The Sand Creek Bridge in Buchanan County, Iowa was the first in the nation to use a specific type of non-conventional, high-strength steel that could reduce tonnage needed while still meeting bridge design standards.

RESEARCH SOLUTIONS

Advanced steel offers cost-savings for Iowa's bridges

Steel girders, which are commonly used in Iowa bridges, are made with various types and grades of steel. An advanced, high-strength steel used in vertical buildings was adopted into national standard bridge specifications in 2018. Iowa's Buchanan County became the first in the nation to build a short-span bridge with the improved material. Live-load tests over three years and thorough laboratory testing demonstrated the economic and structural advantages that Iowa DOT and county engineers could realize as the steel grade becomes more widely available.

THE NEED

Steel grades have improved over time, resulting in stronger and more durable materials for building bridges. The weldability and corrosion-resistance of certain steel grades has also improved with advancements in steel technology. A particularly high-strength, low-alloy structural steel was developed in Europe in the late 1970s using a quenching and self-tempering process that results in a hardened surface with a ductile core. After using the steel in vertical buildings for certain applications over the past two decades, a specification for using the material in bridge designs was approved in 2018.

The first bridge in the United States to incorporate this advanced steel, known as A709 Grade QST 65, is the single-span Sand Creek Bridge built in 2019 in Buchanan County, Iowa. While the Sand Creek Bridge is performing as designed, Iowa bridge engineers wanted to conduct further evaluations to determine that the material meets federal design specifications and is advantageous for bridge building.

(continued)

"The laboratory tests and demonstration in the field clearly showed the viability and potential cost savings of this advanced steel grade. Depending on availability, other Iowa counties may decide to test it out."

— **BRIAN MOORE,**
Iowa DOT Secondary Roads Resarch Engineer

RESEARCH APPROACH

A detailed review of the published literature related to manufacturing techniques, costs, characteristics, and performance of the steel preceded full-scale laboratory testing to ensure the material met federal design standards. Two beams, one an exact replica of a girder used in the Sand Creek Bridge, underwent strength and ductility assessments.

With loadings every 15 feet along the beams, researchers tested the configuration both with and without a composite concrete deck on top. While a variety of deflection and strain gauges demonstrated each beam's bending behavior, the primary data came from the center span areas where the maximum load effect occurs.

Loadings past the steel's yield point applied to the steel-concrete composite section indicated the beam's ultimate flexural capacity. Using a sample from the steel beam, tensile and fatigue tests revealed the steel's yield and ultimate strength and point of failure to compare with required mechanical properties of steel bridges.

Finally, three live-load tests conducted a year apart at the Sand Creek Bridge identified any structural changes that may have been directly attributable to the steel.

WHAT IOWA LEARNED

A review of technical manuals and other literature revealed that this advanced steel provides a 30 percent increase in yield stress and a 23 percent increase in ultimate tensile capacity compared with traditional steel, which had originally been specified for the Sand Creek Bridge. Weldability is not diminished, and because the improved steel does not require preheating it can save significant time and expense. Lastly, unlike some other high-yield-strength steels which may become brittle, the advanced steel can be galvanized for additional protection from environmental conditions.

The beams, both with and without the composite concrete, performed very closely to the predicted behavior for elasticity as measured by strain and deflection in the laboratory. The yield strength of the advanced steel exceeded the minimum standards for yield strength, and the fatigue tests similarly revealed its fatigue resistance was consistent with standards.

The cost by weight of A709 Grade QST 65 steel is comparable to traditional steel, but its increased strength means less material is needed for the same bridge capacity. Buchanan County realized a 20 percent material cost savings from the reduction in overall tonnage compared to the initial bridge design. The live load tests over three years indicated no change in structural behavior and performance as designed since being put into service.

PUTTING IT TO WORK

Laboratory results and tests conducted during the Sand Creek Bridge's first few years of service show that the advanced steel has performed well under a variety of conditions. Engineers in other Iowa counties can be confident that the concept of using A709 Grade QST 65 steel for similar bridges has been demonstrated through this project.

ABOUT THIS PROJECT

PROJECT NAME: Evaluation of the Performance of A709 Grade 65 QST Bridge Steel
Final Report | Technical Brief

PROJECT NUMBER: TR-779

REPORT DATE: September 2022

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