



RESEARCH SERVICES SECTION

TECHNICAL SUMMARY

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PROJECT COST:

\$59,288



Extracted epoxy-coated bar samples underwent several tests; the dry knife adhesion test measures the adhesion of the coating to the bar.

Corrosion Performance of Epoxy-Coated Reinforcement Bars

What Was the Need?

Deteriorating reinforced concrete structures burden many of the nation's transportation departments with escalating repair and maintenance costs. The primary cause of this deterioration is the corrosion of the steel reinforcing bars inside the concrete. This corrosion is caused by exposure to chlorides from seawater in coastal areas and salt-based deicing chemicals in northern climates.

Bridge engineers have long used steel reinforcement bars coated with epoxy to minimize this corrosion, but policies and practices regarding the use of this coating have changed, and concerns remain about its effectiveness over the long term. A study conducted in 1996 by Wiss, Janney, Elstner Associates, Inc. of four 1970s-era Minnesota bridge decks determined levels of chloride concentrations and showed that some epoxy-coated bars had initiated corrosion at cracks in the rebar coating, resulting in some cases in delamination of the concrete deck. Returning to those bridges with new technology to inspect their current condition would provide a data set extending nearly 35 years for analysis and evaluation of corrosion trends.

What Was Our Goal?

Researchers aimed to assess the corrosion performance over a 30- to 35-year period of epoxy-coated reinforcing bars in four bridge decks, providing bridge design engineers the data necessary to improve the long-term performance of Minnesota's reinforced concrete bridges.

What Did We Do?

Researchers performed field and laboratory measurements on four bridges (19015, 27812, 27815 and 27062) built between 1973 and 1978, and located in the Minneapolis/St. Paul area.

In the field, researchers visually inspected the bridges looking for external signs of corrosion; dragged chains over the deck surfaces looking for areas where the concrete had delaminated; and recorded data from half-cell potential measurements, electrochemical spectroscopy and ground penetrating radar. In the laboratory, using core samples removed from the bridges, they measured the chloride content, carbonation depth, concrete density, diffusion rate, general characteristics of the epoxy coating on the bars, and the level of bar corrosion.

Data from the field and laboratory measurements was analyzed, cross-correlated and compared to previous studies to assess the overall performance of the reinforcing bars.

What Did We Learn?

Researchers found the bridge decks to be in generally good condition, showing light cracking, few delaminated areas and only modest corrosion. Only one deck (bridge 19015) had an open spalled (chipped) area. Overall, delaminated and spalled areas constituted less than 1.1 percent of the total area surveyed. The majority of the bars had a chloride ion content of 1.3 lb/cy or lower and had no signs of corrosion. Most of the bars with a chloride ion content of 5.3 lb/cy or higher showed some corrosion.

One bridge (19015) exhibited corrosion, primarily around the joints over the bridge piers. However, the bars did not indicate any section loss. In general, chloride ion corrosion levels and corrosion were greater near joints and vertical cracks. Researchers

“Overall, the bars extracted looked good. We found some that had begun to corrode, but localized to the joints and vertical cracks in the bridge.”

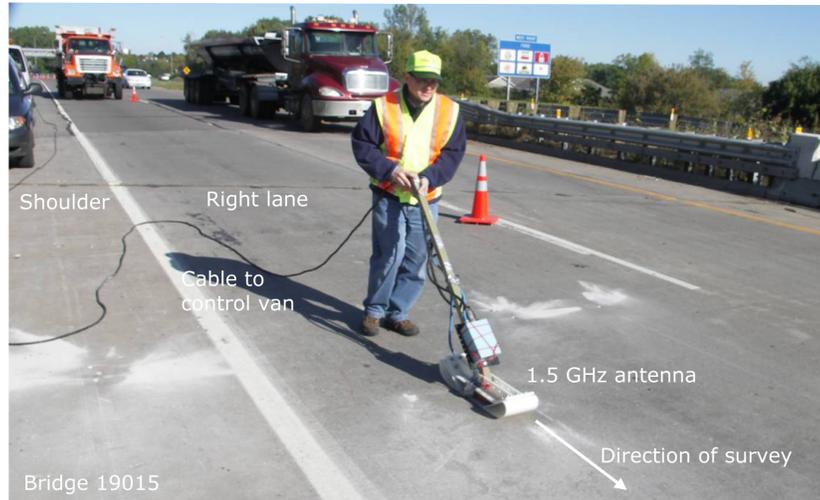
—José Pincheira,
Associate Professor,
University of Wisconsin—
Madison Department of
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Engineering

“We were glad to see that the coating was performing effectively and that our specifications won’t require any significant changes.”

—Paul Rowekamp,
Mn/DOT Bridge
Standards & Research
Engineer

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Researchers used ground penetrating radar (pictured), impedance spectroscopy and half-cell potential measurements in the field to evaluate the level of corrosion of the bars.

recommended that these locations be sealed to prevent deicing agents and humidity from having direct access to the reinforcing bars.

Based upon the gathered data and modeling of the rate of increase in chloride concentration near the bars, those bars located away from cracks or joints and covered by at least 3.5 inches of overlay should not corrode for another 20 to 25 years.

Two of the bridges (27812 and 27815) had decks with 2.5 inches of low slump: high-density overlays that decreased the amount of diffusion through the deck and likely lowered the chloride content at the bars, suggesting that such overlays can improve the performance and extend the service life of bridge decks.

Mn/DOT bridges have two levels of reinforcing bars (termed “mats”) within the concrete structure. Past practice had been to coat only the upper mat because it was closest to the surface, while current practice is for both mats to utilize epoxy-coated bars. Researchers found no sign of increased corrosion activity in coated bars in the bridge with a lower mat of uncoated bars, nor any signs of electrochemical interaction between the coated and uncoated bars that would increase corrosion. Though no lower-mat uncoated bars were examined in the study, rust stains on the bottom of the deck suggested corrosion activity in these bars.

Overall, current Mn/DOT practices were found to be effective, and researchers recommended they be continued. Based upon current fabrication techniques, researchers expect that the epoxy-coated bars made today would be at least as corrosion-resistant as those examined in the study.

What’s Next?

This study was part of a long-term monitoring program. The study may be repeated in another decade to re-examine the health of the reinforcement of these bridges.

Mn/DOT Research Services is considering conducting after-the-fact surveys to gauge the degree to which the workshop facilitated changes in practice at the local level.

This Technical Summary pertains to Report 2008-47, “Corrosion Protection Performance of Epoxy-coated Reinforcing Bars,” published September 2008. The full report can be accessed at <http://www.lrrb.org/PDF/200847.pdf>.