



## RESEARCH SERVICES SECTION

# TECHNICAL SUMMARY

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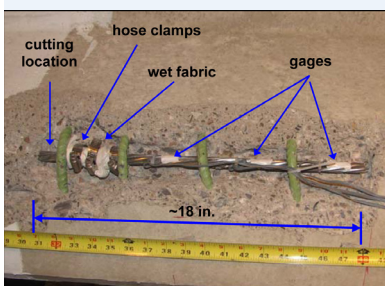
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### Principal Investigator:

Carol Shield, University of Minnesota

### PROJECT COST:

\$264,000



Researchers instrumented all girders inside and outside.

# Self-Compacting Concrete for Prestressed Bridge Girders

## What Was the Need?

Traditional concretes used in precast bridge elements require vibration during construction in order for the wet concrete to fully fill the casting forms. Even with vibration, cast concrete structures require significant labor after the initial casting to fill “bug” holes and improve the surface finish. Self-compacting concrete was first developed in Japan in the early 1980s to eliminate some of these construction inefficiencies. SCC is highly workable and flows through congested reinforcement areas under its own weight alone, filling formwork with a structure free of voids and without the need for applied vibration. Constructing bridge girders with SCC could significantly reduce the labor cost in precast applications.

However, there is limited literature available evaluating the long-term behavior of SCC girders, and the findings among even those studies vary greatly. Also, the American Society for Testing and Materials has not issued test methods that can be used to evaluate the concrete in its fresh state and accurately predict its behavior when hardened. Both Mn/DOT and local concrete girder manufacturers have little experience in handling SCC and understanding its long-term behavior. Such experience is necessary to produce beams with consistent physical properties. Lastly, current highway bridge codes do not distinguish between conventional concrete and SCC, though these have significant differences. Mn/DOT engineers and fabricators need to consider these differences and how to handle them during inspections.

Prior to using SCC in bridge construction to take advantage of the cost-saving benefits of the material, Mn/DOT needed to understand both the wet and hardened characteristics of the concrete in real-world applications; data gathering was needed to evaluate the possibility of future use in building bridge girders in Minnesota.

## What Was Our Goal?

The goals of this study were:

- To determine a reasonable SCC mix design using locally available materials and methods that could be implemented at Minnesota precast concrete plants
- To examine girders fabricated with SCC in the laboratory and compare their characteristics to girders made using conventional concrete

## What Did We Do?

Researchers evaluated the performance in a wet state of 17 mixes using different cements, aggregates and admixtures with varying proportions. Quantitative measurements such as slump flow (characterizing the amount that the wet concrete flows) and qualitative measurements such as visual inspection were all used to summarize the performance of the mixes. Evaluating these mixes in consultation with local plant personnel, researchers determined appropriate SCC mixes. Four SCC and two conventional, 38-foot, full-scale Mn/DOT 36M I-girders were cast from the same forms at two precast concrete plants.

The girders were instrumented to monitor both long-term and short-term performance under laboratory tests. Researchers used design tools and specifications from AASHTO (2007) and ACI 318 (2005) to predict the results and evaluate the tools for their applicability in designing SCC bridge girders. Additionally, a large number of cylinders were fabricated using the SCC mix and used to monitor characteristics such as compressive

*“Mn/DOT is more confident now that beams produced with SCC have been shown capable of providing satisfactory, long-term performance in Minnesota bridges.”*

–Erik Wolhowe,  
Bridge Consultant Contracts Coordinator,  
Mn/DOT Metro District

*“Because SCC does not need vibration to be consolidated, faster construction is possible with less labor and potentially large economic benefits.”*

–Carol Shield,  
Professor, University of Minnesota Department of Civil Engineering

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To find an SCC mix that had the necessary viscosity and flow properties in the fresh state, researchers performed a series of mixing tests.

strength and stiffness, and develop models for creep and material shrinkage.

### What Did We Learn?

SCC with adequate performance in the fresh state was successfully developed for fabrication of Mn/DOT bridge girders, using locally available materials at two precast concrete plants in the Twin Cities area.

Some chemical and physical properties of cement that are not typically listed in the mill report for the cement were found to significantly affect the flow properties of SCC. Among the matters explored, researchers found that the flowability of SCC increases about 1 inch for each 10 degrees Fahrenheit increase in mixing temperature, and SCC girders have longer transfer lengths than conventionally made girders.

### What's Next?

Overall, Mn/DOT engineers were pleased with the results and are confident SCC can be used in the future to construct precast bridge girders.

Further understanding of the sensitivity of the fresh-state properties of SCC to the original cement is the most pressing hurdle to large-scale implementation of SCC as the preferred concrete in constructing these girders. Fabricators also need more experience with the mixing process to make concrete that has the same properties batch after batch. Since the conclusion of this research project, several fabricators have been experimenting with high-slump concrete and producing beams successfully.