RAPID RECONSTRUCTION OF BNSF BR. 482.1 WEST APPROACH

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INTRODUCTION

Reconstruction of the west approach to BNSF Br. 482.1 near Memphis, Tennessee was completed in October 2017. 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. 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 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' of bridge superstructure in four track closure changeouts.

DESIGN FOR ACCELERATED CONSTRUCTION

Planning for ABC begins in the design phase which requires many discussions between the owner and consultant to determine how long the track can be out of service. Primary factors include how much traffic the line receives and if there are any nearby lines to reroute the traffic.

Drilled Shaft-Micropile Hybrid Foundation

To rapidly replace the west approach and align with the existing river truss, new foundations had to be constructed on the existing alignment and under traffic. A hybrid drilled shaft-micropile foundation was used to reduce the potential movement of the 125-year-old existing timber pile foundations during construction. Drilled shafts ranged from 8' to 10' in diameter and were 55- to 74' in length. Micropiles extended below the shafts for an additional 55' to 80'. Movement of the existing tower bents was closely monitored using survey targets, and no adverse movement was detected during construction.

Designing for ABC

The existing bridge superstructure consisted of open deck plate girder spans and a 339' deck truss. The existing foundations were made up of varying height steel tower bents and masonry piers. The new superstructure span lengths were determined by spacing the foundation elements between the existing tower bents. With the reconstruction of the approach split into four changeouts, designers had to detail transitions between the phases. This required converting existing spans into jump spans and detailing transitions between the existing open deck bridge and the new ballasted deck bridge. 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.

Two steel spans,178'-1" and a 191', 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. The pier cap was prepped with channels that were later used for the bi-lateral span roll-ins.

MASS CONCRETE

All columns and pier caps had dimensions in three directions that were greater than 6’ and were thus considered mass concrete, as described in the project specifications. The first mass concrete pour was the Pier 3 footing. The pour occurred on June 8, 2016 when the max ambient air temperature was approximately 90-degrees Fahrenheit. Cooling tubes, chilled aggregate, and thermal blankets were utilized to ensure the internal concrete temperature and the temperature differential were within the project specifications. In the summer time when ambient air temperatures are high, the controlling factor for thermal control tended to be maximum internal concrete temperature. In contrast, the Pier 27 footing was poured on December 21, 2016 when maximum temperatures ranged between 40- and 50-degrees Fahrenheit. During winter time, the maximum concrete temperature differential controlled. No cooling tubes or chilled aggregate were used during the Pier 27 footing pour, only multiple layers of thermal blankets. The Pier 27 footing was under thermal control for three or four times that of the Pier 3 footing was under thermal control. If a concrete pour is not on the critical path and temperatures can be maintained within the project specifications, less rigorous thermal control measures may be used. However, the decision to use cooling tubes on this project allowed for a much faster progression through the concrete phases of the project.

PHASED CHANGEOUTS

Four track closure windows ranging in duration from 36 to 52 hours were used to replace the approach superstructure. All new steel spans, except for the four long steel spans were erected with one crane during the changeouts. 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 that were used to roll the 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 of missing the time constraints during the changeout window.

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 that would be transferred to the final two spans of the project which allowed those spans to roll in more smoothly.

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 under 36 hours. All new spans were 88’-2” in length and were preassembled on the ground prior to the changeouts. For the first three changeouts, the existing bridge was made into a temporary jump span to transition the new ballast deck bridge to the existing open tie bridge.

Phase IV Changeout

The final changeout occurred in August 2017 and replaced the remaining 548’ of approach. Prep work required prior to the changeout included constructing a pier through a 339’ deck truss, strengthening the truss in preparation to be lowered, erecting extensive falsework towers to support the strand jacks, and erecting 178’ and 191’ spans onto extended pier caps. During the changeout, the ends and middle sections of the 339’ deck truss were removed prior to lowering the span with strand jacks. Some sections of the deck truss had thick multiple layers of steel which would reweld back together. This greatly lengthened the time for removal. As soon as the deck truss was lowered below the new girder spans, the 178’ span was rolled 23’-8” transversely and 3’-8” longitudinally to align with the existing river pier, and then the 191’ span was rolled transversely by 23’-5” into alignment.

Figure 1: Preparing to roll a 176’-6” steel span into final position during the Phase 1 changeout

Figure 2: After lowering the 339’ deck truss using strand jacks. Crews prepare to roll two steel spans during the Phase IV changeout.

SUMMARY

In conclusion, ABC techniques that were detailed during the design included the hybrid drilled shaft micropile foundation, 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 with minimal impact to traffic.