RAPID RECONSTRUCTION OF BNSF BR. 482.1 WEST APPROACH

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BIOGRAPHY

Ashley Cook is a Bridge Engineer for HNTB Corporation in Kansas City, Missouri. Ms. Cook has worked for HNTB since 2010 where she has split her time on highway, rail and movable bridge design. Ms. Cook obtained a B.S. and M.S. degree in civil engineering from Iowa State University and is a licensed professional engineer in the State of Missouri. Ashley is an active member of AREMA Committee 7.

Temple Overman is a Bridge Engineer for HNTB Corporation in Kansas City, Missouri. Ms. Overman has worked in the Railroad & Movable Bridge group since 2012. Her experience includes the design and rehabilitation of bridges, routine bridge inspections, and serving as the resident engineer overseeing reconstruction of the West approach to BNSF Br. 482.1. Ms. Overman holds B.S. and M.S. degrees in civil engineering from the University of Kansas and is a licensed professional engineer in the State of Missouri. Temple is an active member of AREMA Committee 8.

SUMMARY

Reconstruction of the 125-year old BNSF Br. 482.1 West approach near Memphis, Tennessee was completed in 2017. The existing 2,712-ft long approach, designed by George Morison, consisted of two girders supported on steel towers of varying height. Deck plate girder spans ranging in length from 73-ft to 191-ft were used to replace the approach on the existing track alignment. Accelerated bridge construction (ABC) techniques were utilized to changeout the existing approach in four track closure windows ranging in duration from 32 to 52 hours. ABC techniques utilized included lateral slides of three deck plate girder spans ranging in length from 176-ft to 178-ft, a multi-directional slide of a 191-ft deck plate girder span, and the use of strand jacks to lower an existing 339-ft long deck truss span. Success of the project was tied to the close coordination between the owner, contractor, and engineer of record. Br. 482.1 received a Merit Award in the Prize Bridge competition in 2018 under the reconstruction category.

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Introduction

Reconstruction of the west approach to BNSF Br. 482.1 near Memphis, Tennessee was completed in October 2017. HNTB provided design and construction inspection services and Kraemer North America served as the prime contractor to the client BNSF Railway. Accelerated Bridge Construction (ABC) techniques have been used by the rail industry for decades, although the term ABC was not used the entire time. This paper will discuss various steel design aspects of the two-year project that were instrumental to the successful implementation of chosen ABC and erection methods and lessons learned from replacing 2,712 feet of bridge superstructure in four track closure changeouts.

History

The Memphis bridge was the first to cross the lower Mississippi River in 1892 and it remains an important crossing for the BNSF Railway today. George S. Morison, a prominent railroad bridge designer at the time, was the chief engineer for the original bridge design and construction. Construction of the bridge began in 1888 and it was open to traffic in 1892. The original bridge consists of an east approach, the "bridge proper", as it was called by Morison (truss spans that cross the river), and the west approach viaduct. The original piers and towers supporting the west approach were a combination of masonry, concrete and iron towers. The west approach superstructure consisted of 2-girder open deck spans at varying lengths of approximately 29' up to 88' which led up to the final approach span which consisted of a 339' deck truss. Various rehabilitation and strengthening projects have been performed previously, but the West Approach replacement is the first complete replacement performed on this bridge.

Designing for ABC

Various ABC techniques were utilized by HNTB and Kraemer North America in order to replace the approach in four different change-outs. The number of changeouts were selected based on feasible lengths of track closures and construction means during those track closures, which is later described in the construction section of this paper. The use of steel in the design and detailing of the proposed substructure and superstructure facilitated the execution of the ABC methods required.

No work was completed on the existing through truss spans over the river. This required replacement of the west approach to be on the existing alignment. The final replacement span in the approach is supported on the existing river pier, which also supports the through truss. The new superstructure span lengths were determined by spacing the foundation elements between the existing tower bents.

To facilitate the four change-out ABC methods, all proposed cast-in-place piers would need to be constructed while the bridge was still in service. To be able to cast the pier caps below the existing bridge superstructure, the proposed top of pier cap elevations needed to provide clearance below existing low steel. In two of the spans, a deeper girder was utilized than what was required by design, pushing the proposed pier cap elevation lower. The girders, though deeper than required for design, were still efficient and cost-effective due to the use of steel.

All new substructure units were cast-in-place concrete except the abutment. The abutment was designed as a precast concrete cap, backwall and wingwalls that could be fabricated off-site and quickly installed during a changeout. The cap sits on driven steel H-piles that were installed during shorter track closure windows prior to the first changeout. During the changeout, the precast cap was welded onto the H-Piles, and the precast backwall was welded to the cap using embedded steel plates.

Figure 1: Welding of Abutment Cap to H-Piles During the Phase 1 Changeout

With the reconstruction of the approach split into four changeouts, designers had to detail transitions between the phases. This required removing approximately half of the existing span into two to create a jump span and detailing transitions between the existing open deck bridge and the new ballasted deck bridge. This was done through the design of a steel ballast retainer and a steel bolster supporting the existing span on the new pier cap.

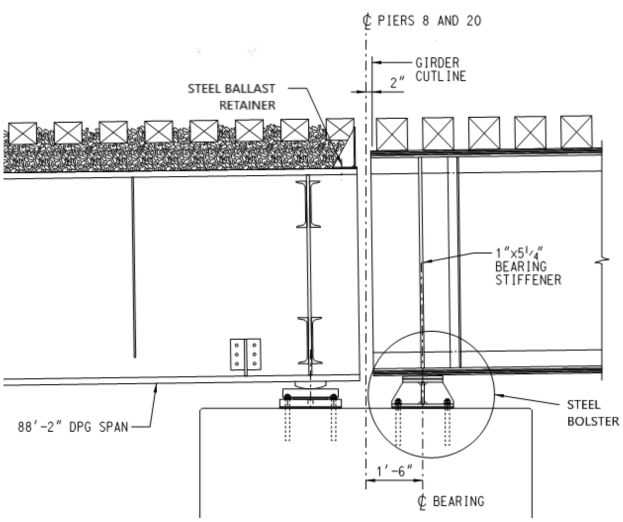

Figure 2: Transition of New DPG Spans to Existing Steel Jump Spans

New spans consisted of steel deck plate girders ranging in length from 72'-6" to 191'. Four longer spans, ranging in length from 176'-6" to 191' were needed to cross over a newly converted pedestrian path, a county road, and to replace the deck truss. The shorter spans had steel deck pans while the longer spans had cast-in-place concrete decks. The shorter spans were detailed in two units which could be fabricated offsite and then shipped in two sections. This reduced the amount of assembly time in the field as the only remaining field work included bolting up center diaphragms between the units, welding a center deck plate, and installing handrail. During the changeouts, the shorter spans were picked into place with a single crane.

A 178'-1" and a 191' deck plate girder span were used to replace the 339' deck truss. Pier 27 had to be carefully detailed as it included a 7' diameter column, an 8' wide x 7' deep pier cap, and falsework to fit through the deck truss. After analyzing the existing span, some lattice members were removed to aid with the construction of the pier. The Pier 27 cap was detailed with an 8.5" step to accommodate the difference in elevations between the two deck plate girder spans.

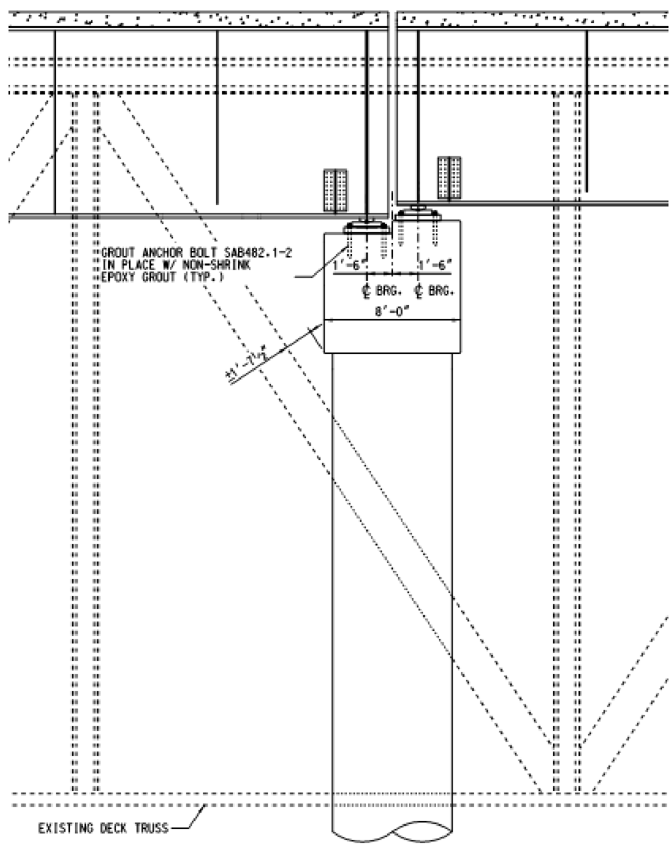

Figure 3: Pier 27 Cast-in-Place Pier Cap and Column Threaded Through Existing Deck Truss

Construction

Four track closure windows ranging in duration from 36 to 52 hours were used to replace the 2,712-ft long approach. Extensive planning and construction took place prior to each changeout which included constructing new substructure elements between the existing steel tower bents, assembling steel spans, and planning out each hour of the changeout to ensure the work would be completed safely in the allotted time. Five pier caps were extended from the contract plans to aid with erecting the long steel spans prior to the changeouts. Steel channels were installed on the pier caps to roll the longer deck plate girder spans into place. This allowed time prior to the changeout to complete diaphragm bolting, pour and cure the cast-in-place deck, and waterproof the deck with little to no impact to rail traffic. If these spans were assembled on the ground, a two-crane pick would have been required to erect the spans. This would have greatly increased the risk that an accident may occur and of missing the time constraints during the changeout window. The existing approach was an open-tie deck, while the replacement approach was a ballasted deck. Final existing spans in the first three changeouts were cut approximately mid-span and then supported on a steel bolster on the new pier cap. Ballast retainers were installed on the last replacement span in each changeout to hold back the ballast from the open tie jump span.

Phase I Changeout

The Phase I changeout took place in November 2016 and replaced 748’ of bridge in 40 hours. Rollers were utilized to transversely roll the two 176’-6” steel spans 17’-6” during the changeout. The project team learned a few valuable lessons while rolling the two long spans in this phase. Lessons learned included ensuring that the top of the capbeam supporting the roll-in channels is completely level and also to install the rollers as close to the changeout window as possible, to prevent any debris from building up inside the rollers. These lessons were transferred to the final changeout, which allowed for the roll-in of the remaining two long deck plate girder spans to move more smoothly.

Figure 4: 176-6” Span Roll-Ins During the Phase I Changeout

Phase II and III Changeouts

The Phase II and III changeouts occurred on February and April 2017, respectively, and each replaced 708’ of bridge in 36 hours. All new spans were 88’-2” in length and were preassembled on the ground prior to the changeouts. The first three changeouts utilized the transition detail and design mentioned in the design section of this paper. The existing bridge was made into a temporary jump span and supported on a steel bolster to transition the new ballast deck bridge to the existing open deck bridge.

Phase IV Changeout

The final changeout occurred in August 2017 and replaced the remaining 548’ of approach. Preparation work prior to the changeout included constructing a pier through the 339’ deck truss, erecting extensive falsework towers to support the strand jacks and the 178’-1” span, erecting 178’-1” and 191’ spans onto extended pier caps, and strengthening the truss in preparation to be lowered.

Falsework towers supported on H-piles were installed in three locations on each side of the deck truss. Each falsework tower supported a 225-ton strand jack. A transverse beam was installed between the three falsework towers to support the truss as it was lowered. Once the falsework towers and new Pier 27 were erected, the 191’ span was erected onto extended pier caps at Pier 26 and Pier 27. A two-crane pick was used to erect two girders at a time prior to the changeout. By doing this, time was saved since the girders could be spliced together on the ground and bracing against the existing bridge was not needed.

Stresses in the some of the deck truss members were reversed from tension to compression during the lowering. Prior to the changeout, these tension members had to be retrofitted in order to withstand the compression loads. The 178’-1” span, which was the final span in the west approach, could not be installed directly to the North of its final position. This was due to the location and size of the existing through truss’s bearings on the river pier. The 178’-1” span was supported on both Pier 27 and a falsework tower, 3’-8” to the West of its final position. During the changeout, the ends and middle sections of the 339’ deck truss were removed prior to lowering the span so they would clear the existing support piers and the new Pier 27, which was constructed through the deck truss. Some sections of the deck truss had thick multiple layers of steel which would re-fuse back together while torching. This greatly lengthened the time for removal of the truss. As soon as the deck truss was lowered below the new girder spans, the 178’-1” span was rolled 23’-8” transversely and 3’-8” longitudinally to align with the existing river through truss, and then the 191’ span was rolled transversely by 23’-5” into alignment. The 178’-1” span, the final span to be replaced in the west approach, had a ballast retainer installed on its East end to transition the ballast deck approach to the through truss open deck. Replacement of the spans in the Phase IV changeout completed the reconstruction of the West approach.

Figure 5: After lowering the 339’ deck truss using strand jacks, crews prepare to roll two steel spans during the Phase IV changeout.

Conclusion

In conclusion, ABC techniques that were detailed during the design included the use of a steel H-Pile supported abutment, steel DPG spans, converting existing spans into a jump span to transition between the phased changeouts, and detailing Pier 27 to fit through the existing deck truss. These details were paired with the contractor’s ABC techniques which included extending five pier caps to aid with erection and assembly of the longer spans, using rollers to move four spans into place, and using strand jacks to lower the deck truss. These techniques were used together to successfully changeout the west approach to BNSF Br. 482.1 in four changeouts with no safety incidents and minimal impact to traffic.