Research Brief

Wisconsin Highway Research Program
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Improving Bridge Concrete Overlay Performance

Research Objectives

- Evaluate, identify and mitigate causes of cracking in low-slump concrete overlays for bridge decks
- Provide guidance for maintaining low-slump concrete overlays and recommend changes

Research Benefits

- Substantially reduce or eliminate incidents of cracking while restoring high-performing, low-slump concrete overlays
- Review best practices and investigate potential alternative overlay types

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Background

Long-term exposure to deicing salts and reinforcing bar corrosion can lead to significant distress in deck slabs after roughly 40 to 60 years of service. Concrete overlays are commonly used on bridge decks to extend the service life of the deck when signs of distress become evident. This practice has successfully extended the service life of the bridge deck and postponed the more costly but eventual deck replacement. Even though the concrete mix design and placement procedures have not changed over these decades, extensive cracking of the overlays has been noted in recent years in states across the country. This study reviewed experiences and best practices of other states' concrete overlays and conducted laboratory studies to evaluate and determine the appropriate concrete overlay systems for Wisconsin.

Methodology

As part of this study, a comprehensive online survey of bridge deck concrete overlay performance was performed. Twenty-four responses from eleven states were received. Then, an experimental research program was initiated to study the causes of cracking in concrete overlays.

These included calorimetry tests to evaluate heat of hydration, ring tests to assess restrained shrinkage, field slab tests to evaluate cracking potential under realistic environmental conditions, salt ponding tests to evaluate chloride penetration, and dog bone restraint tests (a new test) to assess the effect of various curing procedures on cracking potential in concrete. Seven different mix designs (variants of the current WisDOT Grade E mix) were tested.

Results

Test results showed that all seven mix designs exhibited very high strengths with values ranging from 7,700 to 11,000 psi. Addition of 1.5 lb/cy of PVA fiber to the mixes with or without the reduction of cement content resulted in higher compressive strengths. The latex modified concrete had the lowest compressive strength of all mixes, but still exhibited a high strength. The calorimetry tests indicated that the new Type IL cement can generate higher peaks of heat flow compared to the Type I cement. The reduction of cement content (i.e., increasing the water-cement ratio from 0.36 to 0.5) resulted in reduced heat flow for both IL and I samples. Finally, replacing

"This research helps WisDOT better understand the causes for concrete overlay cracking and provides several strategies for improving their performance."
–James Luebke, WisDOT

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cement with fly ash resulted in progressively smaller heat flow peaks.

The salt ponding test results indicated that the latex modified concrete had the lowest chloride content. The reduction in cement content or addition of fly ash did not increase the chloride content. The ring tests reveal trends in the development of restraint strains in various mixes, including the current WisDOT Grade E mix. The dog bone tests established that wet curing with presoaked burlap and covered with polyethylene sheathing is a better curing procedure when compared with covering the concrete with plastic sheathing alone. The field slab tests indicate that Grade E mix with Type I cement developed an early crack which grew with time.

Placement of overlay using double vibrating screed.

Recommendations for implementation

Based on the tests involved with this study, the research team makes the following recommendations for the Department:

- Place concrete overlays before the deck slab has deteriorated significantly. Overlays are meant to extend the service life of the bridge deck and are less effective if the substrate (bridge deck) is highly contaminated with chlorides, and the reinforcing bars are corroding.
- Reduce Grade E cement by 15%-20% and replace with fly ash when practical.
- Allow 7-14 days for curing with pre-soaked wet burlap covered in polyethylene sheathing. The current WisDOT provision for curing is three days but tests show the benefits of a longer curing time.
- Full- and partial-depth patch repairs should be performed before placing the overlay.