerated corrosion adjacent to the repair (**Fig. 4**).

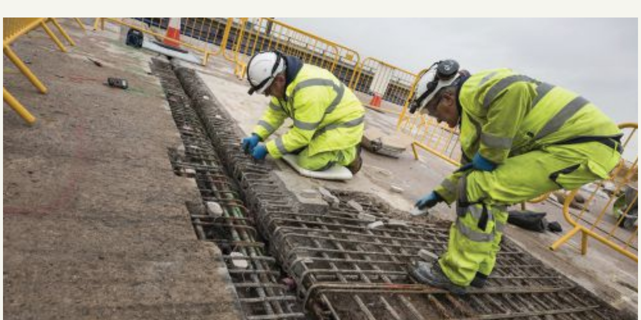

Figure 4. Type 1 galvanic anodes are placed in a concrete repair area to prevent future reinforcing steel deterioration and extend the service life of the repair. Photo: Vector Corrosion Technologies.

Concrete Repair Materials

There are many factors to consider when selecting a concrete repair material. Characteristics that influence repair durability include cracking resistance (drying shrinkage, tensile strength, and modulus of elasticity), permeability, bond strength, thermal coefficient of expansion compatibility, and resistance to freezing and thawing. In situations where the repair material will be subjected to varying loads in service, the properties of the selected concrete repair material (for example, compressive strength and modulus of elasticity) should be similar to those of the parent concrete.

Repair materials can consist of ready-mix concrete; site-batched mortars and concrete; or preblended, bagged materials. Concrete repair materials differ in their set times, flow, and cohesiveness; these characteristics should align with the specific installation method (form and pour, trowel applied, or shotcrete). Portland cement–based repair materials should be wet cured, be covered with a protective material, or have a curing compound applied to prevent moisture loss, shrinkage cracking, and curling. The curing of the repair material can affect bond and durability. For proprietary blended repair mixtures, follow the manufacturer's recommendations.

Finally, implementing a program for quality control helps ensure that the repairs have been completed appropriately. Some basic quality control procedures include confirming that the surface preparation is acceptable, performing repair material testing and bond testing, sounding the finished repair to detect voids or lack of bonding, and documenting the repairs with before-and-after photos (**Fig. 5**).

Figure 5. Before-and-after photos of a concrete repair are recommended as part of a quality control program. Photos: Vector Construction.

Conclusion

The concrete repair industry has developed many excellent sources of information. For starters, the American Concrete Institute and International Concrete Repair Institute publish procedures for various concrete repair techniques. Some of these useful industry documents are listed at the end of this article.

Lasting concrete repairs are not only possible but can become routine when concrete repair practices are sound. Don't patch it—repair it!

Resources

- American Concrete Institute (ACI) Committee 546. 2014. *Guide to Materials Selection for Concrete Repair.* ACI 546.3R-14. Farmington Hills, MI: ACI.
- ACI Committee 546. 2014. *Guide to Concrete Repair*. ACI 546R-14. Farmington Hills, MI: ACI.
- ACI Committee E706. n.d. *Certificate Program: Repair Application Procedures* (online learning). Farmington Hills, MI: ACI.
- ACI Committee E706. 2020. *Field Guide to Concrete Repair Application Procedures—Vertical and Overhead Spall Repair by Hand Application*. RAP Bulletin 6. Farmington Hills, MI: ACI.
- International Concrete Repair Institute (ICRI). 2009. *Guidelines and Recommendations for Safety in the Concrete Repair Industry*. ICRI Technical Guideline 120.1-2009. St. Paul, MN: ICRI.
- ICRI. 2013. *Guide for Using In-Situ Tensile Pulloff Tests to Evaluate Bond of Concrete Surface Materials*. ICRI Technical Guideline 210.3R-2013. St. Paul, MN: ICRI.
- ICRI. 2013. *Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair*. ICRI Technical Guideline 310.2R-2013. St. Paul, MN: ICRI.
- ICRI. 2008. *Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion*. ICRI Technical Guideline 310.1R-2008. St. Paul, MN: ICRI.
- ICRI. 2018. *Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces*. ICRI Technical Guideline 320.2R-2018. St. Paul, MN: ICRI.

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