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LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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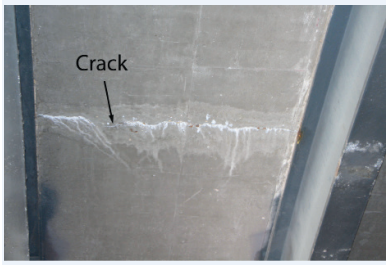
$34,400



Cracks on the undersides of a bridge deck can leak as chlorides corrode steel and seep through the crack.

DEPARTMENT OF TRANSPORTATION
OFFICE OF RESEARCH & INNOVATION

Epoxy-Coated Rebar Bridge Decks Outperform Mixed Rebar Decks

Bridge decks reinforced with one layer of epoxy-coated rebar and a bottom layer of uncoated steel rebar show corrosion damage sooner than epoxy-coated rebar decks. Inspection methods should include a rating for cracking on the underside of decks, and mixed rebar decks may need to be repaired earlier than other decks.

What Was the Need?

In concrete bridge decks, steel reinforcing bars are necessary to add tensile strength and transfer loads to beams. Additionally, steel reinforcement in concrete bridge decks is designed to control cracking, which will extend the service life of the bridge.

Steel also corrodes in salt environments, even when embedded in concrete. Water and road deicing chemicals can reach the steel and damage its strength and integrity. Between 1973 and 1990, MnDOT built approximately 660 bridges with more expensive, epoxy-coated rebar in the top layer of reinforcing matting and standard black rebar in the bottom layer. The coated top layer (only 3 inches below the deck surface) was expected to resist corrosion, and damage from salt and water would not reach the next layer of rebar (another 3 inches down in a 9-inch deck). This technique was also used in a number of county bridges built during that period.

In recent years, MnDOT has used another reinforcing strategy: mixing noncorrosive fibers into concrete mixes to help prevent or minimize cracking and resist corrosion. The older, mixed reinforcement bridges remain in service and few have been redecked. Performance of mixed reinforcement and fiber reinforcement in Minnesota bridge decks has not been compared to the performance of bridge decks constructed with only epoxy-coated rebar.

What Was Our Goal?

MnDOT and the Local Road Research Board (LRRB) sought to compare the performance of mixed rebar decks with all epoxy-coated rebar decks, and the performance of fiber-reinforced decks with no-fiber concrete decks. Both agencies also wanted to learn how to plan preventive maintenance efforts for mixed rebar decks.

What Did We Do?

Researchers reviewed reports from inspections, conducted every two years, for bridges with mixed reinforcement decks and decks with 3-inch strips of fiber reinforcement mixed into the concrete. They narrowed their review to bridge inspection data from 506 bridges with epoxy-coated rebar (including 35 control decks with all-epoxy rebar) built between 1973 and 1990, and 22 bridges with fiber-reinforced concrete and epoxy-coated rebar (including four controls with no rebar) built between 2012 and 2017. All of the bridges were inspected through 2017.

Investigators then conducted site evaluations of 75 mixed rebar decks and 25 all-epoxy rebar decks, as well as 11 fiber-reinforced concrete decks with epoxy rebar and four without rebar. Site surveys focused on confirming the accuracy of recent inspection reports and recording signs of cracking, spalling and other deterioration conditions.

What Did We Learn?

All-epoxy rebar decks outperformed mixed rebar decks, showing less cracking on the top and underside of the decks. Mixed rebar decks deteriorated at a quicker rate on

continued

"These findings may help us shift some priorities for repairing or replacing mixed rebar bridges. We will continue to advocate for the use of all epoxy-coated rebar wherever we anticipate high levels of chlorides."

—Nick Haltvick,
North Region Bridge Construction Engineer, MnDOT Bridge Office

"There's not really a good visual inspection standard for quantifying cracking under the bridge deck, and that's especially important for these types of bridges with mixed rebar. Using only epoxy-coated rebar in decks was a good idea."

—Ben Dymond,
Assistant Professor, University of Minnesota Duluth Department of Civil Engineering

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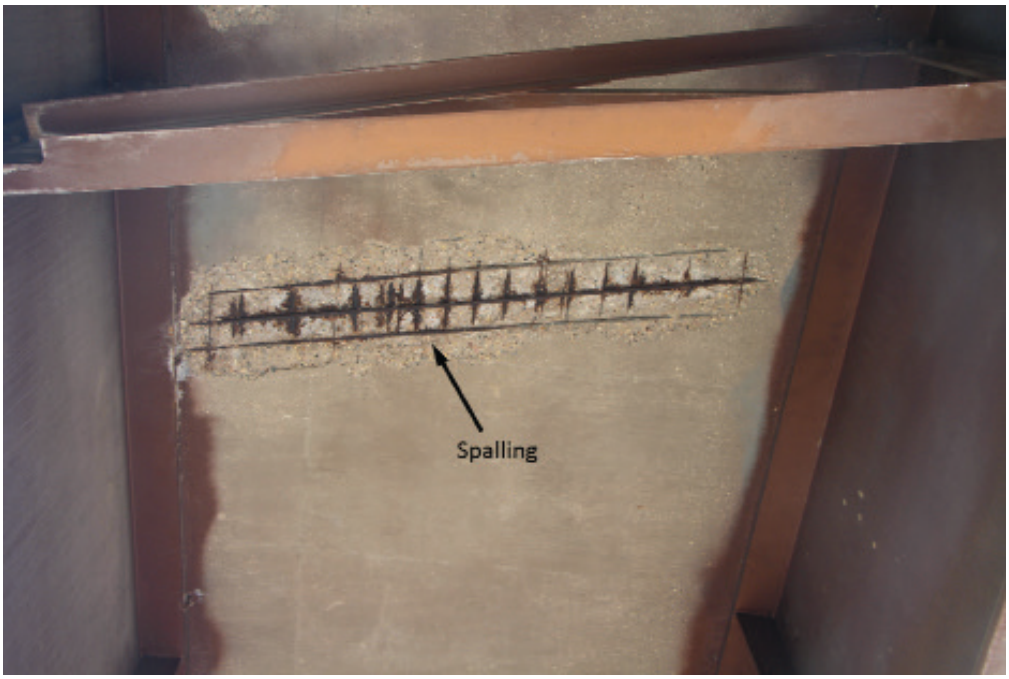

Spalling has occurred because deicing chemicals and water have seeped into the concrete deck through cracks in the deck surface, causing uncoated steel reinforcement to corrode and concrete to spall.

bridges with steel beams than on bridges with prestressed concrete beams. Traffic levels and surface cracking did not appear to affect deterioration of decks in any group.

Data sets were too small to draw any conclusions about possible differences in performance of fiber-reinforced decks compared to bridge decks that were not built with fibers.

Individual bridge elements, such as bridge deck surfaces, have historically been rated from one (best condition) to five (worst condition). Mixed rebar decks earned element ratings of three to four more frequently than all-epoxy rebar decks, and visual surveys identified more deterioration on the underside of mixed rebar decks than all-epoxy rebar decks.

The research team recommended amending bridge inspection procedures to add a new rating element for quantifying crack density on the underside of decks to anticipate and prevent spalling and delamination on the underside of mixed rebar decks. The team also recommended that once the deck condition element in mixed-bar decks holds a rating of two for seven years, more robust cracking sealing techniques should be considered to prevent it from reaching a rating of three. (For most bridges, that repair typically occurs after 8.5 years of service.)

Finally, the team recommended continued evaluation of fiber-reinforced decks as inspection data is collected over time.

What's Next?

This research confirms the current practice of using only epoxy-coated rebar in bridge decks. This method, which has been adopted by MnDOT and a number of county highway agencies, remains a durable solution and offers the best long-term value in terms of repair needs. County agencies will consider the seven-year crack sealing recommendation in maintenance decisions. MnDOT will continue to evaluate fiber-reinforced concrete deck behavior and may adopt a rating method for identifying crack density on the underside of concrete decks.

This Technical Summary pertains to Report 2019-09, "Deterioration of Mixed Rebar and Fiber-Reinforced Concrete Bridge Decks," published February 2019. The full report can be accessed at mndot.gov/research/reports/2019/201909.pdf.