Research Brief

Wisconsin Highway Research Program
Project 0092-16-04
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Staged Concrete Bridge Deck Pours Adjacent to Live Traffic

Research Objectives

- Review the current state of Wisconsin bridge decks constructed or repaired in stages
- Evaluate longitudinal joints and steel reinforcing bars subjected to traffic-induced differential deflections
- Develop recommendations for the design and construction of staged concrete bridge decks

Research Benefits

- Found impacts from traffic can be minimized by moving traffic away from the curing deck and providing a smooth riding surface
- Recommended practices to increase bridge integrity and prevent the most common flaws found in staged-construction decks: air voids

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Background

Heavy traffic loading and harsh environmental conditions cause concrete bridge decks to degrade over time, necessitating repair or replacement. Additionally, aging infrastructure must be updated and expanded to meet increasing traffic demands. To maintain traffic and mitigate disruption to road users, bridge replacement, rehabilitation and widening are often performed in stages.

Staged bridge construction can create challenges. Vibrations induced by traffic during curing of the cast-in-place concrete may affect the bond between the concrete and embedded reinforcement, potentially reducing the durability of longitudinal joints. The goals of this project were to evaluate the extent to which live traffic affects the integrity and performance of longitudinal joints and provide recommendations for improving staged concrete-deck construction practices.

Methodology

The research team reviewed regional practices for constructing bridges in stages and selected 41 existing concrete deck-on-girder bridges throughout Wisconsin for visual inspection, focusing on the presence of cracks, spalls, corroded reinforcement, joint leakage and other signs of deck deterioration.

The team also monitored two bridges throughout the staged-construction process to measure the relative displacements at the longitudinal joint as the concrete on the second stage cured. Instrumentation was set up on the hardened concrete deck of the first stage and extended over the freshly-placed concrete of the second. Measurements from string potentiometers, linear variable differential transformers, accelerometers and tiltmeters were used to calculate relative displacement. Measurements were repeated 20 days later, allowing comparison between fresh and hardened concrete.

Instrumentation to monitor deflection set over curing concrete.

Two bridge deck specimens were fabricated in stages in the laboratory and subjected to simulated

"This research will help us construct bridge decks in stages and support our goal to build structures that perform better and last longer."
– Bill Oliva, WisDOT

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traffic-induced vibrations to evaluate their effect on concrete-bar bond and integrity of the longitudinal joint region. Displacement history applied to the specimens was determined based on the results from the field monitoring phase. Additionally, joint leakage tests were conducted to evaluate potential changes in joint leakage with the application of a concrete retarder to the joint face of the first stage concrete deck.

Results

Findings from the inspection of the 41 bridges did not conclusively prove that staged construction causes accelerated deterioration in deck-on-girder bridges; however, evidence shows that flat and haunched-slab bridges may be more susceptible to damage when constructed in stages. Under-consolidation was the most common defect found in deck-on-girder bridges. This is definitively attributable to the construction practice, because it can only occur during concrete placement.

Differential deflections of 0.175 inches or less were not found to affect the integrity of a deck's concrete-rebar bond or ultimate flexural strength. Short-span and medium-span bridges do not experience high enough differential deflection to suffer notable damage, but long-span bridges and bridges with multiple lanes of traffic maintained during curing may be impacted. Although the results from joint leakage tests were not conclusive, laboratory test results suggest that the application of a concrete retarder to the joint face of the first stage concrete deck may help reduce water leakage and thus, reduce deck deterioration over time.

Recommendations for Implementation

Concrete decks should be routinely inspected during and after staged construction, and extra attention should be spent on ensuring the joint-region concrete consolidates properly without any large air voids under the reinforcement or in the shear key. Using one-piece bar couplers will reduce the amount of reinforcement in the construction joint region and should allow the concrete to be more easily consolidated. A 50 bar-diameter lap splice is sufficient in developing the full yield strength of the steel bars and providing continuity between construction stages.

Differential deflection can be mitigated by keeping traffic as far from the curing deck as possible and by ensuring a smooth riding surface.

This brief summarizes Project 0092-16-04,
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