Implementation of Recommendations for Eliminating Longitudinal Median Joints in Wide Bridges

tech transfer summary

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RESEARCH PROJECT TITLE

Implementation of Recommendations for Eliminating Longitudinal Median Joints in Wide Bridges

SPONSORS

Iowa Highway Research Board
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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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This project confirmed that cracking in wide bridge decks appears less dependent on the total width of the deck and more dependent on the restraint from the abutment to large temperature differences between the two. Cracking can be mitigated by reducing the temperature gradients between the deck and abutment by thermally isolating the abutment from the backfill soils.

Research Objective, Focus, and Scope

The primary objective of this research was to follow and document the design, construction, and performance of a bridge in Black Hawk County with a specific focus on the success of the deck crack mitigation efforts. The primary objective was reached through the following efforts:

- Review the literature from the Phase I research work with respect to bridge width limitations and search the current research literature further about the thermal effects on bridge structures
- Perform field monitoring on a wide bridge constructed in Blackhawk County
- Conduct an analytic study on the thermally induced effect on the wide bridge
- Synthesize the findings to develop further recommendations for adoption

Problem Statement

Longitudinal bridge deck joints are commonly used in cases where the roadway carries a larger than typical number of traffic lanes necessitating a greater bridge deck width. The Iowa Department of Transportation (DOT) requires the use of longitudinal bridge joints in wide bridges with the hopes of reducing or eliminating the cracking that has been observed in wide bridges constructed without longitudinal joints.

The longitudinal joints are thought to provide relief from expansion and contraction of the bridge deck resulting from temperature change, shrinkage, and live loads. Historically, however, these joints have been known to leak, allowing chloride-laden water to reach the bottom of the deck overhang and even the exterior girders. This has resulted in cases of premature deterioration.

Wide integral abutment Viking Road Bridge over IA 58 constructed with a thermal isolation barrier and without longitudinal expansion joints

The problem is most severe when the joint is narrow and/or located between median barrier rails where the water can be trapped for long periods of time. Weathering steel bridges are particularly sensitive to this situation as the protective patina may never naturally form. This is a situation where the elimination of one problem (cracking associated with wide bridges) has created a second problem (a problematic longitudinal joint).

Project Background

The Phase I Iowa Highway Research Board project (IHRB project TR-661) was completed to determine the maximum width of a continuous deck that can be used without negatively impacting performance. One of the primary conclusions of this work was that the development of cracking in bridge decks seems less dependent on the total width of the deck and more dependent on restraint of the abutment when significant temperature gradients exist between the bridge deck and the very rigid abutment.

Based on the finite element (FE) results from that study, it was proposed that an effective solution to reduce cracking in the deck might be to place a thermal isolation barrier between the backfill soils and the back side of the abutment, thus maintaining closer temperatures within the abutment and bridge deck.

Research Description

The objective of this research was to follow and document the design, construction, and performance of a newly constructed bridge in Blackhawk County with a specific focus on the success of the crack mitigation efforts. To achieve this objective, the bridge on Viking Road over IA 58 was selected to investigate the effects of a thermal isolation barrier.

The bridge was designed with a width of 228 ft, which is much greater than the maximum width of 60 ft before the use of a longitudinal joint is required per the 2012 Iowa Bridge Design Manual. The bridge deck had no longitudinal expansion joints, only closure pours between adjacent deck pours, in which the deck reinforcement was continuous.

Using the recommendations from the previous research, a thermal isolation barrier was used between the backfill soils and the abutment.

A more than two-year-long monitoring period followed the completion of construction using numerous thermistors and strain gauges at various abutment and deck locations. Additionally, periodic visual inspections were completed to identify if any deck cracks were forming.

In addition, an analytical study was conducted using FE models to investigate the efficacy of the isolation barrier on the bridge deck end structural behavior. The models were calibrated and validated using field-collected strain and temperature data.

Preparing for placement of expanded polystyrene (EPS) block behind the integral abutments to create thermal isolation from the adjacent backfill soils

Installation of EPS isolation barrier

Key Findings

By the end of May 2022, nearly three years after construction completion, no evidence of deck cracking existed.

With a thermal isolation barrier, the temperature difference between the back face and front face at each level of the abutment remained relatively close throughout the year with differences being less than 10°F in most cases. The value of the thermal isolation barrier was especially apparent when ambient temperatures changed very quickly and a greater temperature differential was more likely.

The FE model results indicated that significantly higher deck strains exist when a thermal isolation barrier is not in place to limit the temperature differential through the thickness of the abutment. In fact, the maximum deck strain was found to be 46% greater when the thermal isolation barrier was not included in the models.

Conclusions/Implementation Recommendations

The results support the findings from the Phase I research that the development of cracking in bridge decks appears less dependent on the total width of the deck and more the result of differential temperatures between the bridge deck and integral abutment. The results indicated that a thermal isolation barrier between the abutment and the backfill soils is effective for limiting temperature differentials, which thereby limits the potential for deck end cracking on integral abutment bridges.

The validated FE model analysis indicated that, without the barrier, the strain values at the deck ends of the Viking Road Bridge could exceed the calculated cracking strain of the concrete.

The researchers recommend the use of a thermal isolation barrier between the abutment and backfill soils for wide integral abutment bridges as one way to lengthen the service life of these bridge decks while reducing maintenance, rehabilitation, and/or replacement costs as well.