LAUNCHING THREE TRUSSES OVER THE BNSF NORTHTOWN RAIL YARD

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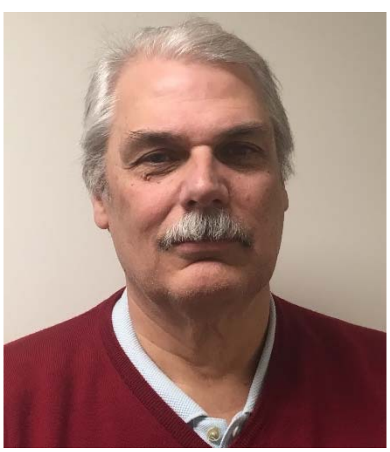

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BIOGRAPHY

Martin Furrer is the leader of Parsons complex bridge group in Chicago and was the Engineer of Record for the steel truss of the St. Anthony Parkway Bridge project. He has 23 years of experience in the management, design, and construction of complex bridges including 20 bridges over major waterways. Mr. Furrer was the Engineer of Record for America's longest freestanding arch bridge in Hastings, MN and is leading the owner's bridge team for the new 850m span over the Detroit River. He received his MS in Structural Engineering from the Swiss Federal Institute of Technology, Zurich.

Greg Hasbrouck is a Supervising Bridge Engineer with Parsons in Chicago and was the Truss Bridge Design Lead for the steel truss segment of the St. Anthony Parkway Bridge project. He has over 14 years of complex bridge experience including the Hastings Tied Arch Bridge and the Christopher S. Bond Cable-Stayed Bridge over the Missouri River in Kansas City, MO. Mr. Hasbrouck received his MS in Structural Engineering from Princeton University and his BS in Civil Engineering from Duke University.

Jack Yuzna has worked in the Civil Engineering field for 39 years, the last 12 as the City of Minneapolis Bridge Engineer. He is a graduate of the University of Minnesota with Bachelor Civil Engineering Degree. Along with programming and delivery of bridge projects, his work experience includes project management of parking ramps, public buildings and roadway projects.

SUMMARY

The St. Anthony Parkway is a historic parkway in Minneapolis, Minnesota that crosses over the busy BNSF Northtown rail yard with five deteriorating Warren trusses needing replacement. The inline replacement structure consists of a skewed 305 foot uncoated weathering steel truss and two-span steel girder structure to meet the railroad's desire to eliminate two piers in their yard. The new truss incorporates unique load path and internal redundancy measures including eliminating fracture critical steel truss members and gusset plates and using a post-tensioned concrete bottom chord to minimize the life cycle cost for the crossing.

BNSF operations and the commuter rail schedule only allowed four-hour track closures for the mainline tracks. The removal of the two existing truss spans over BNSF's mainline tracks and the installation of the new truss span using accelerated bridge construction was studied and suggested in the contract documents. The contractor utilized a launching system to slide the existing trusses from their position over the tracks to the western approach embankment, dismantle them, assemble the new truss and slide it over the tracks using the same girder based launching system.

Launching Three Trusses over the BNSF Northtown Rail Yard

Introduction

The St. Anthony Parkway over Northtown Yard Bridge replacement project is located in Minneapolis, Minnesota, USA. The existing bridge to be replaced was a 535-foot, five-span steel Warren truss built in 1925 that crossed over 23 railroad tracks within the BNSF Railway's Northtown rail yard. It was owned by BNSF and maintained by the City of Minneapolis and the Railroad, and carried both vehicular and non-vehicular pedestrian traffic. The existing steel truss span structures were both structurally and geometrically deficient, containing fracture critical members as well as narrow travel lanes and substandard vertical clearances.

In 2013 Parsons was selected as a subconsultant by the City of Minneapolis to provide preliminary and final design services for replacement of the existing St. Anthony Parkway truss bridge. Parsons' final design of the main span of the new three span replacement structure consists of a 305-foot redundant steel truss structure, incorporating unique load path and internal redundancy measures including eliminating fracture critical steel truss members and gusset plates and using a post tensioned concrete bottom chord. The approach spans consist of conventional steel girders and all three spans incorporate a full-depth cast-in-place concrete deck that is formed with stay-in-place metal deck forms in order to improve safety and minimize construction impacts to the rail yard below.

The removal of the existing truss spans and the installation of the new truss were achieved utilizing specialized construction techniques including the use of launching beams in order to minimize impacts to BNSF's heavily used rail yard. The replacement steel truss was assembled on the approach roadway and launched into final position.

Location

The St. Anthony Parkway Bridge is in northeast Minneapolis's industrial area and crosses over the BNSF's Northtown rail yard. The Northtown Yard is one of the most heavily-used railyards in the Midwest. The Northtown Yard is 3.5 miles long (extending from I-694 at the north to State Trunk Highway 47 at the south) with the bridge crossing located at the southern end of the yard. The yard is an active switching railyard where trains and railcars are sorted. Approximately 20 to 25 percent of all BNSF rail traffic in the United States passes through this yard. BNSF assembles an average of 14 trains of 100 or more cars each day. In addition, 60 or more trains operate daily on two main line tracks adjacent to Northtown Yard. Daily main line traffic includes transcontinental passenger rail and commuter trains. At the crossing location, the bridge spans 23 tracks consisting of 2 mainline; 17 yard; 2 industry; and a pair of runner & receiver yard tracks. The yard also includes several maintenance roads within the yard tracks.

St. Anthony Parkway is on the "Grand Rounds Scenic Byway System" (the Grand Rounds) in Minneapolis. The Grand Rounds has been recognized by the FHWA as a premier National Urban Scenic Byway for its cultural, historic, natural, recreational, and scenic qualities. It is owned by the Minneapolis Park and Recreation Board (MPRB) and is an important element in their regional park system, servicing a large percentage of pedestrian and bicycle traffic in northeast Minneapolis. A cross section of the proposed bridge is shown in Figure 1.

St. Anthony Parkway crosses the BNSF Northtown yard at a 27-degree skew and the approach roadways to the bridge are on significant grades with intersections near each abutment. These constraints significantly limit the ability to modify bridge skew and vertical roadway profiles.

Existing bridge horizontal clearances for distance between tracks and in-yard piers did not meet current code requirements causing concern for rail yard worker safety. The locations of the four piers in the yard also acted as pinch points and severely impeded BNSF operations and flexibility for future expansion. Because of these two issues, the BNSF railroad stated that they will accept a bridge replacement design which allows for only two piers in the yard.

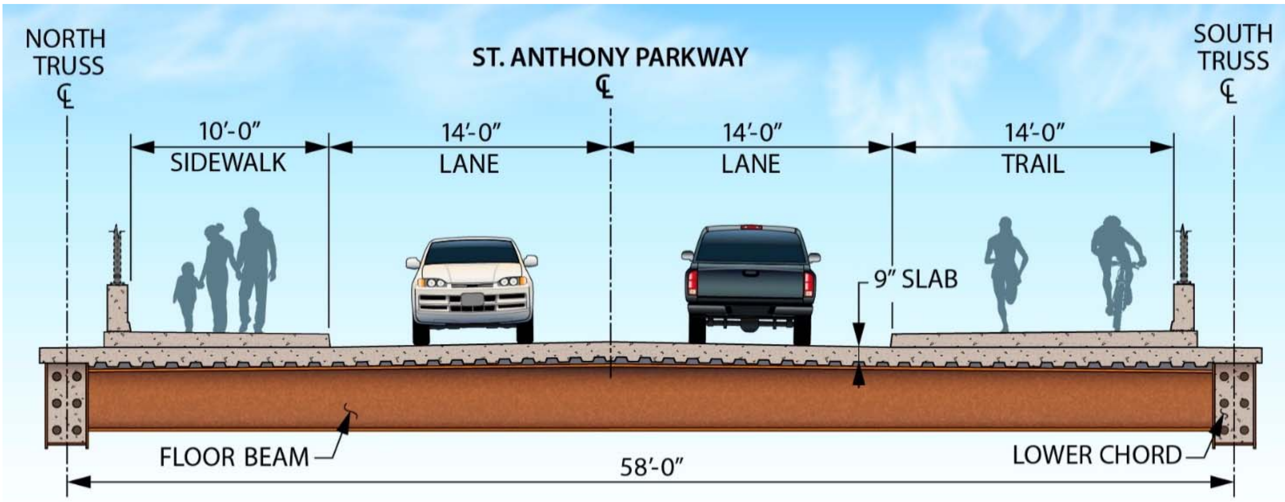

Figure 1 – Cross Section

The new structure must meet all applicable BNSF railroad and Minnesota Department of Transportation (MnDOT) load and clearance design requirements. In addition, the replacement structure must be redundant and minimize or eliminate the use of fracture critical steel members.

The feedback from the community during public outreach meetings was that they were looking for the replacement structure to be visually similar to the existing steel Warren trusses and that it would maintain the urban industrial feel.

The existing bridge was closed to traffic by the City on May 30th, 2014 due to vehicles not abiding by the posted weight limits. It was subsequently reopened for pedestrian and bicycle use only and closed completely for the duration of construction in the summer 2015. This allowed for erection of the replacement structure on the approach embankment and on the existing alignment.

Design Solution

The implemented design solution consists of a 305-foot steel Warren truss structure with two 126'-9" conventional steel girder approach spans. The substructure consists of solid wall concrete piers supported on spread footings and steel H-pile supported abutments. See Figure 2 for the proposed bridge elevation.

The truss does not contain any fracture critical members. The following strategies were employed to eliminate any fracture critical members from the truss structure:

- Utilized split steel member tension verticals and diagonals (two T sections) that are individually bolted to adjacent members with members and connections designed for the fracture of the accompanying twin member and included in the plans as a System Redundant Member (SRM);
- Bottom chord is a post-tensioned concrete member encased with a U-shaped steel shell where the steel shell is providing the tension chord for erection and launching before providing the permanent formwork and steel fascia for the post-tensioned concrete that is poured and stressed after the launch;
- Transverse steel floor beams spaced at roughly 10 ft and made composite with the concrete deck where the deck is shown

Figure 2 - Proposed Bridge Layout

to be capable to sustain the loss on a floor beam by spanning between adjacent floor beams and included in the plans as a SRM.

Parsons design solution was reviewed with FHWA for confirmation that the elimination of fracture critical members and use of SRMs qualifies this truss as not requiring bi-annual hands-on inspections. The design team maximized the use of uncoated weathering steel to enhance the urban industrial feel the community desires. The minimization of future inspection and maintenance reduces the City's life cycle cost for this crossing and minimizes impacts to BNSFs operations.

Removal of the existing trusses and erection of the new truss and approach spans was an integral consideration during design. Parsons' design team collaborated with Parsons Construction Group – the Parsons general contracting business unit – to evaluate constructability and erection approaches that can be achieved in the track shutdown window acceptable to BNSF and discussed below. It was determined that launching the trusses using a set of launching beams was the most likely method a bidding contractor would want to utilize under the given constraints. An optional launching schematic was included in the contract plans where the contractor could utilize the new approach girders by connecting them into braced pairs as the launching beams for removal of the existing trusses and installation of the new truss. A conceptual beam support system that braced steel columns to existing pier for lateral support was also included in the plans.

Railroad Coordination

The principal challenge to replacing the St. Anthony Parkway Bridge was its crossing of the BNSF Northtown Yard. Uninterrupted service through the yard and beneath the bridge is essential to BNSF's operation. BNSF understood the lateral clearance on the ground would have to be provided for the duration of this job in order to provide safe conditions for both bridge and rail workers. As this is already a constrained area, providing these needed clearances during bridge construction would result in a disruption to normal rail service. Windows of time in which rail operations would have to stop within the yard tracks would be required. BNSF stated that it would not allow extended work windows in which its operations are shut down. That meant the project would take much longer to complete; would require a less conventional method of removal and erection; and be more expensive.

The City and BNSF worked to develop track outage criteria that were included in the bid documents. Outages were determined based on track usage. Mainline tracks and the runner & receiver yard tracks were limited to four hour outages. Outages for yard tracks were specified at 10 days for 4 tracks at a time. Outages were extended when possible by coordinating with BNSF flagmen and transportation personnel.

Weekly railroad coordination meetings were required by contract. Attendees of the meetings included the City, contractor and BNSF personnel. At the meeting the contractor would present his anticipated 4-week schedule of proposed impacts to the yard and main line by track. BNSF periodically presented opportunities for extended track windows due to coincidental railroad maintenance work. Mainline windows were requested several weeks ahead of time and would be limited to the mid-day window between the morning and afternoon commuter trains. Many construction activities within the yard were completed under live flagging which allowed for construction work to occur except when a train needed to pass. Coordination was also required during crane activities off railroad property due to the potential to foul the tracks in the event of a crane failure. Finally, there was ongoing coordination with BNSF Engineering personnel who were the railroad's project point of contact. The Engineering personnel reviewed design plans related to removal of the old bridge, construction of the new bridge and construction of temporary falsework needed for removal and erection of the bridge. This coordination included the City's design engineers and the contractor's design engineers.

The City and BNSF goal for the project was to complete the project safely, as expeditiously and cost effectively as possible while minimizing adverse impacts to railroad operations. This was achieved through early coordination with BNSF during design and extensive coordination throughout construction.

Construction

Three bids were received in March of 2015 of which Lunda Construction Company (Lunda) was the low bid at $20.2 million. The bridge portion of the bid was priced at $16 million of which $5.7 million was structural steel at $2.60 per pound. The bid was within 5% of the engineer's estimate and a contract was awarded to Lunda who started work in late summer of 2015 with an expected completion of late summer of 2017.

Lunda's erection approach closely followed the launching approach envisioned by Parsons with two notable changes:

- The three eastern existing truss spans were cut into plains in the yard, as shown in Figure 3, utilizing 10-day closure windows for the yard tracks.
- The removal of the two western existing truss spans and the launch of the new truss was performed on steel launch beams that Lunda fabricated from existing materials they had in their inventory and with obsolete plate girders obtained from the steel fabricator.

Figure 3 - Removal of Eastern Trusses

The launching system was sized for the roughly 800-ton new truss structure but first utilized to remove the two existing most western steel trusses including their concrete deck system over the BNSF's main line tracks to the western approach embankment for demolition. Figure 4 depicts the western approach embankment where the existing trusses were demolished and the new truss assembled.


Figure 4 - Western Approach Embankment

The launching assembly consisted of twin plate girders bolted together with cross bracing near each truss plain (Figure 5). Lunda selected Hilman rollers as the moving vehicle that traveled in channel sections acting as tracks and welded to the top of the launching beams (Figure 6).


Figure 5 - Launching Beams


Figure 6 - Rollers in Channel Track

Transverse beams spanned between the launching assemblies located on each side of the truss. The transverse beams were connected to the truss that was being launched with post-tensioning bars located at each corner of the truss. These post-tensioning bars were used to raise and lower the truss with hydraulic jacks. The transverse beam setup is shown in Figure 7 as used for the removal of Truss 5. Setup for Truss 4 and the new truss were similar.

Figure 7 - Transverse Beam Setup

The longitudinal jacking setup in Figure 8 consisted of a series of post-tensioning bars coupled together and supported on wood blocking spanning between the top flanges of the twin launching beams. Two jacks located at the end of the launching beams pushed against the transversely spanning jacking beam that in turn is connected to the leading post-tensioning bars. The jack force is resolved into the launching beams through a fixed reaction beam behind the jacks.

Figure 8 - Longitudinal Jacking Setup

The selected system was a pull-only system; therefore, it was setup on the western approach embankment for the truss removals and then moved east of new eastern truss pier for the launch of the new truss as shown in Figure 9.

Figure 9 - Setup for New Truss Launch

The existing trusses were removed in October 2016. The 130-foot launched removal of Truss 5 (most western) took two 4-hour windows and included the learning curve of the crews. The 240-foot launched removal of Truss 4 was accomplished in a single extended 6-hour window which was made possible due to the BNSF's permission to launch Truss 4 over live rail traffic after they had observed the launch of Truss 5.

The new truss was fabricated by Industrial Steel Construction, Inc. (ISC) in Gary, Indiana. In addition to the shop assembly of the truss planes, shop assembly of the floor system and the truss end units – portals shown in Figure 10 – was required due to the skewed nature of the bridge. These shop assemblies proved valuable as corrections were able to be made to the portals before the pieces left the shop ensuring a smooth assembly in the field.

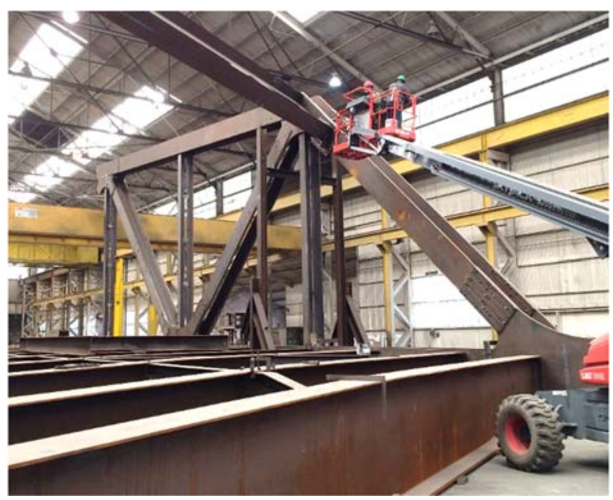

Figure 10 - Shop Assembled Portals

Field assembly on the western approach embankment progressed from the east to west with the crane shown on the left side of Figure 11 supplying the stick built truss elements. After completion of the steel assembly intermediate blocking was removed and the stay-in-place metal decking was installed to act as a working platform for rebar, post-tensioning and concrete installation and as a protective shielding for the railroad traffic.

Figure 11 - Field Assembly of New Truss

The new truss was then launched 310 feet using two 4-hour windows in May of 2017. Once in its final plan position the truss was set down on steel columns attached to the west abutment and the eastern truss pier so that the launching beams could be removed. Lunda then slid the twin plate launching girders laterally using transverse brackets and Hilman rollers that had been pre-mounted on the launching falsework towers (Figure 12).

Figure 12 – Lateral Girder Launching System

From there the launching girders were removed by crane. In June of 2017 the truss was lowered onto the permanent bearings as depicted in Figure 13 using the vertical jacking system of post-tensioning bars and hydraulic jacks.

Figure 13 - Lowering New Truss onto Bearings

The lower chord post-tensioning conduits and hardware, and the reinforcing steel was then installed in the steel shell. After the bottom chord concrete was poured and cured, the post-tensioning tendons were stressed by mid-August. The reinforcing for the concrete deck was installed before the deck concrete was poured, then sidewalks, railing and fencing were installed. Figure 14 shows an aerial photo of the deck pour using two pump trucks.

Figure 14 – Concrete Deck Pour

The new St. Anthony Parkway Bridge was opened to traffic October 27, 2017.

Summary and Conclusions

A unique approach for steel truss redundancy was developed for the St. Anthony Parkway Truss over the BNSF Northtown Rail Yard that eliminates fracture critical members for reduced future inspection costs to the City.

The use of unpainted weathering steel and practical detailing minimize future maintenance work over the rail road tracks while providing the community with the desired urban industrial feel and the familiarity of the truss structural shape that has provided this railroad crossing for nearly a century.

The use of ABC techniques in this case was not primarily driven by the need to quickly reopen the crossing to parkway users but strongly influenced by the rail road site conditions and BNSF's needs to minimize impacts to this busy rail yard and the important coast-to-coast railroad traffic that passes under the parkway.

Figure 15 shows the completed project including a small plaza near the west abutment incorporating portions of the original Warren trusses that had been fabricated using Carnegie steel.

Acknowledgements

Owner: City of Minneapolis, Minneapolis, MN

Prime Consultant: Short Elliott Hendrickson Inc., Minneapolis, MN

Architect: Touchstone Architecture, Tallahassee, FL

Reviewing Agency: Minnesota Department of Transportation, St. Paul, MN

Contractor: Lunda Construction Company, Black River Falls WI

Fabricator: Industrial Steel Construction, Gary, IN

Figure 15 – Completed Project