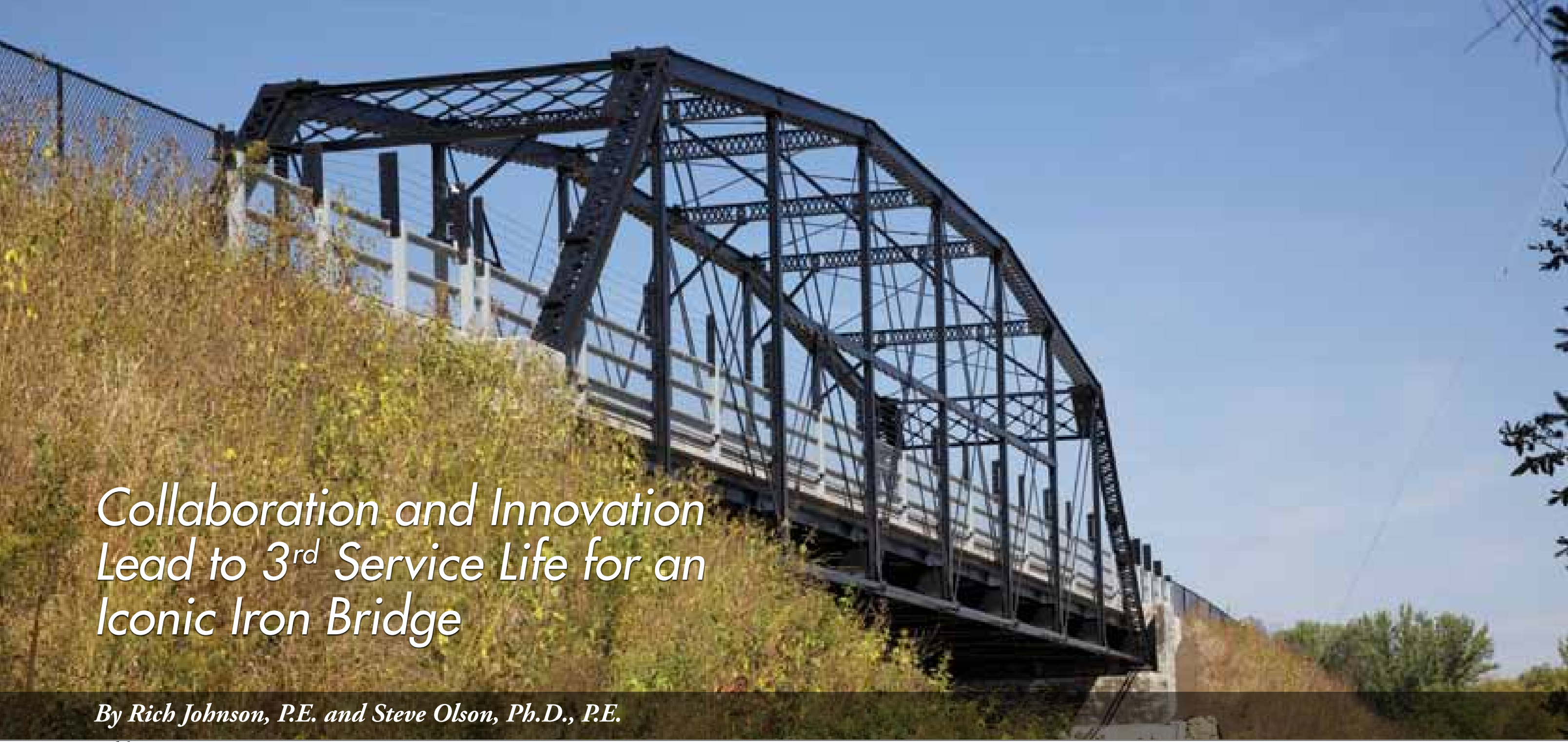


Collaboration and Innovation Lead to 3rd Service Life for an Iconic Iron Bridge

By Rich Johnson, P.E. and Steve Olson, Ph.D., P.E.

Oblique view.

Minnesota was sprouting like a wheat field in 1877, but the growth could not continue unless improvements were made to the state's fledgling transportation system. One such improvement built that year was a 162-foot Parker truss span in Sauk Centre, MN, located in the central part of the state. Years before the automobile age and the mass production of steel, the bridge enabled horses, wagons, buggies and pedestrians to cross the Sauk River.

The bridge was well constructed, with several primary members composed of wrought iron. The inclusion of wrought iron, which stands up to corrosion better than steel, likely played a significant role in the long lifespan of the bridge at multiple locations.

By the 1930s, the bridge no longer met the needs of the Sauk Centre community, but enterprising Minnesotans found a new use for the span. It was disassembled and in 1937 was re-erected in a wilderness area in northern Minnesota, where it carried State Highway 65 over the Little Fork River in Koochiching County, near the small town of Silverdale. For 70 years, Minnesota Bridge #5721 carried logging trucks and other vehicles at this scenic northern Minnesota location.

But as the 21st century dawned, the Silverdale Bridge again faced obsolescence. Besides the fact that the bridge was too narrow for modern highway traffic needs, its badly deteriorated floor system made its load capacity marginal at best. It was time for #5721 to "hit the road" again.

In 2009, the bridge was disassembled and stored in a Minnesota Department of Transportation (MnDOT) facility. During the following two years, a collaborative effort between engineers and historians led to the bridge's evaluation, rehabilitation and re-erection at a Minnesota Department of Natural Resources (MnDNR) trail near Stillwater, MN, just northeast of the Twin Cities. The bridge not only has been preserved but it has come full circle, once again carrying equestrian and pedestrian traffic.

Cross bracing, verticals, diagonals and counters.

The disassembly, relocation and re-erection project was confronted by significant technical hurdles, but those hurdles were overcome through the collaboration of engineers and historians who devised innovative solutions.

A Bridge to Minnesota History

Years before it was dismantled, the Silverdale Bridge was recognized as worthy of historic preservation. In the 1980s and 90s MnDOT, the Minnesota State Historic Preservation Office (SHPO) and their consultants inventoried the state's bridges and identified those with historic significance. Roughly 200 bridges built prior to 1956 were identified as either on or eligible for inclusion on the National Register of Historic Places. Among them was the Silverdale Bridge, which was added to the National Register in 1998.

In 2006, HNTB Corporation and Mead & Hunt prepared a *Management Plan for Historic Bridges in Minnesota* under the auspices of MnDOT, SHPO and the Federal Highway Administration. The Silverdale Bridge was one of twenty-four bridges identified for preservation by MnDOT.

"Maintaining historic properties, including bridges, helps people to understand where they came from – what previous engineers and communities hoped for and what they were able to achieve," the historic bridge management plan stated. "By protecting these reminders of the state's engineering and transportation legacy, the present and the future can be built, since their preservation can save valuable tax-payer dollars and recall a community's hopes and dreams."

Formulating a Strategy

Based on the goals of the historic bridge management plan, engineers and historians worked together to develop a preservation strategy for the bridge. Team members determined that widening and strengthening the bridge for continued use at the Silverdale site would require dramatic changes to the bridge, including a substantial loss of historic material and alteration of character-defining features.

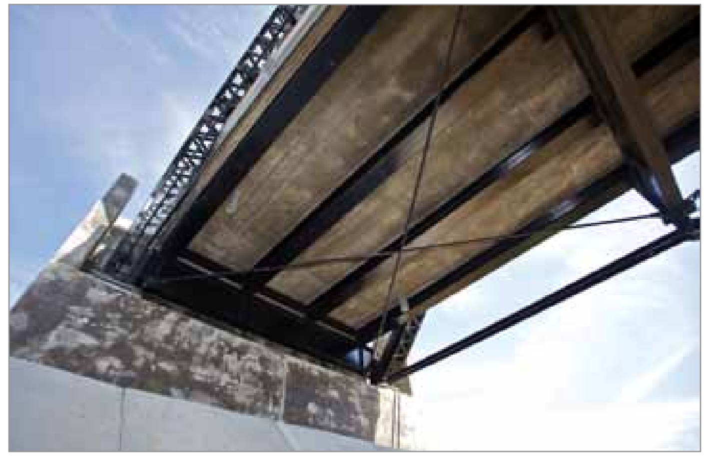
The team ultimately decided the course of action would be to move the bridge to a new site with less demanding expectations on the venerable structure. MnDOT worked with MnDNR to identify the most appropriate site. The stakeholders zeroed in on the Gateway Trail, the most heavily used DNR trail in Minnesota. As part of an abandoned railroad corridor that has been converted to trail use, the Gateway Trail traverses several at-grade crossings with heavily traveled roadways. The team identified an at-grade crossing with sight distance challenges near Stillwater that made it a good candidate for a grade separation bridge.

Laser Scanning Gathers Crucial Data

While the premise of the bridge relocation project was sound, its execution was no easy task. For example, plans related to the 1870s bridge construction had vanished into history, and only a handful of sheets were available from the 1930s disassembly and re-erection.

To overcome the lack of crucial information, the consultant team decided to use laser scanning of the bridge to collect geometric data prior to disassembly and as major components were removed. This technique, which employs a terrestrial laser-imaging system that creates highly accurate three-dimensional images, proved to be extremely useful. Fastener patterns taken from the scans of original portal members and end floor beams were used to detail replacement members. In addition, the scan data facilitated the capacity evaluation of the eyebars that had suffered defects during removal operations. The information gleaned from this geometric evaluation enabled 88 of the 96 original wrought iron eyebars to be incorporated into the bridge at its third location.

Railing details.



Below deck, stringers, sway bracing at abutment.

A Bigger Job Than Anticipated

Extensive rehabilitation was required before Bridge #5721 could be moved to its new home. The re-assembly contractor carefully removed the iron truss components and transported them to White Oak Metals Inc., a steel fabricator in west central Minnesota. There the components were blast cleaned and revived.

After blast cleaning, it was apparent that many of the primary truss eyebars had been damaged during disassembly, despite the great care taken by the construction contractor. The disassembly contractor's hardened tools produced nicks and gouges in the heads of the eyebars as the pinned connections were taken apart. Damage to a floor beam and to several upper chord members also was noted once the members were blast cleaned.

The need for replacement end floor beams, replacement portal members and replacement stringers was expected from the start. But the need to replace 8 of the 96 primary eyebars, as well as the need to fix an interior floor beam and several top chord members, had not been anticipated when the re-assembly contract was let.

New Technologies Boost Old Components

As design work progressed, it became clear that the truss span would lack the capacity to carry full pedestrian loads and a normal weight concrete deck once the bridge was relocated to the Gateway Trail site. To minimize the need to strengthen the primary truss members of the historic structure, the designers decided to use an innovative lightweight concrete deck (110 pcf). This innovation constituted one of the most significant aspects of the new design.

This approach was not a typical MnDOT practice, and it is believed that only one other bridge deck of this type has been constructed in Minnesota. The contractor's initial lightweight mix design did not meet freeze-thaw durability testing requirements, but a revised mix design passed the tests.

Collaboration Produced Another Innovative Solution

Designing the bridge railing for the new site posed yet another significant challenge for the design team: meeting safety concerns while minimizing visual changes to the historic structure.

To meet the challenge, engineers and historians collaborated to devise this solution:

Three horizontal rails from the second bridge site were re-used at the third site. The top re-used rail was set at 54 inches, which is the typical

Portal frame.

Project Participants

Owner: MnDOT (legacy), MnDNR (present)
Designer: HNTB/Olson Nesvold Engineers
Cultural Resource: Mead & Hunt
Contractor: Minnowa Construction
Software: STAAD III and Lusas (analysis)
Cloudworx by Leica (laserscanning data)

height of bicycle railings in Minnesota. The other two rails were evenly spaced below the top rail and the curb, much as they were at the second site.

A stainless steel mesh was placed behind the rails to limit the potential for debris to reach the roadway below the bridge. Above the top rail, stainless steel marine cables were installed on a 6-inch spacing to provide an 84-inch tall railing for equestrian trail users.

The marine cables and stainless steel mesh greatly enhanced the safety of the bridge and, since they imposed very little visual impact on the railing, it retains much the same look that greeted users of the bridge at its second location.

Great Team Produced Great Results

This project enabled Minnesota to sustainably re-use a state asset and preserve a historical segment of the state's infrastructure, for the benefit of residents and visitors. The project faced significant challenges, and it could not have attained success without the hard work, creativity and collaborative spirit of the project engineers and historians. The positive results of their efforts demonstrate the high level of innovation that can be achieved through the collaboration of dedicated experts from different fields.▪

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