SHORT SPAN STEEL BRIDGE ALLIANCE

CASE STUDY

The New Steel

Short Span Shake-Up: Missouri Short Span Bridge Study Finds Steel Saved 25 Percent Over Concrete

By Dr. Michael Gary Barker, University of Wyoming, Professor of Civil and Architectural Engineering
and Dr. Karl Barth, West Virginia University, Professor of Civil and Environmental Engineering

It's a common industry perception that precast bridges are less expensive than short span steel bridges. Like many perceptions, this one is not based on current standards of practice, as proven in the following study. Recently, a bridge consultant in Missouri had the unique opportunity to compare nearly identical short span bridges in his state.

Michael G. Barker, P.E., a professor in the College of Engineering and Applied Sciences at the University of Wyoming, collaborated with Missouri bridge engineering consultant, John Mann, P.E., to perform a true "apples-to-apples" comparison of superstructure costs for steel versus precast concrete in short span applications. The study also included the total construction costs for the project.

"We have one steel beam bridge and one hollow core slab precast concrete bridge that are nearly identical in all aspects," said Barker. "They were both built in 2012 with the same location and topography and with nearly identical roadway length and width, abutments, structural depth and guardrail systems. Even the same local work crew was used to build both bridges."

The results? In a side-by-side comparison of construction square footage costs, the steel short span superstructure provided a 25.8 percent cost savings, with an overall 19.3 percent savings in the total cost of the structure. Here's a look inside the study.

The Basics

Built in 2012, Audrain County Steel Bridge 411 has a 47.5-ft. span and 24-ft. roadway width with 2-ft. structure depth plus slab and no skew. The basic superstructure design consists of four weathering steel stringers fabricated by Oden Enterprises in Wahoo, Neb. The total cost for the project was $111,853 ($97.48 / sq. ft.).

Audrain County Bridge 411

Also built in 2012, Audrain County Concrete Bridge 336 has a span of 50.5-ft. with 24-ft. roadway width and 2-ft. structural depth on a 20 degree skew. It consists of six hollow core precast slab girders. The total cost for the project was $154,035 ($120.83 / sq. ft.). Concrete was selected in this case because the county engineer believed the structure would experience occasional water inundation and assumed that concrete would allow the bridge to reopen to traffic sooner.

In both cases, Audrain County engineers tracked detailed costs for all components of the bridges, from the beginning of design to the end of construction. All superstructure-only costs were tracked separately for the "apples-to-apples" comparison.

Audrain County Bridge 336

Steel

Superstructure Costs		
Material		
Girders	=	$ 21,463
Deck Panels	=	$ 7,999
Reinf Steel	=	$ 3,135
Concrete	=	$ 4,180
Labor	=	$ 5,522
Equipment*	=	$ 500
SUPER TOTAL	=	$42,799
SUPER TOTAL	=	$37.54 / sq. ft.

Concrete

Superstructure Costs		
Material		
Slab Girders	=	$50,765
Deck Panels	=	$0
Reinf Steel	=	$ 724
Concrete	=	$ 965
Labor	=	$ 4,884
Equipment*	=	$ 4,000
SUPER TOTAL	=	$61,338
SUPER TOTAL	=	$50.61 / sq. ft.

25.8 percent savings in total superstructure costs

*County-owned crane (30 ton) used for steel, while a larger rented crane was required for concrete.

(Equivalent county crane cost of $1,520 would result in steel cost of $38.88 / sq. ft.).

When all of the actual costs were tallied, the short span steel bridge superstructure-only construction savings were 25.8 percent in comparison to the precast concrete superstructure. The steel Bridge 411 superstructure cost - including material (girders, deck panels, reinforcing steel and concrete), labor and equipment - came to $37.54 / sq. ft. The precast Bridge 336 superstructure costs - which included material (slab girders, reinforcing steel and concrete for parapet walls and grout), labor and equipment - came to $50.61 / sq. ft.

Mann noted that the lower price per square-foot for the steel bridge was driven by the fact that the steel girders were less than half the price of the slab girders. Crane costs also created some of the savings.

"With the steel bridge construction (Bridge 411), Audrain County was able to use its own 30-ton crane," said Mann. "For precast Bridge 336, the county had to rent a 100-ton crane to handle the heavier load."

Barker added, "Many county engineers forget about the cost of cranes. Steel bridges do not require the heavier equipment needed for heavier concrete bridges. On a small bridge, the cost is significant. The two-day rental and miscellaneous equipment cost was $4,000 for the bridge noted above, compared to $500 for miscellaneous equipment for the steel bridge."

Another advantage to steel is the potential use of simple Geosynthetically Reinforced Soil (GRS) bridge abutments to handle lighter loads. In the comparison above, the county could have saved additional dollars on the project if the abutments had been designed for the lighter steel bridge. GRS abutments are innovative foundation systems available at a lower cost than other conventional foundation materials. The installation process is simple and they can be rapidly constructed - in some situations, in five days or less.

"A short span bridge in the range of 50-ft. is almost always the best value when constructed of steel."

- John Mann

"As a veteran bridge consultant, I believe that engineers who are educated on the cost-effective design of short span steel bridges, with simple and practical details, can realize significant savings with steel," said Mann. "Experienced contractors can typically erect and construct a steel bridge in less time and with lighter equipment for additional savings."

Barker adds, "Details, such as the use of elastomeric bearings, save money because they are easy to install and cost less. Also, there's the advantage of weathering or galvanized steel. I think we'll continue to see wider-spread use of galvanized bridges across the country because you dip them and you're done - providing reduced maintenance and life-cycle costs. County agencies will find that steel bridges are often a better option than concrete. They just need to make the comparison."

According to the Short Span Steel Bridge Alliance (SSSBA), there are many benefits in using steel in the construction of all types of crossings. According to Mike Engestrom, chairman of the SSSBA, steel provides sustainable, accelerated, durable and cost-effective design solutions for engineers, architects, builders, code officials and other construction professionals.

"Studies have shown that prefabricated steel bridges are cost-competitive with other materials when labor, including the use of local crews, and time to install are considered," Engestrom explains. "When ABC (accelerated bridge construction) is preferred, steel provides many options to save both time and money. This information is further validated by comparing the facts and figures of the Audrain County bridges."

Steel Considerations

Audrain County has a long history of selecting steel for bridge construction.

According to Mann, "In our experience, a short span bridge in the range of 50-ft. is almost always the best value when constructed of steel. At 70-ft. or longer, we'll perform a more in-depth analysis to evaluate variables, such as proximity to the precast plant and overall cost. There are some cases where we consider precast hollow core slabs for a super-fast turnaround, but we know we'll have to pay a premium. Overall, I've found that steel is the better buy."

Since 2008, Audrain County has constructed five short span steel bridges with an average length of 53-ft. for an average total project construction cost of $86.09 / sq. ft. In that same time, the county has constructed four concrete bridges with an average length of 37.5-ft. for an average total project cost of $96.32 / sq. ft.

Total Constructed Bridge Cost Comparison

Steel Average Cost of Five Bridges		
Total Cost	=	$ 86.09 / sq. ft.

Concrete Average Cost of Four Bridges		
Total Cost	=	$ 96.32 / sq. ft.

Case Study Video

To view a video that provides additional images and more details about this "apples-to-apples" superstructure comparison, visit the SSSBA website at www.ShortSpanSteelBridges.org.

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Web-Based Tool Delivers Short Span Options

A short span steel bridge, such as Bridge 411 in Audrain County, Mo, could be designed in short order, possibly in minutes, using eSPAN140, a free online design tool. This tool was developed by the SSSBA working in concert with more than 30 companies and organizations from all areas of the steel bridge industry. eSPAN140 (http://www.espan140.com/) is a highly beneficial tool that provides customized steel designs for bridges up to 140-ft.

eSPAN140™

Developed with county engineers in mind, eSPAN140 requires no complex engineering inputs. In just three easy steps, the tool provides a range of available options for standard designs and details of short span steel crossings, including rolled beam and plate girders, modular and truss solutions, buried soil steel bridge structures (corrugated steel pipe and corrugated

structural plate), as well as durability solutions. Industry contacts included in the tool can assist the bridge engineer with budget estimates and pricing information. Using eSPAN140 is simple and quick. A user creates a free account and then inputs project information (location and bridge length), general dimensions (traffic lanes, roadway width, parapet width, etc.), pedestrian access options (number of sidewalks and estimated widths), as well as skew angles, expected daily traffic and design speed. However, a steel short span solution can be completed with as few as three dimensions - length, width and the number of striped traffic lanes. Once data is entered, the design tool instantly produces a customized Steel Solutions Book.
Visit http://www.eSPAN140.com for more information or to get started on a steel bridge design.

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Drs. Barth and Barker are expert consultants to the SSSBA and the directors of the Bridge Technology Center (BTC).
The BTC provides complimentary design support for questions relating to bridge and culvert design.

About the SSSBA

The SSSBA provides essential information to bridge owners and designers on the unique benefits, innovative designs, cost competitiveness and performance related to using steel in short span installations up to 140-ft. in length. SSSBA partners comprise bridge industry leaders, including steel manufacturers, fabricators, designers, fasteners, service centers, coaters, researchers and representatives of related associations and government organizations. For news or information, visit www.ShortSpanSteelBridges.org or follow us on Twitter at www.twitter.com/shortspansteel.

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SHORT SPAN STEEL BRIDGE ALLIANCE

CASE STUDY

NEW TRUSS BRIDGE CONNECTS OKLAHOMA COMMUNITY TO NEW SHOPPING DEVELOPMENT

BRIDGE FACTS

LOCATION:
Oklahoma City, OK

LENGTH: 139 feet

TYPE: Self weathering Viking Style bridge

Vital to increasing customer traffc flow to the Shoppes at Del City near Oklahoma City, OK from a new housing development, this 139 foot long by 24 ft wide self weathering Viking Style bridge was installed by U.S. Bridge in the fall of 2008. In addition to the two lane wide vehicular bridge, a five foot wide sidewalk with wire mesh panels was added to allow for pedestrian flow to and from the mall. Stay in place (SIP) galvanized forms were used for both the roadway and sidewalk to accommodate the final concrete roadway finish. A utility line was incorporated into the design and attached to the underside of the sidewalk portion of the bridge.

Each truss was delivered in three sections and bolted together on site. The bridge was installed over a five day time period

For more information, please contact Mr. Bob Hahn, Director of Sales, U.S. Bridge 1888 872-7434 ext 245.

About the Short Span Steel Bridge Alliance

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American Iron and Steel Institute

The New Steel

CASE STUDY

SOMETHING OLD, SOMETHING NEW
New Bridge Built from Recycled Steel

St. Louis County Bridge
Cherry Township, Minnesota

BRIDGE FACTS

LOCATION:
Cherry Township, MN

OWNER:
St. Louis County, MN

LENGTH: 83 feet

TYPE: Steel beam span/timber deck

At first glance, Bridge 69647 in Cherry Township, Minnesota is a simple 83-foot, steel beam span bridge with a timber deck built to cross the West Two River.

While this bridge typically experiences relatively low traffic volumes, it is an important local connector between the outlying communities. Unfortunately, the old bridge had begun to deteriorate due to weather and regular ice removal (salting) that occurs throughout the long Minnesota winter.

In 2002, the St. Louis County Public Works Department looked to replace the bridge. With many other bridges in the county needing regular maintenance and inspection, county bridge engineers sought a low-cost fix with long-term life cycle benefits. Recycled steel provided the answer.

The engineers opted to re-use 30-year old, 36-inch steel I-beams taken from another bridge that was previously removed from service. In 2003, in-house maintenance crews sandblasted and corrosion-treated the old steel beams, and then used a small crane to build the new bridge on County Road 452.

Jon Stordahl, St. Louis County engineer technician senior (or is he a senior engineer technician?), says, "The nice thing about steel beams is that they are recyclable. Added to this, our county crews built the entire bridge. Crews were able to use a small crane to maneuver the steel beams and other bridge elements into place. The combination of recycled steel and in-house construction saved the county many dollars on this one bridge."

Bridge 69647 is designed to support legal loads over a 70-year or longer life-span.

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CASE STUDY

Steel Bridges Offer Strength in Flood Prone Areas

Bridge 54550 and Bridge 54549
Norman County, Minnesota

BRIDGE FACTS

LOCATION:
Perley and Shelly, MN

OWNER:
Norman County, MN

LENGTH: Bridge 54550: 802-feet long; Bridge 54549: 700-feet long

TYPE: Steel beam span

Located in northwestern Minnesota, Norman County is perhaps best known for its vast production of sugar beets, soybeans and spring wheat among other crops. In fact, of the county's approximate land area of 566,500 acres, about 457,670 acres are used for farmlands that depend on rain and water provided by local rivers such as the Red River of the North, the Wild Rice River and the Marsh River. Norman County is one of the top five agricultural producers (by tonnage) in Minnesota.

During extreme weather events, some of these areas are prone to flooding, particularly along the Red River region. Flooding and weakened soil conditions have taken a toll on bridge foundations in some parts of the county, and, like other parts of the country, many bridges in Norman County have exceeded optimal design life and need to be replaced.

In these cases, the Norman County Highway Department often relies on similar materials used decades before—while incorporating some modern advancements.

Recently, the department looked to replace two bridges that span the Red River of the North. At about 70 years old, the original steel high truss bridges had exceeded their life spans and begun to show deterioration. Norman County contracted Erickson Engineering of Bloomington, MN to design replacement bridges.

The bridge foundations caused significant concern for engineers. The soils in this area are typically soft and the area is prone to flooding. Therefore the new bridges needed to incorporate design elements that minimized the amount of grade raise and also allowed for potential movement, due to the poor soils.

Mick Alm, Norman County Highway Engineer with the Norman County Highway Department, says, "We were concerned about ice jams and debris accumulation during flood events."

Tom Wilson, vice president of Erickson Engineering, says, "The soft soils and occasionally extreme river flows required that we carefully consider pier movement and also minimize the amount of grade raise. In our experience, steel superstructures and substructures offered the best solution for both bridges."

Bridge 54550 near Perley is 802-feet long, with nine spans and a 36-foot roadway width. Bridge 54549 near Shelly was slightly shorter at 700-feet, with only six spans and a 36-foot roadway width.

"Steel beams with steel hinges on the piers were really the only practical alternative," says Wilson. "In partnership with Norman County engineers, we opted to use 36-inch and 40-inch deep rolled steel. The concrete equivalent would have been 54-inches and 63-inches, putting more loads on the existing soils. With the 36-inch and 40-inch rolled steel beams, we had less grade raise."

The old bridges were removed and new bridges constructed over the course of two spring/summer construction seasons.

Norman County's Alm concludes, "Despite harsh winter working conditions, several flood events and occasional rain-outs, the bridges were finished within the prescribed number of working days and within the budget.

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Steel Superstructure

- Less deadload on foundations
- Shallower depth of section to reduce approach grade raise

Steel Substructures encased in concrete

- Hinged steel elements allow for movement in foundations
- Concrete provides protection against flood and debris

American Iron and Steel Institute

The New Steel

SHORT SPAN STEEL BRIDGE ALLIANCE

CASE STUDY

SEVIER RIVER BRIDGE, AXTELL UTAH
Utah DOT Opts for PreFabricated Steel for Bridge Replacement

BRIDGE FACTS

LOCATION:
Axtell, Utah

OWNER:
Utah DOT

LENGTH/WIDTH
75-feet long x 28-feet wide

TYPE:
Prefabricated steel beams with concrete deck

The Sevier River Bridge, located approximately 2.5 miles east of Axtell is a critical thoroughfare for the numerous farmers and ranchers who live in central Utah. It is also structurally and functionally deficient with a sufficiency rating of an abysmal 16.8 per a 2002 inspection by the Utah Department of Transportation. The aging bridge could no longer handle significant loads and, if allowed to deteriorate further, would cause significant travel disruption to nearby communities.

As part of its 2009 Statewide Transportation Improvement Program, the Utah Department of Transportation scheduled the replacement of the Sevier River Bridge – though the Utah DOT planned to do it with a slightly different twist.

Well known for its use of accelerated bridge construction techniques and prefabricated bridge components to speed the construction and repair of the state's aging bridge infrastructure, the Utah DOT opted to replace the Sevier River Bridge with prefabricated steel bridge components.

Tom Christensen, P.E., project engineer with Jones & DeMille Engineering, says, "We specified prefabricated steel on this project for several reasons. One reason was that steel beams are typically shallower than prefabricated, pre-stressed concrete systems, which allowed us to keep a low bridge profile height. The second factor was cost. The prefabricated steel beams were less expensive than comparable prefabricated concrete systems."

Completed in March 2010, the new Sevier Bridge, located approximately 10 feet north of the existing bridge location, is 75 ft long x 28 ft wide steel beam bridge with a concrete deck that sits on piles and caissons. The short span steel bridge was fabricated by Wheeler Bridge, an executive member of the Short Span Steel Bridge Alliance.

The new bridge was designed with 4 longitudinal weathering steel beams. The beams were prefabricated and shipped in pairs. Bolted diaphragms connected the beam pairs after they were set. The concrete deck was cast-in-place and a crash-tested, prefabricated steel railing finished the bridge.

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For more information about prefabricated steel bridges, contact Dan Snyder, manager of business development, Steel Market Development Institute, (202) 452-7100, or email sssba@steel.org.

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About The Steel Market Development Institute (SMDI)
SMDI is a business unit of the American Iron and Steel Institute (AISI), advances the use of steel through market-driven strategies that promote cost-effective solutions in the marketplace. The SMDI focuses on the automotive, construction and container markets, value-added long products, steel recycling, and on new-growth opportunities in non-traditional steel markets. SMDI's Construction Market Council is comprised of nine member companies, including integrated and electric furnace steelmakers: AK Steel Corporation, ArcelorMittal Dofasco, ArcelorMittal USA, Nucor Corporation, Severstal North America Inc., SSAB Americas, Steelscape, Inc., United States Steel Corporation, and USS-POSCO Industries. For more information, visit www.steel.org.

CASE STUDY

New Short Span Steel Bridge Removes In-Water Bridge Piling and Improves Habitat Conditions for Fish and Wildlife

BRIDGE FACTS

LOCATION:
Washington County, Oregon

OWNER:
Washington County Land Use & Transportation (LUT)

LENGTH/WIDTH
75 ft. X 22 ft.

TYPE:
Rolled structural steel girders with a concrete deck

The Meacham Road Bridge crosses the East Fork of Dairy Creek approximately 22 miles west of Portland, Oregon. This bridge is a critical crossing, providing the only access to approximately 68 properties in the county. The bridge project area lies entirely within rural Washington County and is surrounded by farmlands.

Challenge

Originally constructed in 1957, the old bridge was built with longitudinal timber stringers with a transverse timber deck system. It was approximately 20 feet wide by 69 feet long and consisted of four equal spans of approximately 17 feet. The old bridge was damaged several times by large debris collecting on and between the bridge piles within the creek. During flood events, debris accumulated against the three in-stream bents supporting the bridge. The flood debris also caused upstream flooding and at times, made the road impassable.

Solution

A new single-span-bridge was built to replace the old four-span-bridge. The new bridge design has helped to resolve the flood debris problem by allowing it to pass freely underneath.

Steel Market Development Institute

The New Steel

The new bridge is approximately the same size as the existing bridge, but is a single span with no supports in the stream. In addition to reducing flood debris accumulation, the new structure improves habitat conditions for fish and wildlife by restoring natural stream hydrology.

Washington County's Department of Land Use and Transportation was awarded a FEMA Hazard Mitigation Grant through the Oregon Office of Emergency Management to replace the out-of-date bridge.

New Bridge Design

The replacement bridge uses rolled structural steel girders with a concrete deck. The superstructure design is a 75-foot single span consisting of seven W24x131 structural steel girders with an 8-inch-deep deck using high-performance concrete. The roadway width is 22 feet. With two concrete bridge rails, the total deck width is approximately 25 feet. The deck surface is concrete with no asphalt concrete wearing surface.

Dr. Karl Barth, Ph.D., the Jack H. Samples Distinguished Professor at West Virginia University and Director of the Short Span Steel Bridge Alliance's Steel Bridge Technology Center, notes that rolled steel beams are a logical choice for this crossing. "The use of rolled beams was the right choice for this project," he says. "In this particular situation, the girder spacing of the rolled beams was selected to minimize superstructure depth. In return, the hydraulic opening below the bridge was maximized. The horizontal and vertical alignments between the old and the new bridges remain essentially unchanged."

The roadway design criteria are based on the 2004 American Association of State Highway Transportation Officials (AASHTO) reference, *A Policy on Geometric Design of Highways and Streets, with the supplemental Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT<400),* 2001.

The bridge was designed according to the 2010 AASHTO *LRFD* Bridge Design Specifications, 5th Edition. The design loading is HL-93 with an allowance of 25 psf for a future wearing surface. The structure is located in Seismic Zone 2. The site peak ground acceleration is 0.19g for the 500-year (serviceable) return period and 0.27g for the 100-year (no collapse) return period.
The total project estimate, including design and construction, is $882,700; with $662,025 funded by FEMA and $220,675 funded by Washington County's Road Fund (gas tax).

The replacement bridge was completed in the fall of 2012.

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Project Team

- Designer: Peter Pagter (OBEC Consulting Engineers) – 541-683-6090
- Contractor: Jeff Carter Construction, Inc. – 503-589-4676
- Fabricator: Fought & Company, Inc. – 503 639-3141
- Owner: Washington County Land Use & Transportation (LUT) – 503-846-7800