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ACI 364.3T-10
TechNote

Treatment of Exposed Epoxy-Coated Reinforcement in Repair

Keywords: coating; corrosion; corrosion inhibitor; electrical resistance; reinforcing bars; epoxy-coated; reinforcing steel; repair; ring corrosion; sacrificial anode.

Introduction

When epoxy-coated steel reinforcement is exposed in a repair area, the exposed reinforcement requires treatment prior to repair material placement.

Question

When epoxy-coated steel reinforcement is exposed in a repair area, how should the reinforcement be treated before placing the concrete repair?

Significance

The repair of structures containing epoxy-coated steel reinforcement presents issues that differ from structures containing uncoated steel reinforcement.

Answer

The coated steel should be treated to avoid creating corrosion cells that may result in accelerated corrosion of the reinforcement.

Discussion

During concrete removal and preparation of the repair area, the epoxy coating on the bars within the repair will be damaged, may already have defects or, as part of the repair procedure, be completely removed. Measures should be considered to avoid or minimize the risk of accelerated corrosion.

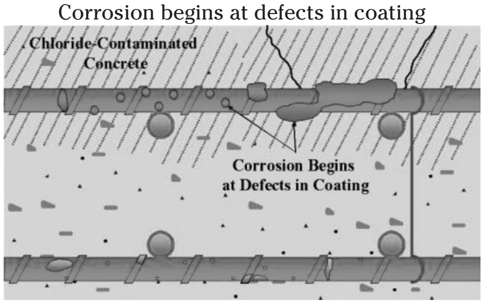
It is common practice to clean, prepare, and re-coat any exposed epoxy-coated steel reinforcement during the repair process, usually with an epoxy coating compatible with the existing fused coating on the steel. Additional protection should be considered because of the difficulty to re-coat the steel completely. Areas left uncoated (defects) may result in corrosion problems after the repairs are completed.

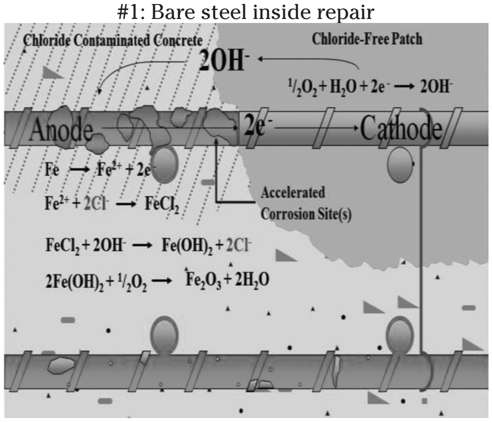
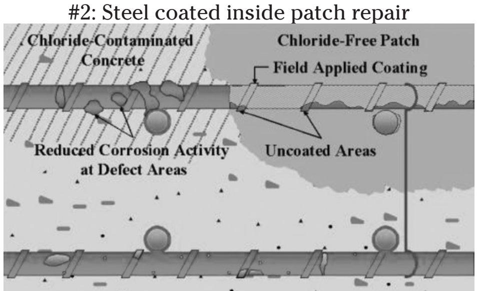
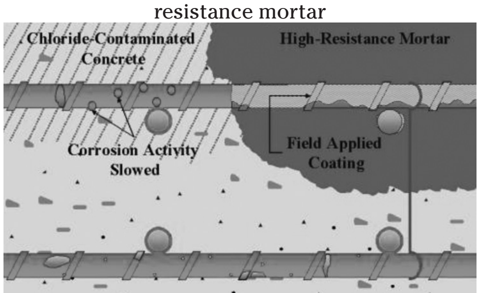
When a concrete repair is undertaken, chloride-contaminated or carbonated concrete is typically removed and replaced with repair material. In many cases, not all of the contaminated concrete is removed. After the repair, the reinforcing steel may be in contact with concrete outside the repair area having varying levels of contamination. The differences in pH levels and in chloride ion concentrations between the new repair materials and the remaining contaminated concrete will result in differing corrosion potentials or voltages through the length of the reinforcing bar. A current will flow as a result of these voltage differences, leading to corrosion.

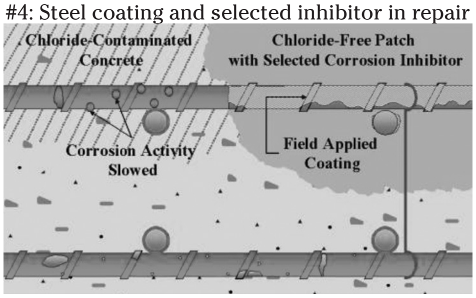
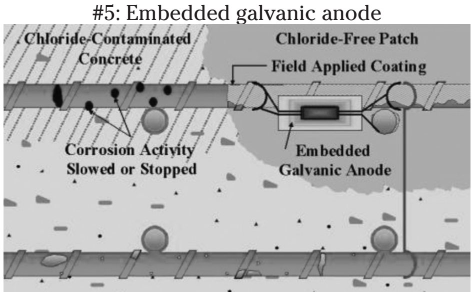
Reinforcement locations surrounded by concrete with the highest moisture and chloride contamination are likely to corrode first. Corrosion will occur in locations where there is both a defect in the coating and a sufficient level of contamination present. In general, the corrosion rate is proportional to the ratio of the cathodic area to the anodic area. Because the amount of coated steel is often far greater than the exposed steel, the rate of corrosion of the exposed steel can be extremely high. Additionally, the repaired area increases the cathodic (protected) area. As a result, corrosion of the steel immediately adjacent to the repair area at locations with defects or where the epoxy has delaminated will continue, and the rate may even accelerate. The uncoated area of steel inside the repair area will contribute toward the overall corrosion cell, which could result in corrosion of steel in the existing concrete in the locations where sufficient contamination, oxygen, and moisture are present. It is also possible that corrosion will occur within the patch by current flow between any re-coated epoxy coating defects.

In addition to coatings, other options exist to address these issues. They include the use of noncorrosive reinforcement, metallic coatings for steel reinforcement (both sacrificial or noble and nonsacrificial types), chemical inhibitors, and cathodic protection systems (both impressed current and galvanic types), which are discussed elsewhere (ACI 222R; ICRI 310.R). It is recommended that supplemental corrosion protection be provided for existing steel reinforcement by coating the reinforcing bar using either a high-electrical-resistance repair concrete that may contain an appropriate inhibitor, embedded galvanic anodes, or both, as illustrated in Table 1. A combination of corrosion protection methods from Table 1 will usually provide better corrosion protection than any individual method.

Table 1—Repair options for epoxy-coated steel reinforcement

Before repair	
Corrosion begins at defects in coating 	Initial corrosion of steel at defects in coating Results: cracking, delamination, and spalling of concrete

Repair options		**Benefits**	**Limitations**
#1: Bare steel inside repair 	Reinforcing steel cleaned inside repair area, repair completed with cementitious mortar, or concrete providing an elastic modulus similar to parent concrete	Requires minimal effort **This procedure is <u>not recommended</u>, but is provided for comparison purposes.** **See illustration for example of corrosion current flow**	Large area of uncoated passive steel in patch may accelerate corrosion at concentrated points in concrete next to repair area
#2: Steel coated inside patch repair 	Reinforcing steel cleaned inside repair and re-coated with epoxy	Reduces area of "passive" steel available and reduces corrosion rate	Difficult to coat bar entirely, defects in coating leave residual "passive" areas of steel that may accelerate corrosion in concrete next to patch
#3: Steel coating and high electrical resistance mortar 	Reinforcing steel cleaned and re-coated, high-electrical-resistance mortar used to complete patch	Combined protection, both epoxy coating and high-electrical-resistance mortar work to reduce local corrosion cells	Corrosion activity reduced compared with previous options, but not halted

#4: Steel coating and selected inhibitor in repair 	Reinforcing steel cleaned and re-coated, selected inhibitor added to increase electrical resistance between steel in repair and adjacent concrete	Combined protection, both epoxy coating and selected inhibitor work to reduce local corrosion cells	Corrosion activity reduced compared with Options #1 and #2, but not halted
#5: Embedded galvanic anode 	Reinforcing steel cleaned and re-coated (optional), embedded galvanic anodes attached to steel. Wires from galvanic anodes should be connected to uncoated portions of reinforcing, requiring that portions of epoxy be removed	Combined protection, epoxy coating (optional) reduces rate of corrosion; galvanic anode also reduces corrosion in area next to repair	Protection depends on electrical continuity of reinforcement; protection diminishes with distance from anode

Summary

The use of coatings can be beneficial in reducing the surface area of steel available to promote corrosion. The use of high-electrical-resistance repair materials can reduce the corrosion current by increasing the circuit resistance. The use of repair materials that contain inhibitors can be beneficial if the type of inhibitor used increases the circuit resistance. The use of embedded galvanic anodes can be beneficial in providing galvanic corrosion protection to portions of the steel where the epoxy coating is defective, either inside or adjacent to the repair. Treating exposed epoxy-coated reinforcing in repair areas is recommended to suppress ongoing corrosion activity.

Referenced standards and reports

The standards and reports listed below were the latest editions at the time this document was prepared. Because these documents are revised frequently, the reader is advised to contact the proper sponsoring group if it is desired to refer to the latest version.

American Concrete Institute
222R Protection of Metals in Concrete Against Corrosion

International Concrete Repair Institute
310.R Guideline for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Rein forcing Steel Corrosion (formerly No. 03730)

These publications may be obtained from these organizations:
American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
www.concrete.org

International Concrete Repair Institute
10600 West Higgins Road, Suite 607
Rosemont, IL 60018
www.icri.org

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