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ABSTRACT:
Cast-In-Place Concrete Assemblies damaged by chloride ion penetration can be effectively repaired with a careful choice of repair materials.

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03 01 30 Maintenance of Cast-in-Place Concrete.

KEYWORDS:
Concrete repairs, Spalling, Reinforcing steel, Rebar, Corrosion, Chlorides

REFERENCES:
American Concrete Institute (ACI)
ACI 301 Specifications For Structural Concrete
ACI 546.3R Guide for the Selection of Materials for the Repair of Concrete
International Concrete Repair Institute (ICRI)
No. 310.1R Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion.
No. 320.1R Guide for Selecting Application Methods for the Repair of Concrete Surfaces.
No.320.2R Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces

Cast-In-Place Concrete Repairs

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Problem

Cast-in-place concrete walls, slabs, columns, and beams can experience damage from several different mechanisms. One such condition is concrete spalling caused by corrosion of steel reinforcing rods. The corrosion of the steel is often caused by the penetration of chloride ions into the concrete and is most prevalent in concrete slabs.
Chloride ions come from chemicals and various salts, such as road salts, some pool treatments, and salt in the environment near oceans and waterways. The contaminants enter the concrete carried moisture and can penetrate to the reinforcing steel, facilitating corrosion.

Preparation

No concrete repair should ever be undertaken without first establishing the mechanism of deterioration. Engineering analysis of cored samples along with other appropriate testing by firms that specialize in such work must precede any attempt to design repairs.
This article assumes that testing has confirmed that chloride penetration has been identified as the contributory factor in the subject damages. For simplicity the concrete structure is referenced in this article as a "slab", although the discussion applies to slabs as well as walls, columns, and beams constructed of cast-in-place concrete with steel reinforcement.

The Damage

Spalling, a condition manifested by cracks and pieces of concrete breaking off from the slab, occurs when steel reinforcing within the slab corrodes. Just like any other form of rust, the corrosion causes the diameter of the reinforcing to expand. This expansion applies pressure against the concrete, forcing cracks and eventual displacement of a piece of the concrete.
This condition can be caused by penetration by chlorides and other contaminants. While contaminants can penetrate deep into cast concrete, this type of problem sometimes is compounded by insufficient concrete cover over the reinforcing. The appropriate depth of cover varies with design considerations. As an example, per ACI 301, in a concrete slab exposed to earth, water, or weather, the minimum coverage for No. 6 reinforcing rods and larger is 2 inches. Insufficient cover is an important factor to consider in choosing repair materials.

Concrete Repair

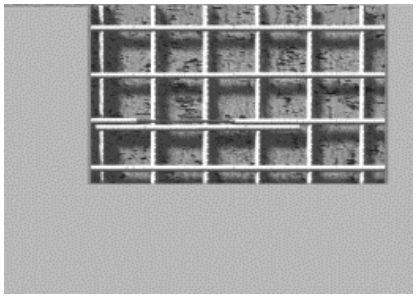
The basic material property considerations in designing patches for concrete repair are:
1. Strength
2. Modulus of Elasticity
3. Permeability
4. Adhesion Properties
5. Protection of Steel Reinforcing

Until recently, the conventional wisdom on concrete patching was to use concrete as similar as possible to the original material
to minimize variances in material properties. For example, matching patches to original material allows for similar moisture absorption between slab and patch. This helps equalize hydraulic pressure between slab and patch, minimizing the possibility of hydraulic pressure causing the patch to fail.
Due to the development of new and

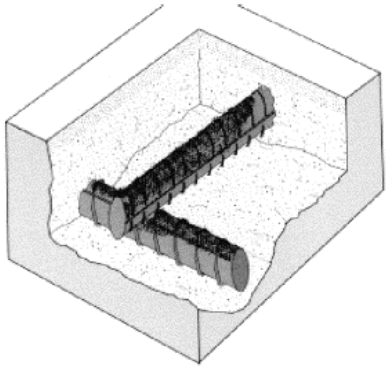
specialty concrete repair products that have enhanced qualities, the industry has shifted approaches to concrete repair.
Using a theoretical concrete slab repair we will discuss repair techniques based on the referenced ACI and ICRI documents. Actual design and applicable standards may vary, depending on site conditions and confirmed properties of the structures to be repaired. This discussion will generically explore each patch material property.

The Scenario

Our theoretical repair site is a cast in place concrete slab, 8 inches deep, with a spall of approximately 24 X 48 inches broken out of the top and edge of the slab. Inspection of the damage reveals #8 rods parallel to the slab edge and perpendicular # 6 rods nearer the surface. All reinforcing is in the horizontal plane. All reinforcing exhibits corrosion, with the #6 rod being situated no more than 1 inch beneath the top surface plane of the slab.



A proper repair demolition would consist of removing compromised concrete back to sound material, and preparing the location according to accepted demolition practices.
The damaged reinforcing should be exposed around its entire perimeter to allow repair material to completely surround the rods, providing rod cover and strength for the patch. Corrosion should be removed from the reinforcing rods down to clean metal.



Repair Choices

The example slab has insufficient cover for the corroded reinforcing. This factor affects the assessment of each property of the repair materials. Rather than try to match the patch material properties to the existing concrete, a different approach can result in a more durable repair. Compared to the original slab the proposed patch should instead be:
Stronger- to minimize damage to the patch from stresses transferred from the slab.
More Elastic- by installing a stronger patch that is more elastic than the original slab, the patch can better absorb slab movement and stresses.
Less Permeable- by installing a patch that is stronger, more elastic, and less permeable, the patch creates a protective shield against the chloride penetration that caused the original damage.
Choosing patch material based on the above addresses all patch material properties, except adhesion.
The standard concrete slurry bond coat applied to all existing concrete and reinforcing surfaces within the patch area can be replaced with one or more enhanced products.
Cementitious epoxy coatings, for example, when properly applied, can form a protective barrier over at-risk steel reinforcement. concrete and reinforcement.

Such an approach can result in a patch that withstands stresses from the original structure, protects the steel reinforcement, and remains durable much longer than a "matched concrete" patch.

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