Research Brief

Wisconsin Highway Research Program
Project 0092-15-03
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Self-Consolidating Concrete for Prestressed Bridge Girders

Research Objectives

- To examine effects of various SCC mixture constituents on the material characteristics and performance.
- To develop mix design guidelines for the use of SCC in PSC girders on WisDOT bridge projects.
- To investigate structural behavior of a full-scale prestressed SCC girder.

Research Benefits

- Developed an SCC mixture design for use in PSC bridges.
- Recommended specifications for fabrication and implementation of prestressed SCC girders.
- Reaffirmed the cost- and time-saving potential of SCC use in bridge girders.

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Background

Self-consolidating concrete (SCC) is commonly used as an alternative to conventional concrete (CC) in precast, prestressed concrete (PSC) bridge girders. The high strength, highly workable mixture can flow through dense reinforcement to fill formwork and achieve minimal segregation without the assistance of vibration mechanisms, saving time and money. Several state departments of transportation have found success in using SCC in precast PSC bridge girders; however, producers in Wisconsin have struggled to maintain uniformity in terms of mixture properties with low segregation, as well as transporting and placing the girder for bridge construction. The objective of this project was to examine effects of various SCC mixture constituents on the material characteristics in order to develop a uniform mixture design that achieves consistent, desired performance.

Methodology

Local materials from three Wisconsin precastors were used to develop SCC trial mixtures for testing fresh and hardened material properties. For designing the mixtures, the research team investigated the effects of cement content and type; aggregate size and type; sand-to-aggregate ratio; and water-to-cement ratio. The mixtures were evaluated in a fresh state using slump flow, visual stability index (VSI), T20, J-ring and column segregation testing. They were then tested in a hardened state for compressive strength at transfer after 18 hours and 28 days.

Five mixtures were selected for further testing under the mixing, curing and quality control procedures of the three precastors, and the specimens' creep and shrinkage were examined for 280 days. One mixture was selected for casting a full-scale prestressed SCC girder to monitor structural performance, and a conventional concrete (CC) girder with similar target compressive strength was fabricated as a control specimen. Prestress losses and camber for both the SCC and CC girders were then monitored in the precast yard for 161 days, and their transfer lengths were measured for 28 days.

Camber was measured early in the morning to mitigate thermal effects.

"The results of this study show that WisDOT can incorporate the use of SCC in bridge girders with confidence. With the data from this research, we have created a special provision and are investigating potential pilot projects for implementation. We look forward to examining other components in our structures that may benefit from the use of SCC."

– Steve Doocy, WisDOT

Interested in finding out more?

Final report is available at: WisDOT Research website.

Results

For the SCC and CC girders, respectively, elastic shortening was 9.07 and 10.61 kilopounds per square inch (ksi); final prestress losses were 8.53 and 6.42 ksi; construction losses were 2.22 and 1.90 ksi; and the total prestress losses were 16.89 and 17.03 ksi. The prestress losses continued to climb until day 161, when the girders were shipped and placed on site; the losses then slowly declined until final recording on day 287.

Transfer length immediately after release was 19.0 inches for the SCC girder and 24.0 inches for the CC girder. At 28 days, the transfer length increased by 1 inch, to 20.0 inches, for the SCC girder and 0.5 inches, to 24.5 inches, for the CC girder. The American Association of State Highway and Transportation Officials (AASHTO) and the American Concrete Institute (ACI) specify transfer lengths of 36.0 and 30.0 inches, respectively, suggesting that their formulas for determining transfer length are conservative.

The variation in camber was 1.63 inches for the SCC girder and 1.38 inches for the CC girder. Each girder reached a peak camber of 4.5 inches, but the SCC girder peaked faster, at 91 days, than the CC girder, at 126 days.

Recommendations for Implementation

Implementation of prestressed SCC bridge girders could save the Wisconsin Department of Transportation (WisDOT) time and money on its construction projects; however, since only one mixture was tested as a fully constructed girder, there is need to validate any other mixture before permitting its use in girder production. This project provides recommendations for performance requirements for the fabrication and quality control of SCC bridge girders. Larger, full-scale SCC girders should be monitored to gather information on long-term structural behavior.

The researchers also recommend investigating the implementation of supplemental cementitious materials to reduce the costs of SCC mixtures to make them more feasible for local producers.

This brief summarizes Project 0092-15-03,
"Self-Consolidating Concrete for Prestressed Bridge Girders"
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