Back on the Job

BY JIM TALBOT

Laser scanning sped the rehabilitation and third deployment of this historic iron and steel bridge.

BRIDGE 5721 IN MINNESOTA recently got its third lease on life. After a high-tech diagnostic survey followed by dismantlement and a thorough refurbishing, the structure, which is now officially identified as Bridge 82524, was reassembled in early 2011, then lifted into place in its third location. This is the second time this early metal bridge, originally constructed sometime in the 1870s, has been dismantled and reconstructed in a new location to serve the changing needs of the area.

The original wrought-iron truss bridge originally carried equestrians and those on foot on Main Street over a river in Sauk Centre, Minn. The hometown of writer Sinclair Lewis, Sauk Centre also served as the model for Lewis' satirical 1920 novel *Main Street*. In 1937 the bridge was disassembled and moved north to Koochiching County to carry vehicular traffic on State Road 65 over the Little Fork River near Silverdale. In 2009 it was again dismantled for refurbishment and moved south for reassembly.

In October of 2011, reincarnated as Bridge 82524, it came full circle. Although still known by many as the Silverdale Bridge, the bridge is now owned by the Minnesota Department of Natural Resources and carries horses and riders on the Gateway Trail over Manning Avenue near Stillwater, Minn.

This structure is one of 24 historic bridges designated for long-term preservation by the Minnesota Department of Transportation (MnDOT). In carrying out preservation projects on this set of bridges, engineers must collaborate with historians. The collaboration process is intended to preserve the bridge's "character-defining features" and to conserve as much of the historic fabric of the bridge as possible. However, replacement bridge parts may be used to satisfy safety, performance and practicality concerns, especially for minor features that improve overall life expectancy.

Structurally, Bridge 82524 is a single-span, 162-ft Parker through-truss with pinned connections. Each side of the truss is composed of eight panels, and together they support a 17-ft-

Tim Davis/HNTB

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◄ ▲ Finished Bridge 82524 at its new site on the Gateway Trail near Stillwater, Minn.

▼ Bridge 5721 in its original location, Main Street of Sauk Centre, Minn., circa 1920.

▼ Bridge 5721 at its second location, near Silverdale, Minn., where it remained until 2009.

MnDOT

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wide deck. The Parker truss is characterized by vertical members, diagonals and a "camelback" shape with sloped upper chords. Being a variation of a Pratt truss, the major diagonals on both sides of the bridge slope down toward the center vertical.

Although with the emergence of the U.S. steel industry steel would by the 1890s become the material of choice for metal bridges, the original Sauk Centre bridge was built with wrought iron, which was typical for 1870s bridge construction. Its primary truss components include eyebars and sections built up using riveted angle and plate components. Paired, punched eyebars serve as the major diagonals and bottom chords. All vertical members are double paired-angle sections with V-lacing. V-lacing also graces the top and bottom of the upper chord channels. Top and bottom crossed rods with turnbuckles provide lateral bracing. For the flooring system, built-up wrought iron floor beams support rolled steel stringers. At the Silverdale site a timber plank deck was used. At its new home on the Gateway Trail, a lightweight concrete deck is supported by new steel stringers.

Appearance Counts

Ornamental touches, which are relatively rare, greatly contribute to the aesthetics of this bridge. The overhead bracing members and their plates are perforated with circles and crosses. Overhead sway bracing consists of four angles with X-lacing and knee braces. The sway bracing also contains ornamental plates, each punched with four circles and a cross. Portal bracing is a lattice of angle sections.

Jim Talbot is a freelance technical writer living in Ambler, Pa.

Workers disassemble Bridge 5721 in 2009 at the Silverdale site.

In the spring of 2011 crews reassembled the truss on the ground near its new location, after which it was trucked into position for hoisting into place.

Laser Scanning

Lack of original design drawings creates a challenge for the rehabilitation of any century-old bridge, and predictably no 1870s plans were available for Bridge 5721. To obtain the baseline data needed to evaluate the bridge and engineer its rehabilitation, surveyors for MnDOT scanned the bridge with a Leica laser scanner prior to disassembly. "Laser scanning dramatically cut the amount of field time required to collect geometric data for the rehabilitation project," said Steve Olson, president of Olson & Nesvold Engineers (O.N.E.) "It also permitted the quick collection of a great deal more information than using conventional surveying methods."

The 3D laser scanner collects data by firing a laser 50,000 or more times per second and monitoring the reflections. The equipment can concurrently take associated photographs of structures. To assemble the scan data for the full bridge, MnDOT surveyors set up the scanner in nine different locations prior to disassembly of the structure. After two and a half days of scanning, they used software to stitch together the data to create a registered "point cloud" consisting of 13 million points, each with x, y and z coordinates.

A point cloud is a geometrically correct digital representation of the bridge that can be viewed from any angle. This detailed representation of the bridge can be readily used for engineering work, as well as for historical records.

Olson points out the point cloud models can be viewed using a variety of software. "It is a great tool to have while working on historic bridge or structural rehabilitation projects," Olson said. "You can slice and dice a point cloud model to get just about any bit of geometric information imaginable."

In addition, crews scanned each major truss member as it was removed to provide information on the fastener patterns. Those operations took place on a scanning table before the pieces were loaded onto a truck and moved to the storage site.

Replacement and Rehabilitation

The latest rehabilitation required replacement of only two of the nine floor beams, specifically the beams at each end. "The data from the laser scans data was used to develop detailed drawings which were then used by the fabricator to make the new floor beams that fit the original connections," Olson said. "We also replaced the roller nest bearings with elastomeric bearings."

Today the bridge has a completely new floor system, from the stringers up. "At the Silverdale site, the roads on both ends drained toward the bridge," Olson said. "Drainage through the timber deck caused the paint system on the steel stringers to fail. As a result, all 10 steel stringers added in 1937 and bolted to the top of the floor beam flanges had extensive corrosion and

Portal bracing is a lattice of angle sections.

Overhead sway bracing consists of four angles with X-lacing and knee braces. The sway bracing also contains ornamental plates, each punched with four circles and a cross.

In May 2011 two cranes lifted the truss and set it on its new abutments on the Gateway Trail.

At the bridge's new home on the Gateway Trail, a lightweight concrete deck is supported by new steel stringers.

required replacement. Additionally, a lightweight concrete deck replaces the original timber deck to minimize the dead load."

The use of lightweight concrete for bridge decks in Minnesota is rare. However, a conventional concrete deck would have weighed enough to require that several truss members be strengthened with additional steel components. Because adding components would have altered the look of the bridge members and detracted from their historic character, the lightweight option was selected.

Photos taken in the early 1900s show that the original portals differ from the 2009 configuration. The project historians decided to more closely match the earlier configuration by going back to portals with lower clearance. "Laser scanned data of the fastener patterns of the existing portals helped us to detail replacement portals and return the portal clearance back to 14 ft from 16 ft," Olson said.

The contractor removed the old lead-based paint on the reused components and applied a new four-coat paint system recommended by coatings consultant KTA-Tator, Pittsburgh, and based on the three-part system that is standard for steel bridges. "We were worried about corrosion in the crevices between the lacing and other components," Olson said. "The recommended fourth component is a penetrating sealer installed between the primer and mid-coat."

In the spring of 2011 crews reassembled the truss on the ground near its new location. In May two cranes lifted the truss and set it on its new abutments on the Gateway Trail. Final touches included installing the deck, painting and adding the equestrian railing. And with that kind of preparation, perhaps it can last another 135 years.

Original Owner
Minnesota Department of Transportation

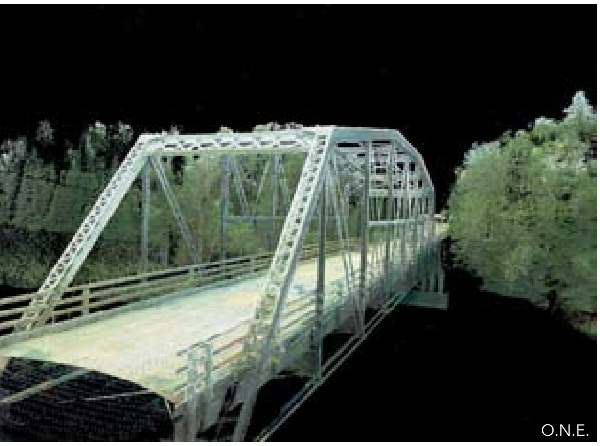
New Owner
Minnesota Department of Natural Resources

Structural Engineers
(Disassembly and Rehabilitation Design)
HNTB, Minneapolis, Minn., and Olson & Nesvold Engineers (O.N.E.), Bloomington, Minn.

Steel Fabricator
White Oak Metals, Dalton, Minn. (NSBA/AISC Member)

General Contractor
Minnowa Construction, Harmony, Minn.

Two and a half days of laser scanning, plus some time to process the data, produced a registered "point cloud" image of the bridge consisting of 13 million points, each with x, y and z coordinates.



A replacement floor beam for each end of the bridge was fabricated using data from the laser scanning process; the roller nest bearings also were replaced with elastomeric bearings.

Final touches included installing the deck, painting, and adding the equestrian railing.

3D Laser Scanning in 2012

Over the last three years the construction market has undergone a complete transformation in the way as-built information is collected. Laser scanning technology has been a driving force behind this change and already has found its way into many projects around the word. Considering how rapidly the premier software providers have adapted to this technology as a data source, especially for BIM-based design software, the expanded use and importance of laser scanning will continue to grow.

Design and construction professionals looking to use this technology should begin their research by looking at the intended application. At this time there is no all-in-one 3D laser scanner, so you must do your research and find the unit that best fits the needs of your company. Below are five points you must address before deciding on a scanner, regardless of your role on the building team.

1. Application – Civil Survey, Build Construction, Exterior, Interior
2. Operation – Internal Survey Crew, Project Managers, Virtulal Design and Construction Department
3. Design Team – Internal Registration, Internal Modeling, Outsourcing All Post-Processing
4. Data Flow – Design Software, Clash Detection, Field Management Software
5. Data Transfer – Cloud, External Hard Drives, Handling Data File Size (1GB plus)

To understand how job-specific project details figure in the selection of particular scanning capabilities, consider the example of an adaptive reuse or renovation construction projects. For AEC personnel working this type of project, creating an accurate model of existing building conditions is critical to understanding the current structure and spatial utilization of a building. Only a few options satisfy those needs while also accommodating the contractor with speed, safety and ease of use. One option would be to use an advanced 3D laser measurement instrument, like the Trimble CX 3D laser scanner, which is designed to help building contractors solve this very problem.

Laser scanning is a very good tool to use in the following applications:

- Capturing existing condition data for accurate adaptive reuse and renovation construction planning and design.
- Comparing the existing structure against the planned design to identify "clashes" prior to construction.
- Verifying the "flatness" of the existing floors to determine if improvements are needed before reuse construction or renovation begins.
- Ensuring pre-fabricated parts will fit in their intended location prior to transportation and installation on the project.
- Creating as-built construction drawings for quality assurance purposes.
- Creating a 3D model of the complete facility for daily operation planning and analysis by building owners.

Total Solutions

Although the companies offering laser scanning technology all support data exchange, to varying degrees, the best solution most often is to use an integrated system. Our firm uses the Trimble line of products. We have found that with the intuitive, streamlined Trimble Access software running on the Trimble Tablet Rugged PC, capturing data with the Trimble CX 3D laser scanner is fast and easy to learn. Data can then be seamlessly transferred to Trimble RealWorks survey software. Once there, the point cloud can easily be manipulated and data exported to the detailing package of choice.

Laser scanning systems are not inexpensive, with a baseline complete package starting at about $60,000. However, our clients have realized significant reductions in the unit cost of data acquisition. With technology that maintains high accuracy over an extended operating range, we capture 54,000 points per second using a typical field setup. A survey that would have taken a full day for a two-person crew just three years ago now can be done by a single person in a matter of hours. It also yields a data package that is greater in quantity by several orders of magnitude, and also virtually error free. The limiting factor today has gone from being data acquisition to data manipulation and use.

—Information provided by Nick Dibitetto, Building Construction Division Manager, Precision Midwest, Warrenville, Ill. MSC

Looking very much like a standard surveying instrument, a laser scanner such as this collects huge amounts of data rapidly and accurately.

Trimble Navigation