Replacement of the BNSF Approach Spans over the Mississippi River

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ABSTRACT: The BNSF Railroad crosses the Mississippi River at Burlington, Iowa. The original 120-year old bridge consisted of six 250-foot approach spans, one 360-foot swing span and two 80-foot girder spans. This paper will focus on the complex planning, equipment and construction activities required to replace the approach structures in five 36-hour closures.

PROJECT DESCRIPTION

The BNSF Railroad spans the Mississippi River as part of the BNSF's Chicago to Denver corridor connecting Burlington, IA to Gulf Port, IL. The original bridge structure, constructed in 1891, consisted of six 250-foot approach span trusses, one 360-foot swing span truss and two 80-foot approach span girders (see Figure 1).

The original bridge had seen significant strengthening and rehabilitation throughout its life but eventually proved unable to keep up with the capacity of its daily train volume, limited in large part by the bridge's 10 mph speed restriction. The new bridge replaced the existing on the same alignment with new piers offset 90 feet from the existing piers. Due to the value of minimizing time of track closure, the new bridge was installed through a series of five 36-hour track closures. The new bridge structure consists of six 250-foot approach span trusses, one 360-foot vertical lift span truss and two approach span girders spanning 92 feet and 132 feet.

The short track closures required extensive planning, precise execution and careful coordination to ensure success during the closure periods. The techniques utilized to accomplish the accelerated construction included: the construction of new foundations under the existing bridge spans while maintaining full operation of the existing bridge; erecting all six new 250-foot approach span trusses offline from the bridge alignment while constructing the foundations with a casing oscillator and reaction frame; removing the existing girder spans with high capacity barge cranes; rolling and floating in the new approach span trusses; removing each existing approach span truss using barges and floating in the new girder spans in on barges. The focus of this paper will be on the following construction activities:

- Approach Span Truss Erection Offline
- Horizontal Sliding of Approach Span Trusses
- Installation Procedures of Approach Span Trusses as part of five 36-hour track closures
- Demolition of Existing Approach Span Trusses on Barges

Figure 1 – Existing 120 year old bridge structure with 360-foot Swing Span

APPROACH SPAN TRUSS ERECTION OFFLINE

With the first phase of the five 36-hour track closures completed — including the replacement of the existing 360-foot swing span with a vertical lift span — the focus of the project immediately turned to the replacement of the approach span structures and the installation of the new piers.

It was determined that the simplest and most efficient way to accomplish the replacement of the approach span trusses — in the four remaining 36-hour tracks closures — would be to install the new piers while the track remained in service and simultaneously erect the new 250-foot approach span trusses. In total, six approach span trusses were erected remotely from the bridge alignment while the new piers were installed. Approach span truss # 1 was erected at the job location because it spanned the existing abutment and was not accessible to any form of barge float-in installation (see Figure 2). The remaining five trusses, Spans 2-6, were erected offline at a location 13 miles downstream from the job site referred to as “Green Bay” (see Figure 3).

Figure 2 – Approach span truss # 1 erected at job site

Figure 3 – Approach span trusses 2-6 erected on track system at Green Bay location

The offline location, “Green Bay,” was selected for several reasons, including its close proximity and easy access for steel delivery, its location upstream of the next major bridge and outside of the navigation channel, and its minimal elevation change between water and land. The main truss erection activities at “Green Bay” took place behind a levee for both protection and to enable the contractor to assemble the structure as a land based operation. After the steel trusses were assembled, they were rolled or slid outside of the levee protection over the water and loaded onto barges a few days before track closure periods.

The approach span trusses, erected at the job site and at “Green Bay,” were built on similar work platform systems (see Figure 4). The work platforms were comprised of (18) 48” x3/4” support pipe piles with W33 cribbing located under each panel point (24’-6” on center). The support piles were tied together with W36x135 “struts.” The W36 “struts” also supported the work platform walkway surface comprised of W18x46’s spanning the W36 “struts” and wood planking at the deck level. The work platform minimized the need for personal fall protection while assembling the bottom chords, bottom laterals and floor system.

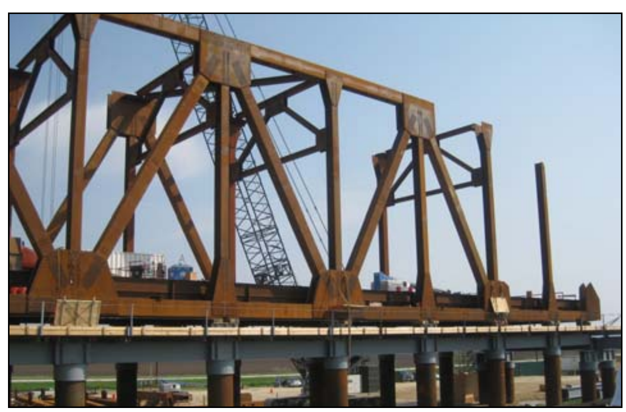

Figure 4 – Work platform used for truss erection

HORZONTAL SLIDING OF TRUSSES

The approach span trusses required horizontal sliding for two reasons: (1) after the trusses had been erected at "Green Bay" they had to be moved from the erection work platform to a position over the water accessible to the barges (2) approach span truss # 1, erected at the job site, required horizontal sliding for final installation during one of the track closures. The horizontal sliding of the trusses was accomplished using a push/pull frame and reaction sled (see Figure 5).

Figure 5 – Push/Pull frame and reaction sled used for horizontal sliding of trusses

The push/pull frame supported the truss at four primary bearing locations using (4) 150-Ton hydraulic jacks at each location. The hydraulic jacks were designed to handle the truss dead load reaction of 850 kips per bearing location plus an additional 150 kips for wind overturning forces. The push/pull system was installed under strengthened jacking points on the floorbeams (see Figure 6 & Figure 7).

The horizontal movement of the truss was accomplished using (2) 100-Ton hydraulic rams with 36-inch strokes. The hydraulic rams, installed on the push/pull frame, push or pull against a stationary reaction sled pinned down to the track beams. As the rams pushed or pulled the reaction sled, the truss and push/pull frame would move along the top of the track beams by rolling on Hillman rollers [(2) 300-Ton rollers provided per bearing location]. The reaction sled delivered the load to the track beams with (2) 3-1/4 inch Diameter 80 ksi pins.

Figure 6 – Push/Pull frame and reaction sled used for horizontal sliding of trusses shown at "Green Bay" location

Figure 7 – Push/Pull frame and reaction sled shown at approach span truss # 1

The track beam system at the "Green Bay" location extended a distance over 300 feet in length (see Figure 2), allowing for multiple trusses to be stored in order to meet schedule. A similar track beam system was installed at approach span truss # 1, with a more modest total length equal to 150 ft.

The track beam system was designed to handle the full 1000 kip roller reaction of the push/pull frame and reaction sled. The track beams consisted of (2) W36x302's with 2"x 32" cover plates top and bottom. The track beams spanned between 2-pile bents (see Figure 8) consisting of (2) W36x260 cap beams and (2) 48"x3/4" pipe pile driven at 1000 kip capacity.

Figure 8 – Typical track beam system pile bent

INSTALLATION PROCEDURES OF NEW APPROACH SPAN TRUSSES

Once the approach span trusses had been erected at the “Green Bay” location and the completed trusses had been rolled or slid into position over the (4) 195-foot by 35-foot by 10-foot deep float-in barges, the trusses were lifted off the track beam system onto the barges with the use of jacking towers. The jacking towers were designed to support the full 3400 kip weight of the new approach span trusses (see Figure 9). The barge draft generated by the weight of the approach span truss was approximately 2’-6”.

At the time of the lift, ballasting had to be performed as a product of the eccentric tower placement on one set of barges. The eccentric tower placement was due to site conditions requiring the new trusses to be installed in between the existing and newly installed piers.

Figure 9 – Approach span truss loaded onto float-in barge jacking towers

The jacking towers used for float-in (comprised of heavy W36’s framing) were used to support (2) W36x302 “lifting beams” in direct contact with the lifted truss (see Figure 10 and Figure 11). The “lifting beams” spanning between the towers were supported at each end by (4) 2-1/4” Gr. 150 threaded rod which could raise the truss through a range of approximately 20 feet.

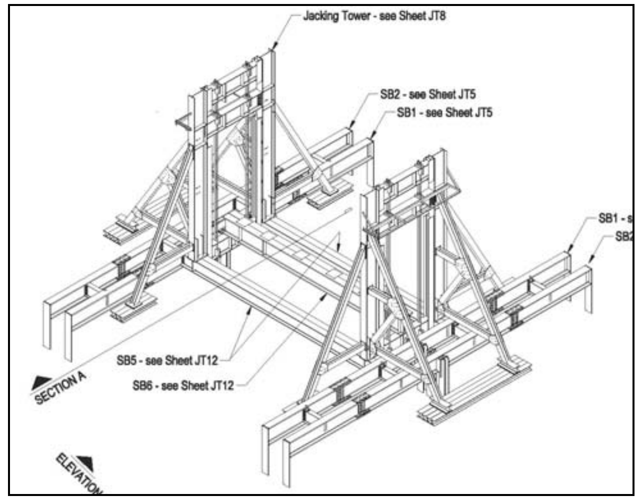

Figure 10 – Isometric view of jacking tower for truss float-in

Figure 11 – Side view of jacking tower and “lifting beam” used for truss float-in

The support of the jacking towers (for all but one barge pair) was provided by a spine beam system that also linked together the dual 35-foot by 195-foot by 10-foot barges. The spine beams consisted of double W36x300's and W40x431's straddling the barge deck and secured to the barges with reinforcing plates welded to the sides of the barges. The one exception to the float-in tower being supported on the spine beams arose because after field testing, two barges were determined to have only a minimal wall thickness of 5/16". The load for this barge pair had to therefore be distributed to a larger area on the barge deck using sandboxes (see Figure 12). Where possible, the sandbox detail is a more effective and preferable detail to get the load to the barge deck. However, this is only the case if the barges are loaded symmetrically. For this particular project, the sand box detail would not work to support each tower configuration because of the unsymmetrical tower placement on the barges required to accommodate interference issues with the existing and new piers.

Figure 12 – Sandboxes support method on barges

The final challenge faced with the float-in installation of the approach span trusses was positioning the dual 35-foot by 195-foot linked barges into final alignment without the use of spuds. The alignment method used, after the tugs positioned the barges within 2-3 feet of the final bridge alignment, was to use come-a-longs to fine tune the final position of the truss (see Figure 13 & Figure 14).

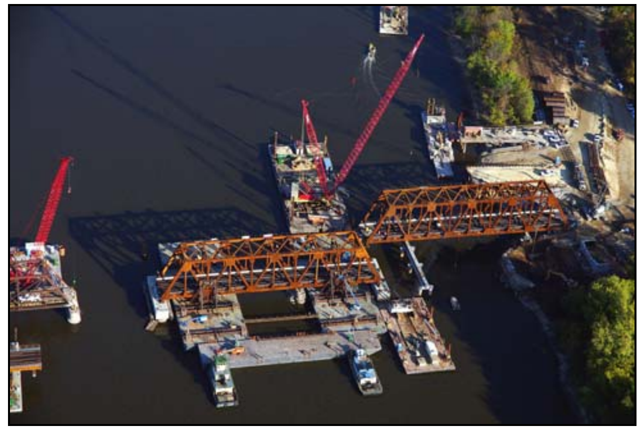

Figure 13 – Tugs positioning truss near final bridge alignment

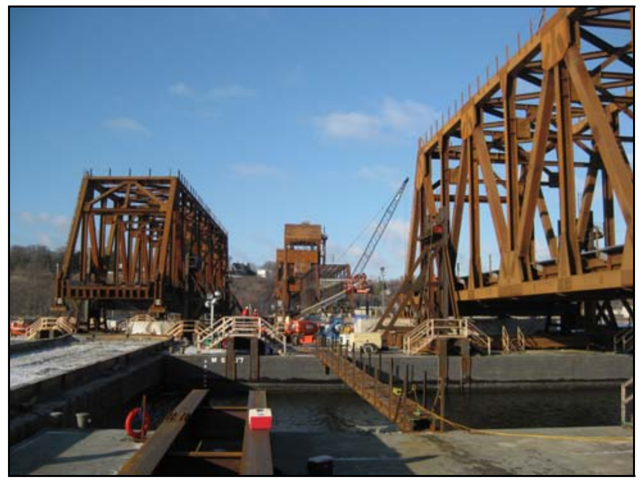

Figure 14 – Alignment of truss fine tuned once barges released by tugs

DEMOLITION OF EXISTING APPROACH SPAN TRUSSES

Each of the five 250-foot existing approach span trusses were floated out during track closures in sequence with the new approach span truss float-ins. The existing approach span trusses were efficient Morrison trusses with true tension members installed where tension members were needed (see Figure 15). That design philosophy presented a problem when attempting to pick the truss at panel point L1 where there was no compression capacity in the vertical hanger (Figure 16).

Figure 15 – Existing approach span truss

Figure 16 – Vertical hanger at panel point 1

The solution was to span to panel points L0 and L2 using the existing bottom chord in combination with a newly installed W24 underslung beam (see Figure 17).

Floating out the existing trusses did not have the luxury of a jacking tower with a 20-foot range similar to the float-in towers. The float out barge configuration relied rather on predicting/monitoring river gages using NOAA stations and communicating with the dam upstream throughout the four seasons of change outs.

The float out barge towers had to be able to be adjusted plus or minus 1-foot within one day's notice (see Figure 17). Two to three days prior to each float-out the barge towers were built to heights that would accommodate the anticipated river gage. A day prior to track closures, the barges were aligned with the existing bottom chord and the newly installed underslung beam (see Figure 18). The barge was secured to the existing bridge and was held at that position until the beginning of the track closure. Once track clearance was given, and the existing approach span truss was cut free, water was removed from the barges using 6-inch trash pumps until the load of the truss was fully taken by the barges and the truss was lifted off the pier 2-3 inches. Tugs then removed the barges from the bridge alignment (see Figure 19).

Figure 17 – Bottom chord and W24 underslung beam used to deliver load around vertical hanger designed for tension

Figure 18 – Barge aligned with existing truss in preparation for track closure

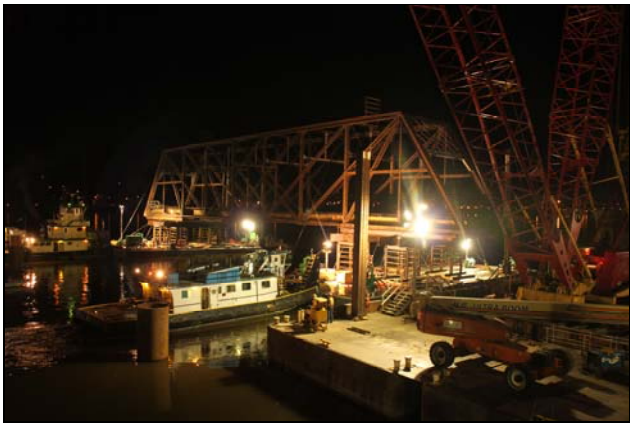

Figure 19 – Barges have truss. Tugs moving outside of bridge alignment.

Once the existing approach span trusses were moved offline, they were taken across the river to be demolished and scrapped. The demolition took place on barges, and while the existing truss removal was achieved with two 55-foot by 120-foot barges, the demolition required a third barge be installed in order to control the relief of stresses as the truss was being deconstructed (see Figure 20 & Figure 21).

Figure 20 – Existing approach span truss with portion of top chord and diagonal removed

Figure 21 – View of third barge and additional tower support provided during demolition

FINAL NOTES

The installation of the approach structures for the BNSF Railroad crossing of the Mississippi near Burlington Iowa was completed March of 2012. One can only hope that the newly erected approach spans live as long and productive of a life as their Morrison style truss predecessors.

The construction items not included in this paper: constructing the foundations with oscillator frame while existing structure remained in use; removing the existing girder spans with high capacity barge cranes and floating the new girder spans in on barges presented their own unique set of challenges that could be considered for their own technical paper.

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