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 accelerated construction techniques required to replace the approach structures in five 36-hour closures.

INTRODUCTION

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, constructed in 1891, consisted of six 250-foot approach span trusses, one 360-foot swing span truss and two 80-foot approach span girders.

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.

Due to the value of minimizing time of track closure, the new bridge was installed through a series of five accelerated 36-hour track closures. The new bridge replaces the existing on the same alignment with new piers offset 90 feet from the existing piers and 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 closures required extensive planning, precise execution and careful coordination to ensure success during the closure periods. The Accelerated Bridge Construction (ABC) techniques utilized for the project included: construction of new foundations under the existing bridge spans while maintaining full operation of the existing bridge; erection of all six new 250-foot approach span trusses offline from the bridge alignment removal of the existing girder spans with high capacity barge cranes; rolling and floating in of the new approach span trusses; removal of each existing approach truss span 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

APPROACH SPAN TRUSS ERECTION OFFLINE

Once the first phase of the bridge replacement was complete (removal of the existing 360-foot swing span with the installation of 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 would be to install the new piers while the track remained in service while simultaneously erecting 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 adjacent to the job location (See **Error! Reference source not found.**) and the remaining five trusses were erected offline at a location 13 miles downstream from the job site (See **Error! Reference source not found.**).

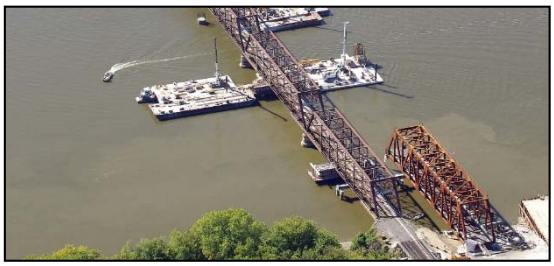

Figure 1- Approach Span Truss # 1 erected at job site

Figure 2 - Approach Span Trusses 2-6 erected 13-miles downstream

The drilled shafts of the new bridge piers were located outside of the existing bridge footprint to allow construction of the new foundations to occur while the existing structures remained open to live traffic (See Figure 3). Due to the required length of the drilled shafts--approximately 200-ft--the 12-ft diameter shaft sockets were placed with oscillators. In a continued effort to construct the foundations without disturbing live traffic, a floating cap beam form was utilized for the installation of the new pier cap (See Figure 4).

Figure 3 - Drilled Shafts installed with oscillator outside of existing bridge footprint

Figure 4 - New pier cap installed with floating formwork

The offline location was selected for its easy access for steel delivery, its location upstream of the next major bridge and because it was outside of the navigation channel. The main truss erection activities 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 over the levee protection and loaded onto barges a few days before track closure periods.

All the approach span trusses were erected on work platform systems comprised of 48”x3/4” support pipe piles and steel beam framing (See Figure 5). The work platform minimized the need for personal fall protection while assembling the bottom chords, bottom laterals and floor system.

Figure 5 - Work platform used for truss erection

HORIZONTAL SLIDING OF TRUSSES

The horizontal sliding of the trusses was accomplished using a push/pull frame and reaction sled (See Figure 6 and Figure 7).

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 support 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.

The horizontal movement of the truss was accomplished using (4) 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 (8) 300-Ton Hillman rollers. The reaction sled delivered the load to the track beams with 3-1/4 inch diameter pins.

Figure 6 - Push/Pull frame and reaction sled used for horizontal sliding of trusses shown at offline location

Figure 7 - Push/Pull frame and reaction sled used for horizontal sliding of trusses shown at job site

INSTALLATION PROCEDURES OF NEW APPROACH SPAN TRUSSES

Installation Overview

The trusses erected 13-miles downstream were lifted off the track beam system onto the barges with the use of jacking towers (See Figure 8). The jacking towers were designed to support the full 3400 kip weight of the new approach span trusses. The barge draft generated by the weight of the approach span truss was approximately 2'-6".

The jacking towers used for float-in (comprised of heavy W36 framing) supported (2) W36x302 "lifting beams" that would be in direct contact with the lifted truss. The "lifting beams" spanning between the towers were supported at each end by (4) 2-1/4" Gr. 150 threaded rod which could raise or lower the truss through a range of approximately 20 feet.

The support of the jacking towers (for all but one barge pair) was provided by a spine beam system that also was used to link the two 35-foot by 195-foot by 10-foot float-in barges. The spine beams consisted of double W36's and W40's straddling the barge deck and secured to the barges with reinforcing plates welded to the sides of the barges.

The support of the jacking towers on one pair of trusses utilized a “sand box” to distribute the load to a larger area on the barge deck (See Figure 9).

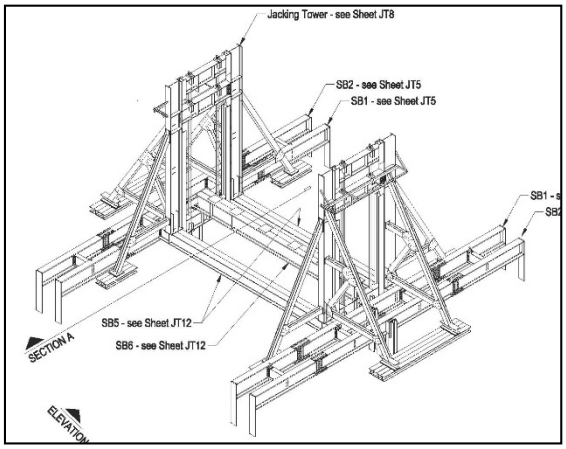

Figure 8 - Isometric view of jacking tower used for truss float-in


Figure 9 - Sandbox support method on barges

Sample 36-Hour Closure Installation Timeline

Closure Objectives:

- Float-out removal of two existing approaches trusses
- Demolition of upper portion of two existing substructures where there was interference with installation of the new approach trusses
- Float-in installation of two new approach trusses
- Installation of one temporary jump span to bridge gap between new superstructure and existing superstructure that had not yet been removed

Preparation Prior to Closure:

- Months Prior to Closure
  - Two new approach trusses erected at offsite location on sliding track
  - Two existing trusses reinforced in preparation for removal
  - New piers installed while existing structure remained under live traffic
- Days Prior to Closure
  - New approach trusses loaded onto float-in barges and moved to bridge site
  - Float-out barges moved into positon and aligned with existing approach trusses. Position of float-out barges secured awaiting official closure of track.

36-hr Closure Timeline:

- 0 to 12-hrs
  - BNSF Railway Company officially closed rail traffic
  - Two existing trusses removed using float-out barges (See Demolition of Existing Approach Span Trusses section for details). Existing approach trusses temporarily stored away from bridge alignment.
- 12-hrs to 24-hrs
  - Portions of existing substructures interfering with two new approach trusses demolished
- 24-hrs to 36-hrs
  - Two new approach trusses installed using float-in barges
  - New ballasting and rail installation completed

Following 36-hr closure:

- Float-in barges prepped for next closure
    - Upstream float-in towers removed and float-in barges removed out from under newly installed approach spans
    - Float-in barges moved back to offsite bridge erection location.
- Existing truss demolition
    - Two existing approach trusses moved to offsite location to be surgically disassembled while on barges. (See Demolition of Existing Approach Span Trusses section for details).

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 very efficient Morrison designed trusses with true tension only members installed where tension members were needed.

This efficient existing design philosophy presented a challenge when attempting to pick the truss at panel points where there were eye-bar type vertical hangers. 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.

Floating out the existing trusses did not have the luxury of a jacking tower with a 20-foot self-adjusting range in height similar to the float-in towers. The float out barge configuration relied on the "old-school" method of 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. 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 and were secured to the existing bridge and held at that position until the beginning of the track closure (See Figure 10). 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 11).

Figure 10 - Barge under existing truss prior to track closure

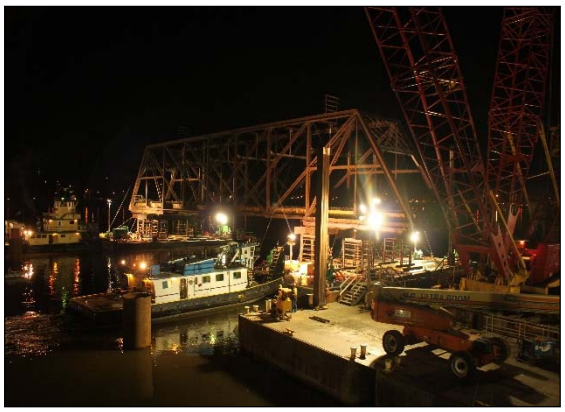

Figure 11 - Barges move trusses out from bridge alignment

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 12).

Figure 12 - Existing approach span truss with portion of top chord and diagonal removed

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 designed predecessors.

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