



Historic Bridge Bulletin

From the Director's Desk

Thank you for your interest in the *Historic Bridge Bulletin*. The success of our newsletter is directly related to your participation and we urge you to send us articles about historic bridge rehabilitation techniques, the history or design of particular historic bridges, success stories about funding or community support, or original research in any field related to historic bridges. Please consider writing an article for the *Historic Bridge Bulletin*!

Articles should be sent as attachments to info@historicbridgefoundation.com and be between 500 and 1000 words. At least one photograph or drawing should be included. Articles should be submitted as Microsoft documents and the photographs in JPEG, PNG, or TIFF format and include captions

The *Historic Bridge Bulletin* is published three times a year: March 1, July 1, and November 1. The deadline for articles is one month before publication, thus due dates are February 1, June 1, and November 1 respectively. HBF will still accept submissions after the due dates, but in those cases your article may be assigned to the following issue.

If you have questions regarding any of these requirements, please do not hesitate to contact us at the above email or visit our website (www.historicbridgefoundation.com) for submission requirements. You may also contact me directly at kitty@historicbridgefoundation.com. We will be happy to help.

Kitty Henderson,
Executive Director

In This Issue:

From the Director's Desk

**Marsh Arch Bridges of Kansas:
A Few Colors In The Rainbow**

Big and Awesome Bridges

Crossword Puzzle: Bridge Basics

Case Study: Freedom Bridge

Upcoming Conferences

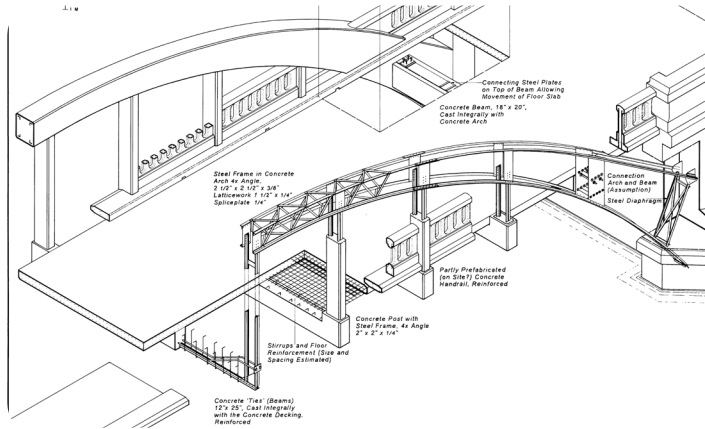


The bridge on historic Route 66 (US-281) over the Canadian River near Bridgeport, Oklahoma is noted for its 38 pony truss spans. *Photo by Nathan Holth.*

Marsh Arch Bridges of Kansas

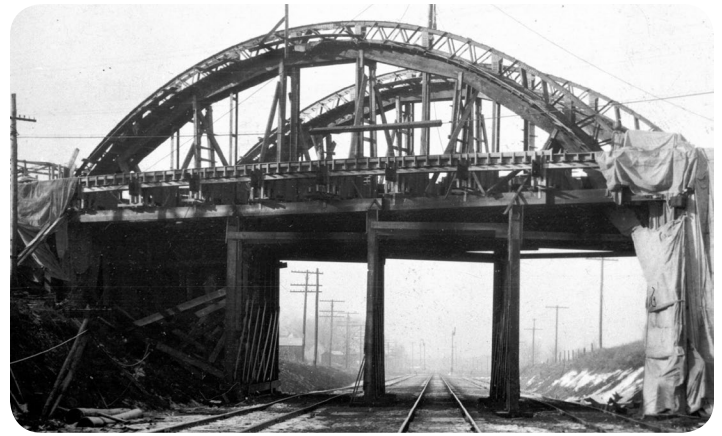
A Few Colors In The Rainbow

By Nathan Holth



Historic American Engineering Record prepared this drawing for the Lake City Bridge in Iowa. It shows the typical form of the reinforcing within Marsh arch bridges.

In the early 20th Century, as engineers experimented with concrete in bridge construction, a new design of bridge was developed. Commonly called a "rainbow arch bridge" the type was in general a concrete through arch bridge. Some of the earliest bridges included one in France by M.A. Considere (1904) and, in 1909, two bridges in North America:



This photo shows the construction of a Marsh arch bridge in Newton, Iowa, after the steel was erected, but before the concrete was poured. Photo Courtesy Historic American Engineering Record.

the Benson Street Bridge by E. A. Gast in Lockland, Ohio and the Middle Road Bridge by Frank Barber in Toronto, Ontario. Around this same time a number of additional examples were built in Europe as well.

In 1912, James B. Marsh, an engineer working out of Des Moines, Iowa patented a concrete through arch design that soon became known as a rainbow arch bridge. A second patent awarded to James Marsh in 1921 represented a further refinement of his design. The name "rainbow arch" is not a new one. The name was referenced in James Marsh's second patent as well as on the bridge plaque for the Soden Grove Bridge. His design of the rainbow arch was notable for its use of an encased skeleton of



Resting on the stone piers of a former iron Post truss, the 1923 Soden Grove Bridge is a tied arch with a plaque noting the bridge to be a 126-foot rainbow arch. Photo by Nathan Holth.



The impressive three span Creamery Bridge in Osawatometie was built in 1930 and rehabilitated in 2013. Its arches are not tied, and extend below the deck into the sides of piers. Photo by Nathan Holth.

riveted built-up steel for the interior reinforcement, as opposed to a system of reinforcing rods (rebar) that is more commonly associated with reinforced concrete construction. Rainbow arch bridges that are associated with Marsh and have this solid steel reinforcement are often subclassified as “Marsh arch bridges.” James Marsh’s company, the Marsh Engineering Company, apparently did well marketing these bridges in the state of Kansas, where even today an impressive collection of Marsh arch bridges survives.

In studying the Marsh arch bridges in Kansas, it quickly becomes apparent that these bridges must be divided into two important subtypes: standard arch and tied arch. Arch bridges typically thrust their forces horizontally into their substructure. As such, the ends of the arch ribs typically end at an angle (skewback) at the pier or abutment, which must be substantial enough to handle the horizontal forces of the arch. A tied arch is different because it introduces a tension-handling bottom chord that runs between the ends of the arch, typically at the deck level of the bridge, and serves to carry these horizontal thrust

forces, preventing them from being thrust into the substructure. This in turn eliminates the need for a skewback design, and instead allows the ends of the superstructure to rest on top of the substructure in the same way that truss and beam bridges bear on a substructure.

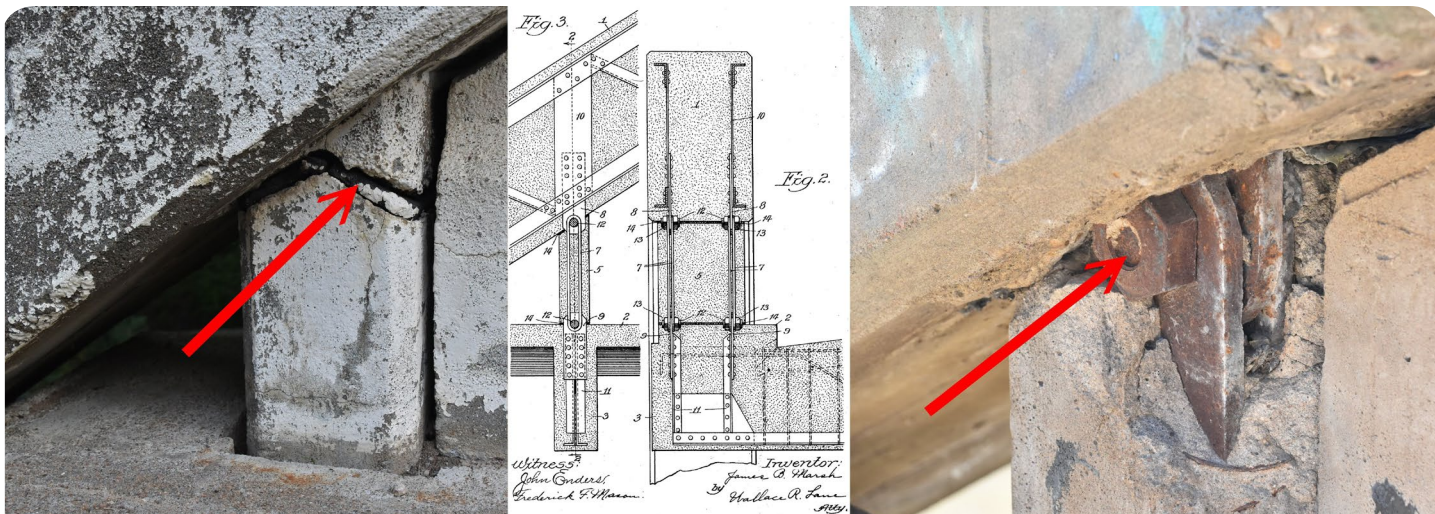


While unfortunate, deterioration can be a valuable learning tool in the field. Shown here are various areas of deterioration on Marsh arch bridges, where riveted steel bars and angles have been exposed, confirming the Marsh type of reinforcement. Photos by Nathan Holth.



With its inset rectangular panels, the tie of the 1927 Bronco Road Bridge in Chautauqua County is clearly visible in this photo. Photo by Nathan Holth.

Examples of both standard and tied arch design can be seen among the surviving Marsh arch bridges in Kansas. Distinguishing between the two types is simple. The standard arch bridges have arch ribs that extend below the deck and meet the walls of the piers or abutments at an angle. The tied arch bridges have arches that end at the deck and rest on top of the piers or abutments. Additionally, the tied arch bridges have a tie running along the edges of the deck,



In the long term, the joint shown in James Marsh's second patent (above center) has proven to be a common area of deterioration on surviving Marsh arch bridges. To the left, a joint with little deterioration is shown. To the right, a much more deteriorated joint lost its concrete encasement revealing the steel hinge within. Photos by Nathan Holth.

architecturally detailed with inset rectangular panels, which is not seen along the deck of the standard arch bridges.

Without detailed study of each bridge, it is not always clear why some of the Marsh arch bridges utilize a tied arch design. However, a tied arch bridge with its eliminated horizontal thrusts would be suited for locations where a less robust substructure

Another interesting detail noted on the Marsh arch bridges in Kansas is at the end hangers (verticals) on the arch. In hangers with little or no deterioration, the original design featuring a little gap in the hanger concrete with an expansion pad present is visible, making it evident that there is an expansion joint on these end hangers, something not found on the interior hangers. On a number of these bridges, however, the concrete around this detail has deteriorated and broken away, revealing that the steel within includes a pin hinge at these locations. James Marsh's second rainbow arch patent awarded in 1921 appears to explain what this detail is. In the patent, Marsh notes that movement of the floor system during temperature changes increases



The National Avenue Bridge in Fort Scott is noted for its impressive 200-foot span. Photo by Nathan Holth.

was desired. Additionally, a tied arch may have helped make it easier reuse substructures from a previous bridge that were not designed to handle the horizontal arch thrusting forces. A good example of this is the Soden Grove Bridge. This tied Marsh arch bridge rests upon the stone pier and abutment of the previous bridge, which was an iron Post truss bridge.



Historic US Route 66 only enters the state of Kansas for a few miles in the southeast corner, but in that short distance it includes this Marsh arch bridge, the only one on the historic highway. Photo by Nathan Holth.



The 1926 Rock Creek Bridge near Meriden is a good example of a small-scale rainbow arch bridge with no overhead bracing. *Photo by Nathan Holth.*

from the center of the span to the ends. He also notes that the long hangers near the center of the bridge are long enough to flex in accordance with these changes. However, he notes concern with the shorter hangers at the ends where he also anticipates greater movement due to temperature changes. His 1921 patent improves upon his original 1912 patent by introducing a joint at each end of these short end hangers to address this movement.

As of 2016, the collection of Marsh arch bridges in Kansas is made up of over 20 bridges. The 1923 Soden Grove Bridge in Emporia is the oldest dated example. The bridge with the longest overall length and also the most spans in a single bridge is the Broadway Bridge in Wichita, with eight spans totaling 800 feet. The longest surviving Marsh arch span in Kansas is also the newest: the 200-foot span of the National Avenue Bridge in Fort Scott was built in 1933.

The only place in North America where a comparably impressive collection of rainbow arch bridges is known to exist is Ontario, Canada. In Ontario, however, the bridges are not associated with James Marsh, nor do they utilize his patented riveted



The province of Ontario has an impressive collection of rainbow arch bridges which are not Marsh arch bridges, two of which are shown here. *Photos by Nathan Holth.*

steel reinforcing design. Rather, these bridges are reinforced with steel rods (rebar). It is interesting to note that in Ontario these bridges are not commonly known as rainbow arch bridges, but are instead called concrete bowstring bridges. As the “bowstring” name suggests, nearly all rainbow arch bridges in Ontario are of the tied arch variety.

Nathan Holth is the editor for the Historic Bridge Bulletin. He also is author of the website HistoricBridges.org. In researching and advocating for the preservation of historic bridges over the past decade, he has photographed thousands of historic bridges across North America.

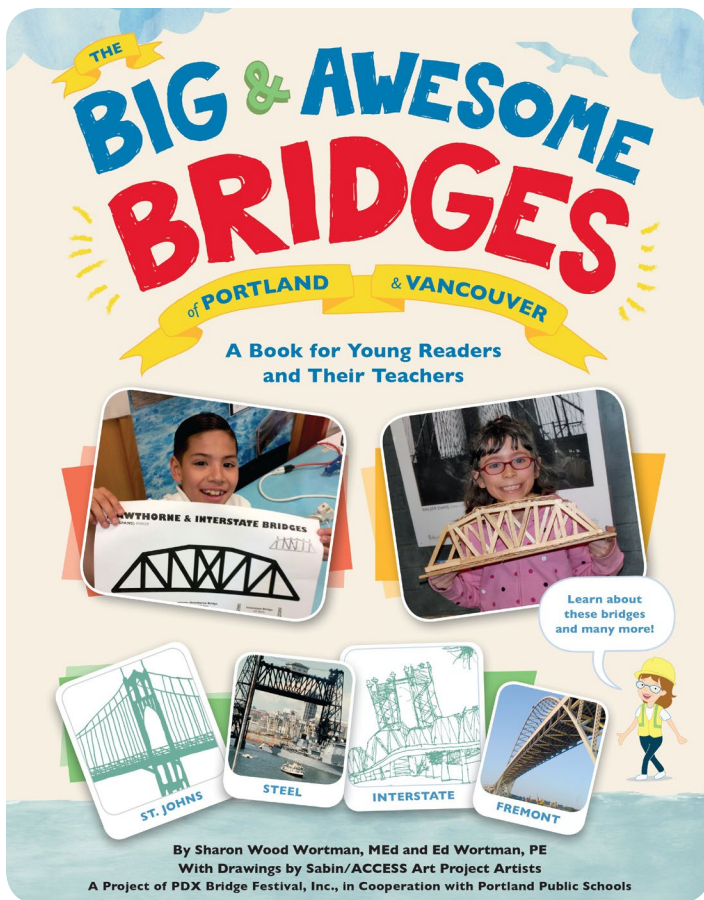
Big and Awesome Bridges

By Sharon Wood Wortman and Ed Wortman

The Portland area is home to each of the three main bridge types (arch, beam/girder/truss, suspension) and the three main movable bridge types (basculer, swing, vertical lift)--among them the longest tied arch bridge in North America, the oldest operating vertical lift bridge in the country (maybe the world), a unique double decker combination railway/roadway bridge, a one-of-a-kind Rall basculer, and a cantilever truss that doesn't look like a typical cantilever. In all, 22 roadway and railway bridges cross the Willamette and Columbia rivers in the Portland area, most of which are legal for walkers and bicyclists to use. In 2015, the collection expanded with the opening of Tilikum Crossing, a cable-stayed bridge designed just for



Notable for its four span configuration, the 1926 Dewlen-Spohnhauer Bridge formerly carried US-160, but today serves only local traffic when US-160 was realigned slightly to the south. *Photo by Nathan Holth.*



Big and Awesome Bridges Book Cover

light rail, walkers, and bicyclists—no motor vehicles allowed! The designers of all these structures include such world-class engineers as today’s David Goodyear, and yesterday’s John Lyle Harrington, Gustav Lindenthal, Ralph Modjeski, David Steinman, Joseph Strauss, and John Alexander Low Waddell.

Portland Public Schools, the largest school district in Oregon, have been teaching about bridges as part of elementary school social studies curriculum since the 1950s. Despite this, there has never been a book on the subject of bridges for students or teachers. Sharon Wood Wortman and her husband Ed, a civil engineer, worked with more than 140 artists and content contributors, and more than 100 funders to design, print and distribute *The Big & Awesome Bridges of Portland & Vancouver — A Book for Young Readers and Their Teachers* for free distribution to local classrooms.

Sharon and Ed had already written books about Portland’s bridges for adults, but wanted to develop a book that would appeal to readers no matter where they lived or what their age. Sharon had written a book about Portland’s bridges, *The Portland Bridge*

Book, published in 1989 by the Oregon Historical Society Press. Together they wrote and updated two more editions of *The Portland Bridge Book*, published in 2001 and in 2006. The 2006 edition includes the engineering drawings created in 2005 when, under the supervision of Eric DeLony, the Historic American Engineering Record did an in-depth study of Portland’s historic truss bridges for the Library of Congress. The 2006 edition of *The Portland Bridge Book* won a silver medal from Independent Publishers. In 2005, Sharon created “Bridge in a Box,” a bridge building and testing kit that comes with seven patterns of local truss bridges, a glue gun, glue sticks, other bridge parts and a glossary of engineering terms.

Sponsored by the nonprofit PDX Bridge Festival, Inc., *Big and Awesome* includes full-color photos and illustrations; detailed facts and to-scale line and elevation drawings of the Portland and Vancouver big-river bridges; interviews with bridge engineers and other experts; students’ bridge poetry and art; math exercises; a glossary; and step-by-step instructions to build and load-test a truss bridge. It also includes an outline of the history of transportation, a chapter on bridge foundations and earthquakes, and even a few bridge games. And throughout the book, a character called The Bridge Lady alerts readers about what to look for when looking at each bridge up close.



Young participants at a free “Build It!” workshop in May 2016 show off their model bridges at the Troutdale Library, in Troutdale, Oregon. Photo by Sharon Wood Wortman.



A sample of the diverse collection of bridges in Portland. Top: Broadway Bridge, Ralph Modjeski's 1913 Rall bascule bridge. Bottom left: St. Johns Bridge, David Steinman's 1931 suspension bridge. Bottom right: Steel Bridge, Waddell and Harrington's 1912 telescoping double-deck vertical lift bridge. Photos by Nathan Holth.

Big and Awesome is a continuation of Ed and Sharon's commitment to educating children about bridges. They started developing a bridge building unit a dozen years ago to get children building and load testing model truss bridges made out of popsicle sticks and tongue depressors using low-temp hot glue guns. Sharon had been teaching week-long "Portland

Bridges" summer classes at the time for the Oregon Museum of Science and Industry and decided to add a hands-on component so students were actually building their own bridges. A friend rounded edges off squares of steel plate, with individual pieces weighing from 2 pounds to 5 pounds. The students were invited to select their own weights to add to the test bucket, and were given a choice of loading their bridges until they could hear wood cracking, or to keep going to "mass destruction." The goal was always to design and build the least amount of bridge that will carry the most load. Finished bridges generally weigh an average of six ounces and some of these young engineers have built trusses that carry more than 100 pounds, without failing!

The book retails for \$50, with a 20% discount offered to all schools and teachers who buy ten books or more. For information on ordering the book, visit <http://www.bigandawesomebridges.org>.



In 2015, Sharon worked with 120 third graders in Hailey, Idaho who built and load tested model bridges. One of the load tests is shown here. Photo by Sharon Wood Wortman.

Sharon and Ed met in 1993 and married in 1998. They have been crossing bridges for 21 years and plan to do so for years to come. Visit them at www.bridgestories.com.

Bridge Basics Crossword

Solution at end of newsletter.

Across

2. One of the two most basic and common truss configurations where diagonal members form a repeating “V” pattern.
7. The bracing at each end of a through truss is called this.
9. This was commonly used to connect truss bridges built in the 19th Century.
11. This term describes the portion of the bridge that traffic travels on.
12. This is the portion of the bridge substructure that is present on some structures and provides support to the superstructure in between the extreme ends of the bridge.
13. The general term for a structure that spans an obstacle.
14. The common name for a Double-Intersection Pratt truss, from the last name of its inventor.
16. A bridge type whose supporting structure is composed of a framework of triangles.
18. The upper and lower portions of a truss web.

20. This type of concrete deck arch bridge has visible vertical columns that rise above the arch to the deck. Two words.
22. This is the portion of the bridge which holds the superstructure of the bridge.
23. This type of bridge features a curved structure that transfers its loads to the ends of the curved structure.
24. A type of truss bridge that has overhead bracing (ie bracing above the roadway).

Down

1. Spans that are built at an angle, meaning their ends are not perpendicular have this.
3. This is the portion of the bridge substructure at the two extreme ends of a bridge that supports a superstructure.
4. This type of movable bridge has one or two leaves that rotate up to open the channel for boats.
5. This type of movable bridge turns on a pivot pier to open the channel for boats.
6. This bridge type has curved cables that extend from towers and are connected to and hold the deck.
8. This type of movable bridge raises directly up over the waterway to clear the channel for boats.
10. This type of metal bridge was common in the 1870s and is sometimes referred to as a truss, arch, or both.
15. A type of truss bridge that has the trusses above and beside the roadway, but no overhead bracing.
17. A substance used in construction that is composed of cement and aggregate.
19. Transverse beams that support the bridge deck. Two words.
21. One of the two most basic and common truss configurations where diagonal members angle toward the center and bottom of bridge.
22. Term for the gap or gaps between supports of a bridge that are connected by the superstructure.

Case Study: Freedom Bridge



Why might it be worth the effort to place into a long-term storage a historic truss bridge that is being replaced? The unique reuse of the Freedom Bridge in Carroll County, Indiana, in 2014 is a great example. This large pin-connected Pennsylvania through truss bridge with a 300-foot span was built in Owen County by the Lafayette Bridge Company in 1898, and was replaced and put into storage in 2001. A plan to reuse the bridge at Conner Prairie Interactive History Park fell through, and many years later a far more unique solution materialized: use the bridge as a pedestrian overpass to carry the Wabash & Erie Canal Association's Monon High Bridge Trail over a new expressway, the Hoosier Heartland Highway. This adaptive reuse has created a unique experience and an iconic landmark for the area. After enduring miles and miles of bland concrete overpasses, drivers are confronted with a spectacular view: this complex and graceful bridge soaring over the highway. Pedestrians crossing over the highway enjoy an equally impressive experience. The tall trusses and extensive bracing soar above and visually overcome the safety fencing that is required for pedestrian overpasses.

Prior to installation over the highway, the bridge was restored with a focus on in-kind restoration to maintain original materials and design. Work included riveting, pack rust removal, heat straightening, as well as selected replacement of some parts. Where parts were replaced, original parts were used as patterns for replication. As evidence of how meticulous the restoration was, original lattice railings were restored in place behind the required modern safety fencing. For the original railing, a few railing panels were missing, and a few more were welded replacements. Both the missing and welded panels were replaced with riveted replicas matching the original panels.

General engineering for the project was by DLZ, with the truss restoration design by J.A. Barker Engineering (now part of VS Engineering). The general contractor for the project was Rieth Riley with the truss restoration subcontracted to Camden Construction.



Upcoming Conferences

2016 Preserve Iowa Summit.

Location: Davenport, IA

Date: September 15-17, 2016

Website: preserveiowasummit.org

Missouri Preservation Conference

Location: Hannibal, MO

Date: October 9-21, 2016

Website: preservemo.wordpress.com/conference/

PastForward, the National Trust for Historic Preservation Conference

Location: Houston, TX

Date: November 15-18, 2016

Website: savingplaces.org/conference

Details: PastForward is the premier educational and networking event for historic preservation professionals, volunteer leaders, and advocates. Expert practitioners lead learning labs and field studies, all designed to provide tools that participants can use to improve their own communities. Preservation Studio offers attendees the chance to explore exhibits, see live demonstrations and watch films. In addition, the live streaming TrustLive engages new audiences as they explore preservation through new lenses.

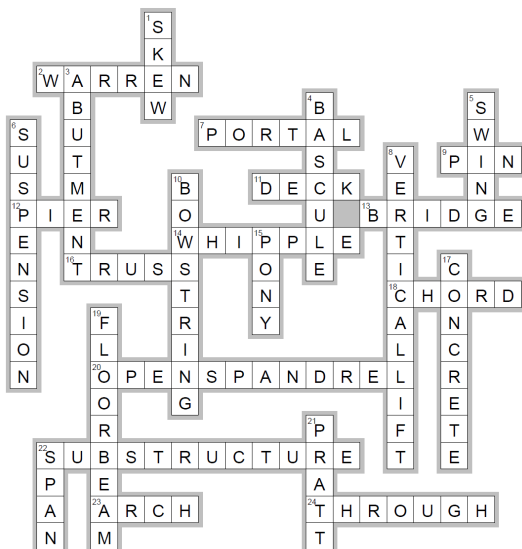


Quincy Memorial Bridge over Mississippi River, Quincy, Illinois. 1928 continuous through truss designed by Joseph Strauss. *Photo by Nathan Holth.*



Half bedstead approach span of 1882 Euritt Bridge in Decatur County, Iowa. *Photo by Nathan Holth.*

Crossword Solution



Built in 1905, the Asylum Bridge in Osawatomie, Kansas features a unique truss design that is difficult to classify. *Photo by Nathan Holth.*