Project Summary

Texas Department of Transportation

0-5134: Self-Consolidating Concrete for Precast Structural Applications

Background

Self-consolidating concrete (SCC) is defined as highly flowable and nonsegregating concrete not requiring mechanical vibration. This research evaluated the potential for implementing SCC in precast plants for the fabrication of pretensioned bridge girders. Implementing this material in precast plants has the potential to increase production and safety and decrease costs of precast, prestressed concrete products.

To achieve the full benefits of SCC, it is common to reduce the coarse aggregate content and increase the cement paste content. Challenges in developing SCC mixture proportions included achieving adequate passing ability, adequate release strength, and a cementitious materials content of less than 700 lb/yd^3 (415 kg/m^3) simultaneously. Concerns with increasing the paste content include the potential for increased creep, decreased shear capacity, nonstandard relationships between compressive strength and other mechanical properties, reduction in bond, different in-service performance as compared to conventional concrete (CC), and increased costs.

What the Researchers Did

Researchers from TTI and CTR teamed to perform this research. CTR researchers developed SCC mixture proportions expected to be representative of SCC in Texas for pretensioned bridge girders; evaluated the setting characteristics, heat generation, and shrinkage of these mixtures; and developed recommendations for inspecting SCC.

TTI researchers performed research to evaluate if girders containing SCC can be designed using the *American Association of State Highway and Transportation Officials* (AASHTO) *Load and Resistance Factor Design* (LRFD) *Specifications*. Various mixture constituents and proportions were evaluated for mechanical properties, shear characteristics, bond characteristics, creep, and durability.

The team fabricated, tested, and compared the structural behavior of four full-scale girder-deck systems, 40 ft (12 m) long and containing CC and SCC.

Research Performed by:

Texas Transportation Institute (TTI),
The Texas A&M University System

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Project Completed: 12/31/07

What They Found

The CTR research team concluded that it was necessary to exceed the maximum limit of 700 lb/yd^3 (415 kg/m^3) of cementitious materials required by the 2004 *TxDOT Standard Specifications*. The setting times of the SCC and CC mixtures were similar. The SCC generated greater total heat than the CC. The maximum temperature limits from the 2004 *TxDOT Standard Specifications* were not exceeded in the mixtures. With comparable 16-hour release strength, the amounts of shrinkage of the SCC and CC mixtures were similar.

Filling ability and passing ability should be measured with the slump flow and J-ring test, respectively. Both the slump flow and T_{50} should be measured. Segregation resistance should be measured with the column segregation or sieve stability test methods.

The TTI research team concluded that the AASHTO LRFD (2006) prediction equations for the modulus of rupture, modulus of elasticity, and splitting tensile strength can be used to estimate the mechanical properties of SCC for concrete compressive strengths from 5 to 10 ksi (34 to 70 MPa). New equations were also developed for higher-strength SCC.

The AASHTO and modified compression field theory (MCFT) equations may overestimate the shear capacity for both SCC and CC when the compressive strength is greater than 10 ksi (70 MPa). A new equation was developed for estimating the shear capacity of SCC and CC for these conditions.

Similar creep and reductions in bond of top bars embedded in concretes were observed for the SCC and CC. The AASHTO LRFD (2006) equations for creep and the development length of top bars are appropriate.

The durability of SCC was similar to CC with the exception of the freeze-thaw performance. It is recommended that either SCC be used in environments where the number of freeze-thaw cycles is low or the SCC have a minimum 7 ksi (48 MPa) release strength when used in freeze-thaw environments.

Girder-deck systems with Type A SCC girders exhibited similar flexural performance as those with Type A CC girders. The AASHTO LRFD (2006) equations for the cracking moment, nominal moment, transfer length, development length, and prestress losses are appropriate for SCC girder-deck systems similar to those tested in this study.

Researchers observed some segregation of the SCC when fabricating the full-scale girders. Producers should be aware of this potential segregation issue and monitor the aggregate moisture carefully.

What This Means

The research findings indicate that SCC is suitable for use in precast plants in Texas, specifically those plants producing precast, prestressed girders. However, the research also found that the fresh properties of SCC can be sensitive to environmental and transport conditions. While there are many potential benefits of utilizing SCC, precast plants should have a good quality-control program in place to ensure successful implementation.

For More Information:

0-5134-1 Self-Consolidating Concrete for Precast Structural Applications: Mixture Proportions, Workability, and Early-Age Hardened Properties

0-5134-2 Characterization of Self-Consolidating Concrete For Design Of Precast, Prestressed Bridge Girders

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