CASE STUDY

Merchants Rail Bridge Project in St. Louis Succeeds With Detailed Engineering and Precise Construction Planning

The historic Merchants Bridge in St. Louis has been a vital link for rail traffic since it first opened in 1889. However, by the early 2010s, years of heavy use had caused serious structural degradation, forcing rail authorities to strictly limit crossings. Due to speed and load restrictions, crossings were averaging only 38 trains per day by the time a $222 million bridge replacement project kicked off in 2015.

Awards

- American Railway Engineering and Maintenance-of-Way Association Dr. William W. Hay Award for Excellence
- American Council of Engineering Companies Missouri Grand Conceptor
- Engineering News Record Midwest Regional Best Project
- Railway Track & Structures Top Project
- Supply & Demand Chain Executive Top Supply Chain Projects

1,560
TOTAL LENGTH OF TRUSS SPANS IN FEET

3,245
TOTAL PROJECT LENGTH IN FEET (INCLUDING APPROACH SPANS)

9M
WEIGHT IN LBS. OF EACH STEEL TRUSS SPAN

4
SEISMICALLY RETROFITTED PIERS IN RIVER

$456M
PROJECTED 20-YEAR ECONOMIC IMPACT

Challenge

For more than a century, the Merchants Bridge has stood as a model of great civil and structural engineering for the rail industry. Featuring three main truss spans each measuring 520 feet long, supported by four masonry piers resting on bedrock beneath the Mississippi River, the double-track bridge serves as an important link for east-west commerce moving across America's Heartland.

However, by 2010, decades of constant use had resulted in progressively more serious structural integrity concerns, prompting the Terminal Railroad Association (TRRA) of St. Louis to impose strict operational limitations on the bridge. TRRA — owner of the bridge that serves Amtrak and five Class I railroads — began restricting train speeds to no greater than 20 mph and allowing only one train pulled by a single six-axle locomotive to cross at a time. After it became apparent that the accelerating deterioration was surpassing TRRA's ability to keep pace with maintenance investments, the association decided that rebuilding the bridge was the only way to avoid a total shutdown.

Solution

A comprehensive evaluation of new bridge span options was the first order of business once TRRA brought the design team of TranSystems with Burns & McDonnell as a major subconsultant on board in 2015. A number of design options were considered, including the possibility of shortening some spans and adding support piers within the Mississippi River. Ultimately, the team determined that replacing the original three truss spans with new 520-foot trusses and strengthening the existing piers was the preferred option.

The engineering design incorporated a ballasted deck system replacing the original open-deck, rail-on-tie configuration. Steel pans below the trackage hold the stone ballast, which ranges from 8 to 12 inches deep. The ballasted deck provides a more durable design, extending the service life of the bridge by providing additional support and dampening vibrations caused by today's heavier trains. The new design also helps to keep the tracks at uniform levels on the bridge deck.

In addition to the new ballasted deck design, the track centers on the new bridge deck were widened from 12 to 15 feet, providing more operational flexibility and improved safety.

Strengthening the Piers

Evaluating structural integrity of the existing bridge piers was another key part of the project. The original piers were built during the 1880s as stone masonry structures. They had originally been constructed by lowering caissons to the riverbed, pumping water out of the enclosure and then excavating sediment to allow the caissons to be slowly lowered until they were resting on bedrock. Concrete was then poured into the excavated void, which included additional timber cribbing at the bank piers, until it reached the riverbed level. At this point, pier shafts were constructed with granite and limestone masonry blocks, with rock rubble dumped into the center as fill. Finally, near the top 6 feet, shaft walls became solid masonry blocking to form the pier cap.

The engineering solution developed by the design team was to encase the original masonry piers with a minimum of 3 feet of new concrete surrounding the original pier shaft and cap and approximately 7 feet of concrete at the original footing level. Cofferdams were built around each of the piers to serve as watertight compartments while work proceeded beneath the river level, including installation of steel dowels drilled into the old piers from bottom to top. These elements served to bind and clamp the newly poured concrete to the original masonry.

The engineering study also confirmed scour to streambed conditions, which had been previously mitigated by the U.S. Army Corps of Engineers by dumping large riprap boulders onto the riverbed. The scoured condition further complicated the temporary construction, as no earthen material was available for toe-in of the sheet pile cofferdams. The study determined the old piers did not meet current requirements for Level II or Level III seismic events, or current vessel collision loads as recommended by the American Railway Engineering and Maintenance-of-Way Association (AREMA).

The pier foundations were cleared of the original rocks that had been dumped onto the riverbed so that new micropiles could be constructed around the pier foundations. The micropiles were secured to the bedrock, giving them the required strength to withstand a Level II earthquake or vessel collision.

Tight Construction Windows

TRRA wanted to minimize disruptions to rail and river shipping as much as possible during the three-plus years that construction was in progress. This required the engineers and constructors to develop an intricate schedule of short duration outages while major lifts of new and existing bridge spans were performed.

The plan involved a combination of vertical lifts and lateral slide-in operations. This unique and complex approach required the use of two gantry cranes fitted with strand jacks. One end of each gantry rested on drilled shafts installed for this purpose, while the other end sat on one end of the newly reinforced pier. Once the cranes were in place, old trusses could be lifted, slid over and lowered to waiting barges for removal. Then, new trusses could be safely lifted and slid laterally into place.

The three new truss spans were assembled on barges sitting along the riverbank. Measuring 80 feet tall and 520 feet long, each truss was composed of 14 steel panels made of components that had been fabricated elsewhere before delivery and final assembly on-site. The panels feature a conventional Warren truss diagonal design pattern — a proven configuration that delivers maximum strength for bridges carrying ultra-heavy loads.

Once a truss span was fully assembled and ready for placement, the construction team, led by Walsh Construction, had 10 days to remove the old span and replace it with a new one. The sequence began with a 24-hour river traffic closure. During this nearly round-the-clock operation, empty barges were moved into place in the span between the gantry cranes to receive the existing trusses.

After connecting strand jack cables to the old bridge span, it was lifted off the piers, moved about 59 feet to one side, lowered to barges waiting below and then floated away. Once removal was completed, river traffic could commence while preparations were made to the pier tops and new bearings were set in place. Once those preparations were complete, another 24-hour river closure began, allowing the newly assembled truss to be floated into place, lifted with strand jacks and slid into position atop the piers..

Major Economic Boost

By the time construction commenced in 2017, the load-bearing capacity on the old bridge had significantly declined to levels far below current operating conditions. Upon completion in 2022, the Merchants Bridge load capacity was increased to E80, as needed to accommodate modern train weights, as well as simultaneous operations over both tracks of the bridge.

Within a few months after the bridge was completed, an average of 70 trains were crossing the bridge each day, resulting in a 49% increase in rail tonnage. With no need to reroute a substantial portion of rail traffic to other crossings, the increased rail traffic coming across the new bridge is expected to provide an estimated $456 million boost in economic activity over the next 20 years.

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