THE CHAMP CLARK BRIDGE

BIOGRAPHY

Jeff Smith is a Senior Project Manager and Bridge Section Manager in the St. Louis office of HNTB. He served as the Deputy Design Project Manager through design and Project Manager during construction of the new Champ Clark bridge. He has 28 years of experience encompassing both the design and construction of major bridges. He received his BS in Civil Engineering from Purdue University and his MS in Structural Engineering from the University of Illinois.

SUMMARY

The existing Champ Clark bridge carrying US highway 54 over the Mississippi River at Louisiana, Missouri was completed in 1928. But after 90 years of service, frequent maintenance required to keep the bridge safe and the narrow 20-foot wide roadway drove the decision by the Missouri and Illinois Departments of Transportation to replace the bridge.

The RFP issued by MoDOT and IDOT required the design-build teams to develop a safer, reliable bridge with 405 feet of navigation clearance, requiring minimal maintenance, and providing at least a century of service life. The project was awarded to the Massman Construction-HNTB team in July 2017.

The design-build team won the project by optimizing span lengths, avoiding BNSF railroad right-of-way, and by accelerating construction while minimizing the potential for schedule delays through the use of full depth precast deck panels. The final design features an 1845-foot main unit with four lines of 12 foot deep steel plate girders, including twin 420 foot long navigation and auxiliary channel spans. The 442-foot-long Illinois approach unit consists of prestressed concrete NU girders. The new deck provides two 12-foot lanes with 10-foot shoulders, providing a structure that residents can safely utilize for the next 100 years.
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History

Named after local resident and former speaker of the US House of Representatives, James Beauchamp Clark, the Champ Clark Bridge at Louisiana, Missouri has connected residents of Pike County Missouri and Pike County Illinois for nearly a century. Local businessmen long recognized the need for the structure but it was 1926 when fundraising and planning efforts began in earnest. A brief timeline consists of:

- February 12, 1926 – Louisiana Chamber of Commerce mapped out plan for new bridge. They challenged the Pittsfield Chamber of Commerce to “Bring Illinois paved highways down to the river opposite Louisiana, and we will take the pavement on to the Pacific Ocean.”
- Three days later, Congressman Clarence Cannon had a bill for a charter moving through congress which was signed by President Coolidge on May 5, 1926.
- March 19, 1926, John Harrington of Harrington, Howard, and Ash (a precursor of HNTB) surveyed proposed locations, selected the site and estimated a bridge could be constructed for $1M and would pay for itself within 10 years. 10 days later, field engineers were on site obtaining borings. Field offices were located directly beneath the first span of the bridge.
- October 1926, substructure work was begun by the Missouri Valley Bridge & Iron Company.
- May 1928, the superstructure was completed by the Wisconsin Bridge & Iron Company.

Thus, construction began 7 months after the initial bridge survey and the bridge was completed only 27 months following the beginning of formal planning. The resulting 2278-foot-long bridge features a 1673 foot, 5-span Pennsylvania through-truss unit with a main span of 417 feet and a 6-span, 605-foot plate girder unit for the Illinois approach.

Current Status

Frequent maintenance over the past 20 years has forced closure of the bridge for extended periods of time and at significant inconvenience to local residents. Additionally, the existing bridge only provides 20 feet of clearance for two-way traffic, requiring shut-down and police escorts for wide loads. Passing semi-trucks frequently lose mirrors. In fact, with the new bridge being constructed immediately downstream of the existing bridge, Massman resorted to installing safety netting on existing truss panels to put a stop to falling mirrors endangering their work crews.

Thus it became clear to MoDOT, IDOT and the residents of Louisiana, MO that a new bridge was desperately needed. The resulting RFP issued by the two DOT’s required the design-build teams to develop a safer, reliable bridge with 405 feet of navigation clearance, requiring minimal maintenance, and providing at least a century of service life. Following a 4-month procurement process, the project was awarded to the Massman Construction-HNTB team in July 2017.
Span Arrangement

The Massman-HNTB design-build team provided the best value for the project by optimizing span lengths, avoiding BNSF railroad right-of-way, and by accelerating construction while minimizing the potential for schedule delays through the use of full depth precast deck panels. The biggest factor guaranteeing a low-maintenance 100-year design life was the inclusion of a polyester polymer concrete (PPC) overlay to effectively seal the deck from chlorides and wear, while providing a smooth riding surface over the panels and infill joints.

Given the navigation span requirement, steel plate girders were a natural choice. The final configuration features an 1845-foot main unit with four lines of 12-foot-deep steel plate girders, including twin 420-foot-long navigation and auxiliary channel spans. The 442-foot-long Illinois approach unit consists of prestressed concrete NU girders (see Figure 2). The new deck features two 12-foot lanes with 10-foot shoulders, providing a structure that will meet the long-term needs of local residents, farmers, businesses and through-travelers.

The span arrangement was laid out to expedite construction. The required clear navigation span of 405 feet resulted in the 420-foot main span. In order to eliminate an additional pier in the river, a second 420 span proved cost-effective. Although vertical clearance is less than for the designated channel, this span can serve as an auxiliary navigation span. HNTB and Massman also studied spans over the BNSF tracks running along the Missouri river bank. Here, two prestressed girder spans were an option. However, given the challenges and requirements involved with working on railroad property, the team decided to extend the steel plate girder unit to clear the BNSF right-of-way entirely (see Figure 3). This approach also allowed the entire 2288-foot structure to contain only two expansion joints (with the Illinois abutment being integral), which was part of the team’s approach to addressing MoDOT’s desire to minimize long-term maintenance.

Figure 3 – Steel Erection over BNSF Tracks
Steel Design

Based on previous designs for bridges of similar span lengths, it was evident that 12-foot deep webs would provide an optimal design. From that beginning point, HNTB was able to work with Massman and fabricator, Veritas Steel, to assess tradeoffs between steel weight and fabrication costs to identify the best location to haunch the web down to 10 feet in the first and second spans.

Knowing that MoDOT wanted to absolutely minimize required maintenance over the 100-year design life, the team was sensitive to lateral bracing. Analysis showed that with minimal increases in flange sizes, permanent lateral bracing could be eliminated. This proved cost-effective in terms of fabrication and erection in addition to eliminating the long-term maintenance liability. The erection engineer did determine that temporary bracing was needed at midspan locations during some stages of erection. But this was simply accomplished using small HP sections clamped to the top flanges at strategic locations.

During the spring 2017 procurement, HNTB realized that the upcoming AASHTO LRFD 8th Edition code was re-envisioning how splices need be designed. While previous editions required inclusion of a moment due to eccentricity of the web splice, the new Code would only require, at a minimum, designing for the lesser of the web shear resistances on either side of the splice. Since the code was not published yet, the team consulted with MoDOT as to the legitimacy of this approach. With their approval, HNTB was able to significantly reduce the size of the web splices by approximately 40%.

Due to the length of the spans, additional splices were of course necessary beyond the traditional locations at points of contraflexure. However, during deck placements and prior to being made fully composite, the top flanges at these locations are at capacity. In these cases, web splices are also required to be sized to provide the necessary additional capacity of the section. During the shop drawing process, through contacts with KDOT, HNTB was informed of upcoming, but not yet released errata to the sections of the Code discussed above that revised how the web splice moment forces should be calculated.

Originally, the Code revisions specified that the horizontal force carried by the web bolts should be determined using a force couple between mid-depth of the web and the center of the larger flange, resulting in a horizontal force based on 100% of the web bolts and a moment arm from mid-depth of the flange to mid-depth of the web, approximately D/2. This approach defied statics since there would be an unbalanced horizontal force in the web without a corresponding opposite force in the flange.

Per the Code errata revisions, the force couple is defined between the upper and lower halves of the web bolts. Here the moment arm is slightly less than D/4 for each centroid of the upper and lower bolts, effectively cutting in half the horizontal force on any given web bolt. Fortunately, the only impacted locations were one splice line that required one additional column of bolts and two splice lines that required two additional columns of bolts. As a result of timely internal communication, the changes were able to be made before fabrication began.

Deck Design

The design of the main steel unit also features full-depth precast deck panels. Massman determined that this approach offered the benefits of minimizing labor risks as well as allowing the majority of the deck to be constructed throughout the winter months. After the panels are set, they are made composite with the girders using a self-consolidating concrete (SCC) mix, placed in shear stud pockets and girder haunches. The system does not utilize post-tensioning, but incorporates continuity joints with interlaced U bars between panels (see Figure 4). Once the SCC has reached strength, the continuity joints are filled with a rapid-set concrete mix. Massman devised a form system hung from the joint reinforcing that can be placed from above the deck and can remain in place. Thus, no under-deck access is required, further expediting construction.
Massman elected to place the rapid-set mix in the continuity joints with volumetric mobile mixing trucks driving on the panels. From an analysis perspective, the erected panels produce a pseudo-composite situation with each panel being composite but not continuous until the closures between panels are poured. In this case, web bend-buckling was critical due to minimized top flange sizes. For analysis, the panels were considered as bracing the system but not contributing to composite properties. Ultimately, an integrated sequence of panel setting, haunch concrete placement, and infill concrete placement was devised to ensure no components were overstressed during construction operations. The first span of panels placed is shown in Figure 5.

Once all panels have been set, made composite and infill joints placed, the deck is overlaid with a PPC overlay. The overlay is nominally 3/4” thick, but can be increased to 2” thick as necessary to conform to profile grade. PPC provides a flexible, impervious barrier against chloride intrusion, effectively sealing the underlying structural deck from corrosive attack. In-service cracking is essentially non-existent. With the first PPC overlays that date back to the early 1980’s continuing to perform successfully, it is anticipated that the overlay will not require replacement for 30 years or more.

Substructure

Preliminary geotechnical investigations characterized the bedrock as shale, which would have necessitated the use of polymer slurry to maintain the integrity of the rock sockets during shaft construction. However, HNTB geologists suspected the rock was more appropriately described as calcareous hard shale/limestone and would not degrade in water during the drilling operations. Slake tests were run on retrieved samples to confirm the stability and the use of slurry was able to be waived. Ultimately, elimination of slurry resulted in significant material costs savings and shortened the construction of the shafts by more than 2 weeks. Rock barrel cores retrieved during production of the drilled shafts validated this assessment.

Piers for the steel unit are shown in Figure 6 and consist of dual 11’-6” shafts with 11’-0” rock sockets. 5/8” thick permanent steel casing was also used for construction. Waterline struts between shafts allow both shafts to share in resisting barge impact loads. However, this configuration still did not provide quite enough capacity. To avoid adding components or upsizing elements, the design team expanded the structural model to include multiple piers and to account for the stiffness of the superstructure. This approach demonstrated
that impact loads to any single pier could be partially distributed between adjacent piers, providing sufficient capacity to resist the required loads.

**Figure 6 – River Pier**

Approach piers were originally designed as traditional cap-column-pile footing systems. Following procurement, in the spirit of partnering, MoDOT suggested galvanized pipe pile bents as equivalent pier types. This tactic was appealing to Massman in that it limited below-grade work in the flood-prone overbank. Ultimately, the design utilized 3 and 4 column bents with 4’-0” diameter by 1” thick galvanized pipe piling. Anchorage of the piles to the caps is provided by shear studs welded to the inside of the pipes below the development length of the vertical reinforcing resulting in complete composite action between the piles and the cap (Figure 7).

**Figure 7 – Pipe Pile Studs**

**Roadway Design**

Roadway construction was designed for two phases incorporating a shifted alignment, along with the use of rock embankment to allow for more aggressive but stable side slopes, providing a maintenance of traffic plan to keep US-54 traffic unimpeded throughout bridge, roadway embankment, and paving construction.

Phase 1 roadway improvements centered on the US-54/Route-79 intersection in Louisiana, increasing curb return widths to allow the free movement of large trucks through the intersection and eliminating the need for traffic to wait while trucks navigate their turns. Pedestrian facilities were also added and upgraded to meet ADA standards.

Phase 2 roadway improvements realign US-54 from the Route-79 intersection eastward to just east of the Sny levee in Illinois. 10’ shoulders are provided throughout the improvements to better facilitate the movement of large vehicles and farm machinery.
The existing Illinois approach roadway cuts through a notch in the Sny levee that must be sandbagged during high water events, forcing closure of US-54. The new project raises the grade approximately 8’ above the existing pavement from the bridge eastward over the levee, keeping the roadway above the 500-year flood elevation. The MOT plan utilized a temporary shoofly to allow for reconstruction and fortification of the levee within the existing and proposed roadway footprints. An overall view of the project, facing west, is provided in Figure 8.

![Figure 8 – Aerial View of the Champ Clark Project](image)

Given the significant community interest in the project, the team decided to provide local residents with the opportunity to provide input on the final appearance of a retaining wall along the bluff on the Missouri approach roadway. After Massman selected a block wall supplier, the community was invited to choose amongst four different aesthetic treatments. Roughly 10% of the population participated in the survey, with the rosemary-colored Ledgestone pattern shown in Figure 9 being selected.

![Figure 9 – Retaining Wall](image)

**Conclusion**

The new Champ Clark bridge will provide a safe, reliable crossing of the Mississippi River for residents of both Missouri and Illinois for the next century. The Massman-HNTB design-build team laid out the span arrangement and chose materials to provide value to the two states’ DOTs through minimization of expected maintenance during its design life. In fact, this goal drove the decision-making process throughout construction.

The project is on schedule to be completed and open to the public in the summer of 2019.
Acknowledgements

Owner: Missouri and Illinois Departments of Transportation

Contractor: Massman Construction Company

Fabricator: Veritas Steel

References
