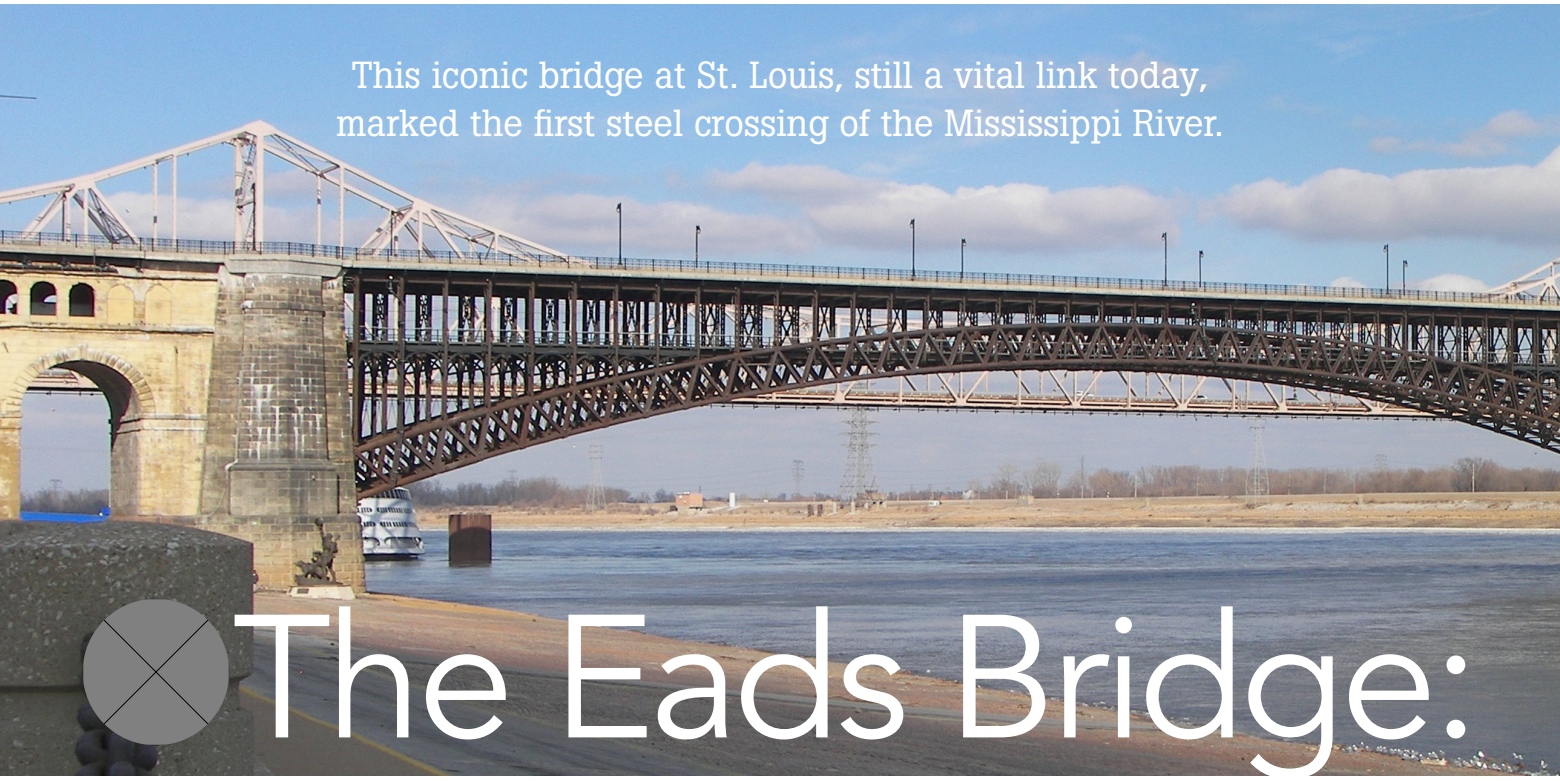

This iconic bridge at St. Louis, still a vital link today, marked the first steel crossing of the Mississippi River.

The Eads Bridge: A Revolution in Bridge Building

BY JIM TALBOT

STEEL CENTURIONS
SPANNING 100 YEARS

Our nation's rich past was built on immovable determination and innovation that found a highly visible expression in the construction of steel bridges. The Steel Centurions series offers a testament to notable accomplishments of prior generations and celebrates the durability and strength of steel by showcasing bridges more than 100 years old that are still in service today.

THE EADS BRIDGE, named for its designer, chief construction engineer, and visionary champion James Buchanan Eads, officially opened on July 4, 1874. Eads, a self-taught engineer, essentially willed the bridge across the river, dealing with financing, legislative obstruction, balking steel companies, and the opposing interests of ferryman, river traffic, and rival Chicago. Along with the famous Gateway Arch nearby, it stands as a primary civic symbol of St. Louis.

The Eads Bridge represents a masterpiece of engineering for its time, notable for the following:

- First major bridge to cross the Mississippi River
- First to make extensive use of steel and span bracing
- First with arch spans of 500 ft
- First to use cantilevered construction, avoiding falsework that would hinder river traffic
- First in the U.S. to use the pneumatic caisson for deep underwater pier construction

The bridge connects St. Louis, on the Missouri side of the river, with East St. Louis, Ill. With its construction, St. Louis hoped to continue its role as the gateway to the west. The burgeoning growth of Chicago to the north jeopardized that role.

This mammoth project greatly advanced the science and art of bridge design and construction. When completed, the bridge was the longest arch bridge in the world with three spans of 502 ft, 520 ft, and 502 ft. Four massive stone piers anchored to bedrock support the spans. The total bridge length with approaches stretches to 6,442 ft. The Eads Bridge provides an 88-ft clearance to the river below.

Wikipedian Kbh3rd

▲ The Eads Bridge across the Mississippi River at St. Louis, 2009.

▼ The Eads Bridge was the first to use cantilevered construction, avoiding falsework in the river.

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Vision Becomes Reality

Pier construction began in 1867, shortly after the Civil War. The west pier was completed with a cofferdam, despite massive difficulties. Workers had to cut through a veritable junkyard of sunken steamboats and debris. For the east pier, Eads switched to a pneumatic caisson, having observed its use on a smaller bridge project while traveling in Europe for health reasons. He greatly improved the design of the caissons and while he was at it, invented the sand pump to remove gravel, sand, and silt from them to expedite progress. The east abutment reached a record 103 ft below mean water level. At these depths and air pressures, caisson disease, which was not well understood at the time, overtook some of the workers, resulting in 14 deaths and more than 100 cases of severe disability.

Once the piers were in place, early in 1871, Eads turned his attention to the steel superstructure. Each of the three arches consists of four tubular ribs—two on each side of the bridge—connected by steel bracing. The tube sections are 18 in. in diameter and 10 ft to 12 ft long. Couplings join the straight tube sections at a slight angle to form the arch. Altogether the bridge has 1,036 tubes, 1,024 main braces, and 112 huge anchor bolts, plus tension rods, nuts and bolts.

Perfecting the Steel Alloy

The contract called for testing of every part with rigid specifications regarding "elastic limits" and "modulus of elasticity," which at the time were unfamiliar terms to the steelmakers and fabricators. Six months went by before they fashioned a single cylindrical tube stave worth testing, of which six were needed to form each arch tube. Eventually a rival steel firm, with the aid of a metallurgist imported from Europe, found an acceptable formula that solved the steel tube problem.

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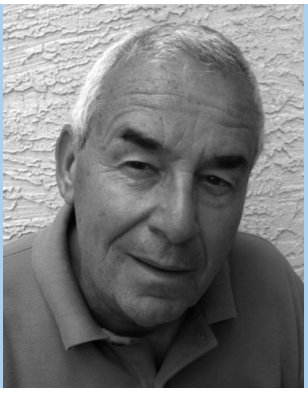

A Mississippi River Man

James Eads is one of history's most interesting engineers. His whole life revolved around the Mississippi River. This self-taught engineer initially made his fortune in salvage, walking the river bottom under a diving bell to find sunken ship cargoes.

Eads designed, built, and financed the iron-clad river gunboats that had devastated Confederate river fortifications and did much to ensure Union victories in the western campaigns of the Civil War. Following that he managed against all odds (with more government hindrance than help) to build the bridge that today bears his name across the Mississippi River.

Eads also fought for legislation and financed the building of narrow jetties at the mouth of the Mississippi to open up commerce on the river. Often the channels through the delta were not deep enough for ships to pass, and many would be stuck for long periods waiting to get in or out. With his jetty design, the river's velocity did the job of scouring and creating depth.

The anchor bolts that secured the iron skewbacks to the piers, most of which were steel, also proved troublesome. Each was 34 ft long and weighed more than 3,000 lb. Initially, the testing machine was breaking 80% of them. Eads would not relax his standards. By mid-summer the steelmakers managed to make bolts that survived testing in sufficient quantities.

Much of 1872 was spent finding ways to create the couplings that would join the arch tubes. Few were surviving the testing machines. Eventually trial and error plus the greasing of palms solved this particular problem. But only half the couplings needed were produced over a two-year period.

Closing the Arches

By the spring of 1873 work began on the cantilevered construction of the arches. That was none too soon, as a loan of a half million dollars from the House of Morgan in London depended on the arches being closed by September 19, 1873.Work crews first erected temporary wooden towers atop the piers. The towers supported "cables" to hold the arch halves and bracing in place as they crept in space towards each other to meet in midstream between piers. The cables themselves consisted of sections of steel bars about 1 in. thick, 6 in. to 7 in. wide, and 27 ft long.

Eads specified the arch tube lengths slightly longer than the actual distance required because the arches would compress once the cables were removed. Originally Eads figured the arches would lap each other by about 2¼ in. But the estimate of the steel's modulus of elasticity proved too low. Later he estimated the arch tubes would lap by 3¼ in.

Eads wasn't worried. He had already devised a solution to close the arches if needed. His idea was to cut duplicates of the final arch tubes in half, take 5 in. off their length, and cut opposing screw threads inside two ends. He would have ready wrought iron plugs with corresponding screw threads on each end. These "extensible links" would close the arches, using the threads to adjust the distances as needed. Steel bands would later cover the exposed threads.

It turned out that this solution was necessary. Unseasonably hot weather offset the action of cable jacking and 60 tons of ice to shorten the final tubes sufficiently. Finally giving up, the crews used Eads' extensible links to close the arches two days ahead of the loan deadline.

When the bridge was finally completed, Eads assembled 14 large locomotives, as many as were available to him, to test the structure ahead of the grand opening. Their tenders filled with coal and water, the locomotives crisscrossed the bridge several times in various configurations. Designed to carry 3,000 lbs per linear ft, the bridge currently can carry 5,000.

The bridge opened to great fanfare on July 4, 1874. In attendance were President Ulysses S. Grant, who had been elected shortly after the pier construction for the bridge began, as well as governors, mayors, legislators, financiers, and more than 150,000 onlookers. A 14-mile parade, a fireworks display, and saluting guns on each side of the river contributed to the festivities.

Adapting to the Times

The bridge has two decks. The original top deck carried horse-driven vehicles and

offered two lanes for pedestrians. The bottom deck originally served passenger and freight railroad traffic. Surprisingly, the railroads boycotted the bridge for more than a year after its opening. They preferred to continue the practice of unloading cargo, ferrying it across the river, and reloading it on the other side.

The year 1974, 100 years after its opening, marked the bridge's last regular train service across the lower deck. In 1991 deterioration and lack of traffic completely closed the bridge. But two years later Metro, the St. Louis region's public transportation agency, made use of the lower deck for its light-rail system MetroLink. And spearheaded by the city and regional TrailNet system, the widened upper deck reopened on July 4, 2003 with four lanes for automobile traffic and a refurbished south lane for walkers, runners, and cyclists.

Metro and the city of St. Louis currently share ownership of the bridge. The city maintains the top deck and Metro takes care of everything else. Reportedly, MetroLink runs roughly 290 trains daily across the bridge. Occasionally the top deck of the Eads Bridge is closed to automobile traffic while it serves as a site for festivals and celebrations. A new nearby bridge over the Mississippi will open in 2014, reducing automobile traffic demand. A design competition underway has the Eads Bridge playing an integral role in renewal of the St. Louis Gateway Arch grounds.

Metro recently acquired funding from the American Reinvestment and Recovery Act of 2009 to completely rehabilitate the bridge. The three-year project includes replacing aging support steel, sand blasting and painting the entire superstructure, and repairing the MetroLink track system. MetroLink will maintain service in both directions on one track while working on the other. The tracks interlock, meaning trains can cross from one to the other.

Now a National Historic Landmark and tourist attraction, this iconic and beautiful 137-year-old bridge continues to arouse the emotions and pride of the St. Louis populace. Additionally it functions as an effective intermodal form of transportation across the Mississippi River. The rehabilitation work under way will preserve this engineering masterpiece for many years to come. It's easy to imagine the Eads Bridge celebrating 200 years of service as a significant connection between America's east and west. Hail to this Steel Centurion. MSC

Missouri History Museum, St. Louis

▲ The Eads Bridge in the 1920s, offering trolley service on the top deck.