By Vaughn O'Dea

Beneath the Surface

Resurfacers address concrete defects of municipal water and wastewater environments.

▲*Typical concrete corrosion found in a wastewater treatment plant.*
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Important structures can face reduced service life when concrete is unnecessarily exposed to conditions often found in municipal water and wastewater treatment environments.

For example, water treatment operations use chemicals that corrode concrete. Likewise, inspectors often observe as much as 1/8-inch concrete loss per year within wastewater collection and treatment structures resulting from biogenic sulfide corrosion.

Within these aggressive exposure conditions, rehabilitating and protecting concrete is consistently a challenge to the operators who rely on protective coating systems to create a monolithic barrier between the corrosive environment and concrete substrate. But for these protective coating (barrier) systems to be effective, it is essential for contractors to properly repair the concrete surface before topcoating.

Studies have shown that a predominant mode of concrete attack when using a protective coating system in these environments is caused by pinholes in the barrier system which create a discontinuous film. These small voids in the protective coating allow gasses or corrosives to penetrate the otherwise impervious coating material and attack the underlying concrete substrate. Theses pinholes and holidays are caused when entrapped air within the substrate is released into the coating.

Cementitous resurfacers

Contractors who specialize in the protective coatings industry know to pay special attention to repairing concrete structure before applying protective topcoats. Typically, cast-in-place and precast concrete can contain bugholes, pinholes, and other surface imperfections that form during concrete placement.

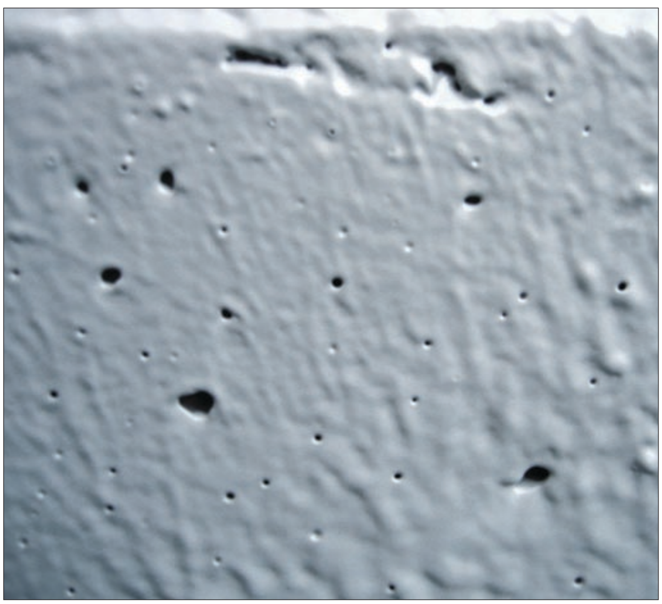
Applying protective coating systems directly to a surface containing imperfections will undoubtedly result in pinholing, outgassing, and bughole-induced outgassing of the barrier film. Resurfacing the substrate improves the film quality of a protective coating by eliminating possible pinholes and bughole-induced outgassing and facilitates long-term barrier protection of concrete. Contractors commonly use cementitious resurfacers to address the surface imperfections.

For protective coating (barrier) systems to be effective, it is essential for contractors to properly repair the concrete surface before topcoating.

Aware of the importance of this repair procedure, material manufacturers have been introducing new cementitious resurfacing materials and repair methods exclusively designed for use under high-performance protective coatings. The best choices for repair materials are cementitious mortars using ingredients with similar properties, which most closely match those of the host concrete.

Four common cementitious repair composites used to repair water and wastewater structures can be classified as:

- Epoxy-modified cementitious mortars
- Acrylic-modified cementitious mortars
- Portland-based cementitious mortars
- Calcium aluminate-based cementitious mortars



When concrete pinholes and bugholes are not remediated before the protective coating is applied, outgassing results.

When using these mortars, contractors must understand the mechanisms involved in proper surface preparation, application, curing, and preparing these materials before applying the outer protective coating.

Preparing the surface

Regardless of the choice of repair component, the first step is to create a proper surface profile and a high degree of cleanliness to help ensure the repair material adheres to the concrete substrate.

Recommendations for surface preparation vary significantly among manufacturers of cementitious resurfacing materials. Surface preparation recommendations range from high-pressure power washing to clean and dry fractured aggregate profile to methods outlined in SSPC-SP13/NACE 6 for achieving an ICRI CSP-5 surface profile. These inconsistencies often cause confusion–and often failures–for contractors who must sort through the manufacturer's instructions and compare them to the requirements of the protective coating system and specification documents.

For this reason, material manufacturers recommend using industry-accepted surface preparation standards, such as the ones created by the Society for Protective Coatings (SSPC), National Association of Corrosion Engineers (NACE), the American Concrete Institute (ACI) and International Concrete Restoration Institute (ICRI), to create consistency and clarity.

The goal of this effort is to meet the prescribed adhesive specification. For example, most requirements in typical water or wastewater repair applications call for the adhesion of the protective coating system, including repair material, to exceed the concrete's tensile strength (generally around 350-450 psi). Using a portable adhesion tester according to ICRI 03739 or ASTM D7234 confirms this.

Intended minimum thickness

Contractors also must consider the intended minimum thickness recommendations for various cementitious mortars. Typically, epoxy-modified cementitious resurfacing materials can be applied at a minimum thickness of $^{1}/_{16}$-inch, compared to the $^{1}/_{4}$-inch to $^{1}/_{8}$-inch minimum for acrylic-modified resurfacers, $^{1}/_{4}$-inch to $^{3}/_{8}$-inch minimum for portland-based mortars, and $^{1}/_{2}$-inch minimum thickness for calcium aluminate-based materials.

Cementitious resurfacing mortars applied at less than their minimum recommended thickness may be too weak and friable to support high-build, chemical-resistant protective coating systems specified for water and wastewater environments. Double-check the "prepared" surface before installing the protective coating.

Recently at a 6 million-gallon-per-day wastewater treatment plant in Louisiana, a potential costly mistake was avoided. The contractor who was asked to apply the protective coating doubted the quality of the concrete surface repair. The coating contractor suspected the portland-based cementitious mortar used to fill voids and bugholes was inadequate to support the epoxy lining system specified for the sewage plant's severe wastewater headspace environments.

A test was performed using a Type II fixed-alignment adhesion tester (elcometer) on a 5x5-foot section of concrete wall coated with the portland-based cementitious mortar, a common testing protocol for field-applied liquid coatings.

Test results revealed 100% cohesive failure (splitting) of the mortar at less than 80 psi. The adhesion results were well below the anticipated 350-450 psi minimum generally obtained when applied over a cementitious substrate. Engineers determined that a portland-based resurfacer applied at 1/16-inch thickness to new concrete did not develop the proper calcium silicate hydrate matrix, ultimately yielding poor cohesive properties.

Given these findings, the decision was made to remove and replace the portland-based mortar with an epoxy-modified cementitious resurfacer, which exceeded the adhesion requirement when applied at 1/16-inch thickness.

Curing is critical

Whether the concrete surface is new or existing, contractors must follow procedures for proper curing of cementitious materials to develop required mortar properties. Cementitious resurfacers, especially those applied as thin overlays (less than 1/8-inch-thick) are susceptible to plastic shrinkage cracking because their high surface-to-volume ratio promotes rapid evaporation under drying conditions. Many of these cementitious materials are improperly cured, thereby not preserving the necessary water required for proper cement hydration.

Typical cast-in-place concrete wall containing exposed bugholes (upper half of photo) and application of a greenish, epoxy-modified cementitious resurfacer (lower half).

Cast-in-place concrete after SSPC-SP13/NACE 6 surface preparation to expose bugholes and create an anchor profile according to ICRI-CSP5.

This results in a cure-affected zone without the integrity required to withstand the internal stresses high-performance protective coatings create; the outer layer (5 to 10 mm) being considerably weaker by 38 to 43%. This weak outer layer, also known as a laitance layer, must be removed before applying a protective coating system.

Conventional cementitious mortars used for concrete repairs must be externally cured according to ACI 308 or other guidelines governing proper hydration. Only epoxy-modified cementitious mortars are excluded from ACI external curing requirements. The industry outlines procedures for properly curing cementitious materials to avoid drying out before achieving the required hydration. But the curing step is often shortened, performed haphazardly, or eliminated entirely.

Contractors also must understand the curing duration for different types of resurfacers for the materials to achieve proper cement hydration. Epoxy-modified cementitious mortars have recommended curing times ranging from 12 to 24 hours at 75° F.

Acrylic-modified cementitious mortars have recommended curing durations ranging from 48 to 72 hours. Portland-based resurfacers require a minimum curing time of three days for Type III high-early mortar composite and seven days per ACI 308 for Type I and II cements. Calcium aluminate-based resurfacing mortars have recommended curing durations of 24 hours (per ACI 547) to 72 hours when relative humidity is less than 70%.

Research indicates that bond strength development of cementitious resurfacers proceeds more slowly than compressive strength development. This can result in workers mistakenly abandoning curing procedures prematurely when the

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traditional cementitious mortar "seems strong." But once the mortar dries, strength development stops and the mortar patch can fail.

Using liquid membrane-curing compounds is the most practical method of curing vertically placed mortars where conditions are not favorable for wet-curing. The membranes prevent the mortar from losing moisture, allowing strength development.

Preparing for topcoating

A final consideration is properly preparing the surface before applying protective coatings. This includes any cementitious resurfacers. Being cementitious, these materials may form a weak surface layer as a result of using a high water/cement ratio, overworking during placement, exuding fines with bleed water, or improperly curing the mortar.

Removing this weak surface layer (laitance) before applying a protective barrier system is paramount to attaining maximum adhesion of the protective coating system.

Summary

As cementitious repair materials become thinner, differential behavior with the concrete substrate becomes accentuated and enhanced. Repair material properties, such as tensile strength, become more important.

Research indicates that bond strength development of cementitious resurfacers proceeds more slowly than compressive strength development.

Therefore, contractors should pay particular attention to the parameters recommended by the resurfacing manufacturers and to standards governing surface preparation, application, curing, and preparing these materials before topcoating with protective coating systems.

Contractors should always request manufacturers' warnings and clear instructions before repairing new or existing concrete because this information may be ambiguous or often missing from the product data sheets.

Likewise, contractors should request laboratory testing to substantiate claims when applying these materials as resurfacers under high-performance protective coatings.

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