PUTTING RESEARCH TO WORK

BRIEF

Evaluating Methods for Corrosion Control in Concrete Bridges

Corrosion of the steel reinforcement in concrete bridges is a primary cause of the deterioration and early aging of these bridges across the United States. In Wisconsin and other Snow Belt states, the problem is exacerbated by routine winter road salting, which causes high levels of chloride to percolate into the concrete; this significantly increases the rate of corrosion of the steel reinforcement.

What's the Problem?

Significant economic and institutional resources are required to remedy bridge degradation, and bridge owners routinely receive recommendations regarding materials and methods to prevent corrosion. However, most of these recommendations are not supported by unbiased reviews, and repairs are frequently found to have limited effectiveness. Like many Snow Belt states, Wisconsin has tried a variety of solutions to address salt-induced corrosion, but systematic studies had not been performed.

In 2005, researchers completed Wisconsin Highway Research Program project 0092-01-06, "Rehabilitation Techniques for Concrete Bridges," which provided conclusive evidence that coating the ends of reinforced concrete beams with epoxy prevents corrosion of reinforcement more effectively than any subsequent repair. The study also showed that common repair techniques are not very effective in addressing the long-term effects of corrosion. In that study, researchers used a technique of accelerated corrosion involving saltwater sprays and applied voltages to reproduce the long-term effects of weathering and salting in a laboratory environment. There was a need to build upon this research using this technique to evaluate both common and newly marketed techniques for preventing corrosion in concrete reinforcement in recently built bridges and in repairing corrosion damage with an eye to preventing further damage.

Research Objectives

The objective of this project was to evaluate new or promising techniques of repair and maintenance of reinforced concrete bridges in Wisconsin, looking for ways to extend the useful life of bridges and reduce maintenance costs.

Methodology

Two of the more common methods for preventing corrosion in concrete are prevention of chloride penetration by using surface sealants or concrete admixtures, and redirection of chloride ions by using an applied voltage and sacrificial anodes.

This project had a laboratory component aimed at evaluating surface treatments and patching compounds, and it had a field component aimed at evaluating the in situ performance of some surface treatments as well as concrete admixtures.

In the lab, researchers subjected 30 samples of reinforced concrete to six months of accelerated corrosion consisting of periodic wet/dry cycles with applied voltage to induce rapid chloride diffusion into the concrete. The resulting deterioration was designed to approximate decades of accumulated degradation due to weather cycles and salt corrosion in the field. Sixteen of the samples were treated with sealers prior to exposure, modeling the case of new construction. The remaining 14 were cast with mixed-in chlorides, exposed for three months, subjected to patch repair treatments and exposed for three more months, modeling the case of treatment of older, weathered structures. Researchers evaluated the effectiveness of penetrating sealers, surface coatings, galvanic thermal sprayed zinc, galvanic embedded anodes and epoxy-based repair mortar. Depth of chloride penetration, extent of cracking and corrosion of the reinforcing steel were among the characteristics evaluated.

Researchers also evaluated the field performance of nine bridge decks across Wisconsin. Two decks

Investigator

"With the accelerated corrosion technique, we were able to reproduce decades of damage in the span of a few months."

–Habib Tabatabai
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Researchers developed techniques for accelerating corrosion of the steel reinforcement within reinforced concrete bridges, reproducing in six months the delamination, spalling and general degradation that would occur over decades of real-world exposure.

were cast with concrete admixtures intended to reduce chloride penetration, four were treated with surface sealers at various times of exposure and three were not treated to combat chloride penetration.

Results

Researchers concluded that:

- Surface-applied penetrating sealers were effective at preventing corrosion as long as they were applied before the onset of significant damage and were reapplied periodically. Without reapplication, the sealers were ineffective over the long term.
- Epoxy-based coatings offered significant protection, which was enhanced when applied along with galvanic thermal sprayed zinc. The combination offered similar benefits to sealers for new structures but was more expensive than penetrating sealers. The combination offered the best protection on structures that already have significant corrosion damage.
- One of the three concrete admixtures evaluated performed better in the field than the untreated decks, but not as well as sealed decks. Researchers recommend further study of these admixtures.
- Galvanic anode cathodic protection systems alone were ineffective solutions.
- Conventional patch material performed well.

Further Research

Action on this research—especially the institution of periodic reapplication of penetrating sealers—should significantly reduce the maintenance costs and extend the replacement cycle for Wisconsin's concrete bridges. Researchers recommend further field studies of sealers to determine the appropriate time cycle for the reapplication and further field studies of admixtures aimed at finding particularly effective formulas.

Project Manager

"Periodic sealing of the decks is very, very important in order to prevent long-term corrosion damage."

–Travis McDaniel
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