Observation and Documentation of Bridge Deck Construction Using Multi-Crystalline Intermixed Concrete Enhancer and Surface Sealer

tech transfer summary

Concrete additives and sealers have the potential to reduce water intrusion in concrete bridge decks, enhance deck durability, and ultimately extend the service life of bridge structures.

Objectives

This research aimed to observe, document, and evaluate the construction process and early performance of a bridge deck utilizing a specialized admixture, Chem-Crete Multi-Crystalline Enhancer (MCE), and a surface sealer, Chem-Crete PAVIX CCC100. Specific objectives included the following:

- Assess the effectiveness of these products in mitigating the harmful effects of water penetration, including delamination or spalling resulting from freeze-thaw cycles and chloride-induced corrosion of steel reinforcement
- Evaluate the potential of these moisture-prevention products to enhance the durability, reduce the maintenance costs, and extend the service life of Iowa's bridge decks
- Inform future recommendations on product viability, specifications, and design strategies to improve bridge deck longevity across Iowa

Background and Problem Statement

Water intrusion in bridge decks accelerates the degradation of both the concrete and steel reinforcement, posing significant challenges to bridge deck longevity and the overall health of bridge structures. Moisture penetration can lead to delamination or spalling during freeze-thaw cycles and chloride ion infiltration, which can lead to the corrosion of reinforcing steel.

Iowa Highway 5 bridge

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RESEARCH PROJECT TITLE
Observation, Documentation, and Performance Evaluation of Bridge Deck using Multi-Crystalline Intermixed Concrete Enhancer and Surface Sealer

SPONSORS
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PRINCIPAL INVESTIGATOR
Justin Dahlberg, Director
Bridge Engineering Center
Iowa State University
dahlberg@iastate.edu / 515-294-5664
(orcid.org/0000-0002-6184-4122)

CO-PRINCIPAL INVESTIGATOR
Zhengyu Liu, Adjunct Assistant Professor
Civil, Construction and Environmental Engineering, Iowa State University
(orcid.org/0000-0002-7407-0912)

MORE INFORMATION
intrans.iastate.edu

Bridge Engineering Center
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103
www.bec.iastate.edu

The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.

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Bridge deck service life can be extended, in part, by preventing cracking and reducing moisture transport that leads to water intrusion. One proposed solution involves using a specialized concrete admixture—Chem-Crete Multi-Crystalline Enhancer (MCE)—and a surface sealer—Chem-Crete PAVIX CCC100—to reduce water penetration into the concrete.

While initial laboratory data indicated that these products show promise in improving durability and limiting water intrusion, early-age field observations were needed to assess whether they can adequately address common issues, such as cracking, on their own under in-service conditions.

A bridge construction project on Iowa Highway 5 near Centerville, Iowa, presented an opportunity to observe and document the construction process, including application of these products, and evaluate the early-age performance of the treated bridge deck.

Research Description

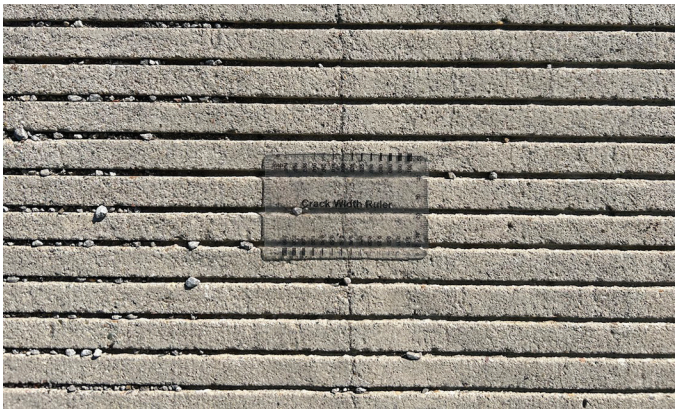
The Iowa Highway 5 bridge is a single-span structure with prestressed, precast girders and a concrete deck featuring epoxy-coated steel reinforcement. The bridge deck was constructed with concrete containing the MCE admixture, and approximately one-half of the deck surface was treated with PAVIX CCC100 to enable comparisons between the treated and untreated areas.

Research activities included the following:

- **Construction observations:** The research team observed a pre-construction test pour at the project site, construction of the bridge deck, and placement of the deck sealer.
- **Periodic field inspections:** The research team visited the bridge periodically over the first 2½ years of service to document any deficiencies in the bridge deck or unexpected conditions, with a particular focus on cracking.
- **Chloride ion sampling and testing:** Concrete powder samples were extracted at 1½ and 2½ years post-construction from six locations on the bridge deck at depths of approximately ½ in., 1 in., 2 in., and 4 in. from the surface. The samples were tested for chloride content using the NT Build 208 method.

A post-construction report on the test pour, biennial observation reports by the Iowa Department of Transportation (Iowa DOT), and Infratek scans were also consulted to assess performance.

PAVIX application



Transverse crack measurement during a field visit

Concrete placement on the Iowa Highway 5 bridge

Chloride content sampling in deck concrete

Key Findings

- The bridge deck was successfully constructed using conventional placement and finishing practices, with no difficulties attributed to the inclusion of MCE in the concrete mixture.
- Third-party laboratory testing demonstrated improvements in several durability-related concrete properties associated with the MCE admixture and PAVIX treatment system.
- Field inspections indicated transverse deck cracking within the first year of service, similar to that observed on recently constructed reinforced concrete bridge decks in Iowa, with crack widths generally remaining narrow. A greater concentration of cracking was consistently observed along the northern half of the bridge deck, but the specific cause could not be determined.
- Cracking patterns remained relatively stable throughout the monitoring period, and no significant deterioration or moisture-related distress was observed. Iowa DOT inspection records similarly indicated that the deck remained in good condition during the early years of service.
- Chloride ion testing showed chloride accumulation near the deck surface due to deicing chemical exposure; however, chloride concentrations decreased substantially with depth, indicating that chloride ingress remained largely confined to the upper portion of the deck.
- Comparisons of chloride ion contents between the PAVIX-treated and untreated areas of the deck did not indicate a measurable reduction in chloride ingress within the PAVIX-treated areas during the monitoring period. While treated locations generally exhibited higher measured chloride concentrations, the cause of this difference could not be conclusively determined.

Conclusions and Recommendations

Based on observations to date, the bridge deck has exhibited early-age performance similar to that of other bridge decks throughout Iowa, particularly in terms of cracking pattern and frequency.

The effectiveness of the MCE admixture and PAVIX surface treatment in reducing visible cracking on bridge decks therefore remains inconclusive. However, laboratory test results and chloride ion profiles indicate that the treatment system may provide long-term durability benefits, including reduced permeability and slower chloride ingress, if early-age cracking can be addressed.

The bridge remains in the early stages of its service life, and continued long-term monitoring of the bridge deck is recommended to determine whether these material-level improvements ultimately translate into delayed corrosion initiation, reduced deterioration, or extended bridge deck service life under field conditions.

Implementation Readiness and Benefits

Early-age laboratory data suggest that Chem-Crete MCE and Chem-Crete PAVIX CCC100 may reduce cracking and limit water intrusion, thereby enhancing deck durability and ultimately extending the service life of bridge structures.

Even so, the effectiveness of these products in reducing visible cracking on bridge decks remains inconclusive. Understanding the long-term performance of these materials through continued monitoring of the Iowa Highway 5 bridge deck will further characterize their behavior and will help inform future bridge deck design and maintenance strategies, potentially improving Iowa's infrastructure.