Construction and Span Replacement for CSX Bridge 64 Crossing North Branch of Potomac River

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ABSTRACT:

CSX Bridge 64 is a double-track bridge near Cumberland, Maryland and consists of three-150' spans. The bridge was successfully replaced during a multi-phased project, highlighted by the main span replacement during a 34-hour closure. Following erection of the new 900-ton bridge spans adjacent to the existing bridge on temporary falsework supports, accelerated bridge construction techniques were executed using independent sliding systems for removal of the existing bridge and for installation of the new DPG spans.

INTRODUCTION

CSX Bridge 64 is a double-track railroad bridge generally located between Pittsburgh, PA and Washington, DC. The bridge is a key component in the CSX east coast network, supporting a train frequency of approximately 20-30 trains per day.

Figure 1 – Project Location

The bridge is specifically located near Cumberland, Maryland and spans the North Branch of the Potomac River at the West Virginia – Maryland border.

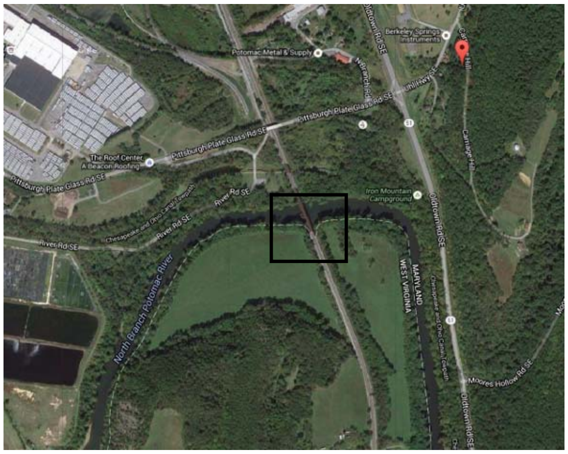

Figure 2 – Site Location

CSX Bridge 64 was completely replaced during 2014-2015 with this project.

The pre-existing railroad bridge was a four-span structure consisting of two girder spans and two longer through-truss spans. The bridge was originally constructed in the 1900's and was retrofit several times during its lifespan.

The new bridge consists of three - 150' DPG spans and was planned to allow for accelerated bridge construction techniques, required to minimize track closure time during bridge replacement operations.

The bridge was successfully replaced during a multi-phased project, highlighted by the main span replacement during a 34-hour closure. Following erection of the new 900-ton bridge spans adjacent to the existing bridge on temporary falsework supports, accelerated bridge construction techniques were executed using independent sliding systems for removal of the existing bridge and for installation of the new DPG spans.

Challenging conditions were encountered and overcome during construction, including the variable as-built conditions of the highly-skewed existing truss spans, presence of shale rock material very near the surface and coordination of multiple simultaneous construction activities during the short-duration change-out.

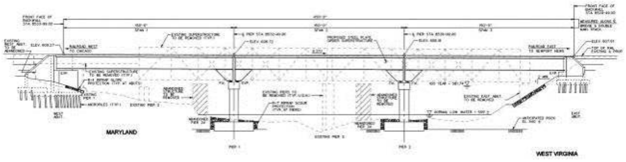

Figure 3 – Bridge Elevation

SITE GEOLOGIC CONDITIONS - Geologic conditions at the bridge site consisted of weathered and unweathered shale rock located very high and near to the surface. These conditions are consistent with the regional geology conditions as a part of the Allegany Mountain Range in the region.

Although the presence of high-quality rock near the surface is advantageous for the final bridge structure, these conditions presented significant challenges during construction.

The bridge replacement construction required the use of temporary falsework structures which each supported significant loads. Foundations for the falsework structures were primarily steel pipe pile which were all founded in the rock material. Placement and seating of steel pipe pile in the rock required significant effort which was costly and time-consuming.

BrIM MODELING FOR ENGINEERING CONSTRUCTION ACTIVITIES

The complex geometry conditions of the bridge construction and demolition operations were considered using Bridge Information Modeling (BrIM) techniques. The TEKLA program was utilized to model all the details of the new bridge structure (based on new construction documents) along with the site-specific geometry conditions, all temporary structures and temporary components required for the sliding activities. The existing bridge structure and associated temporary structures were also modeled using available information from existing plans combined with field measurements.

The geometry conditions during all phases of construction were modeled and studied to detect and prevent potential field issues and conflicts. The bridge modifications, slide track components and movement operations were accurately represented in the model.

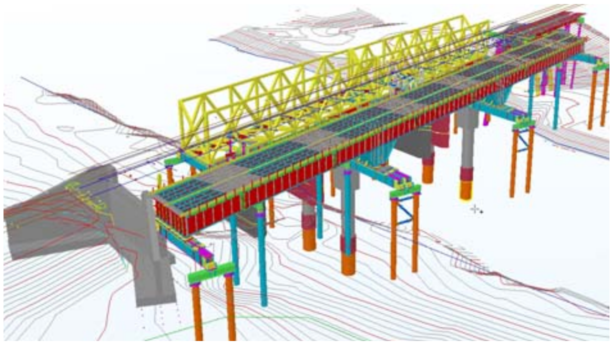

Figure 4 – BrIM Model

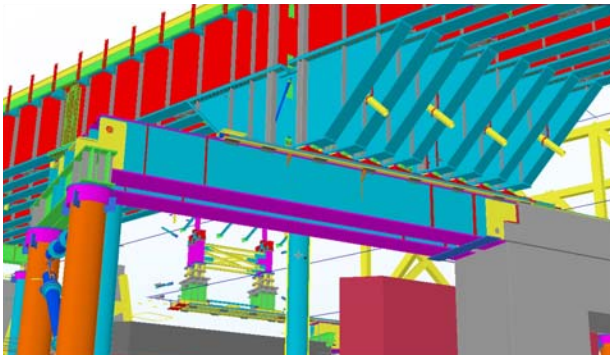

Figure 5 – BrIM Model

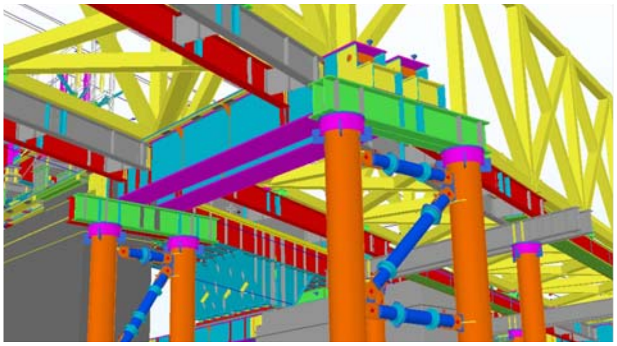

Figure 6 – BrIM Model

Use of BrIM modeling on the project was very useful in planning. Envisioning the overall process was valuable to the construction team in making preparation for the field work. Understanding the complex three-dimensional geometry conditions during all phases was effective in preventing costly delays in the field and was useful in streamlining the construction operations.

NEW DPG SPANS:
DELIVERY, ASSEMBLY & ERECTION

Placement of the new DPG spans was performed in several stages of work:

1. Assembly and temporary support of main girders in staging area
2. Transport of pre-assembled girder units across the river using SPMT's
3. Loading girder units onto falsework structures
4. Lateral slide into position during track outage

The steel DPG spans were erected adjacent to the bridge and parallel to the final alignment. Following girder erection in the temporary location, the system was moved laterally into the final position during a track closure.

GIRDER ASSEMBLY AND STAGING - The new spans were pre-assembled in a laydown yard at site in order to minimize the amount of work required to be completed at heights and to allow steel assembly to start prior to completion of the falsework installation.

Single girder segments were trucked to site in 70ft and 40ft sections. Span 2 was pre-assembled into girder pairs 150ft in length.

Figure 7 – Span 2 Girder Pre-Assembly

These girders were assembled full length to eliminate the need to install any temporary erection bents in the river channel. Span 1 was pre-assembled into girder pairs.

The girders were not pre-spliced for this span due to the limited space available for working on the Maryland side of the bridge. Span 3 was set as 110ft single girders and 40ft girder pairs.

Figure 8 – Span 3 Unloading Off of SPMT

Span 2 and the 110ft sections of Span 3 were assembled on elevated platforms to permit the sections to be moved from the laydown yard through use of Self Propelled Modular Transporters (SPMTs) without having to use cranes to load the segments.

TRANSPORT OF PRE-ASSEMBLED GIRDER UNITS – Once pre-assembly of the girder segments was completed, the segments were moved to the erection location through use of SPMTs. Span 2 segments were loaded onto an 8-line unit with a spacer beam. The spacer was needed to maintain stability of the system during transport. The Span 2 segments were transported out onto a set of sectional barges in the river. A barge stability - floatation analysis was completed to determine the barge size and ballasting needed for rolling the spans out onto the barge.

Figure 9 – Girder Transport on SPMT's Supported by Sectional Barges

Span 3 segments were transported on the same trailer setup as Span 2. This allowed for movement of two 110ft segments or two 40ft segments at a time Span 3 segments were moved from the assembly yard to a crane on the West Virginia side of the bridge. Two segments were moved with each trip. The 110ft segments were immediately set in place. The 40ft sections were staged within reach of the crane.

For transport of Span 1 segments, the spacer beam was removed and the deck of the barges was reconfigured to act as a floating bridge for transport of the segments across the river. The shorter transporter length was needed in order to allow the SPMT to traverse the steep slope on the Maryland side of the bridge
The Span 1 segments were transported one at a time across the floating platform to the Maryland side of the site.

FALSEWORK STRUCTURES FOR GIRDER ERECTION – Temporary falsework structures were required for initial support of the steel DPG spans prior to the lateral slide. These temporary structures were used to facilitate erection of the end spans. The temporary falsework structures were referred-to as "Girder Erection Falsework Bents" (GEFB's) and consisted of simple-span beams supported by pipe pile. The supporting pipe pile were installed to supporting bedrock and were laterally supported by native material and stone rip-rap fill installed for construction access.

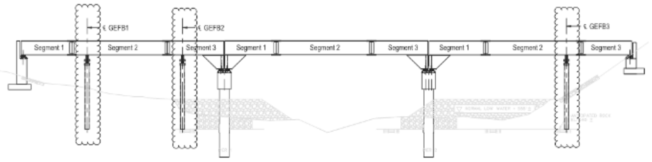

Figure 10 – Arrangement of GEFB Structures

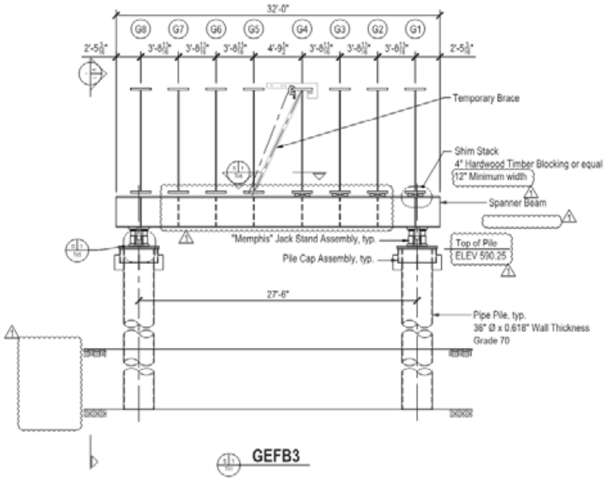

Figure 11 – Typical GEFB Structure Details

The girder erection plan was developed to install the first four girders together as a unit (to comprise one-half of the bridge) on the GEFB structures, release support from the GEFB structures, then to slide those four girders laterally to accommodate installation of the final four girders. As such, the GEFB structures were planned to only support four girders at any time and were designed as-such.

Laterally-supported locking-collar hydraulic jacks were utilized between the top of the piles and the base of the transverse spanner beams to allow for release of support at the desired stage of construction. The elevation and geometry of the GEFB structures were established based on the cambered shape of the girders.

Figure 12 – GEFB Structure In-Use

FALSEWORK STRUCTURES FOR SLIDING – Significant temporary structures were designed and constructed for use in supporting the temporary construction of the superstructure prior to the slide and for use in supporting the lateral slide of the bridge. These falsework structures were aligned with the new bridge piers and abutments such that the side nearest the bridge was supported by the new piers and so that the lateral slide could transition along the alignment from the temporary structures to the new piers and abutments.

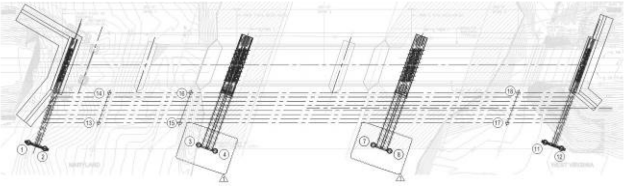

Figure 13 – Arrangement of Falsework

Pre-existing 50'-long box girders were utilized to support the required loads. On the downstream side, the design of the new pier elements was modified to support the box girders. On the upstream side, the box girders were supported on large pipe pile and pile caps.

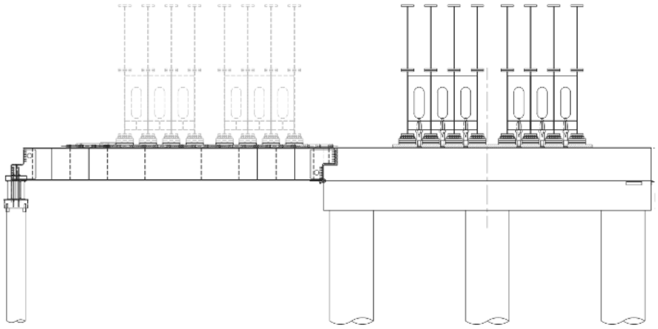

Figure 14 – Falsework Structure Details

The falsework structures were designed to resist anticipated loading during construction including: self-weight, weight of new girder system, stream-flow, environmental loads and inertia effects due to potential sudden acceleration or de-acceleration during sliding.

The slide track was directly supported by the box girders and then transitioned to the new piers and abutments.

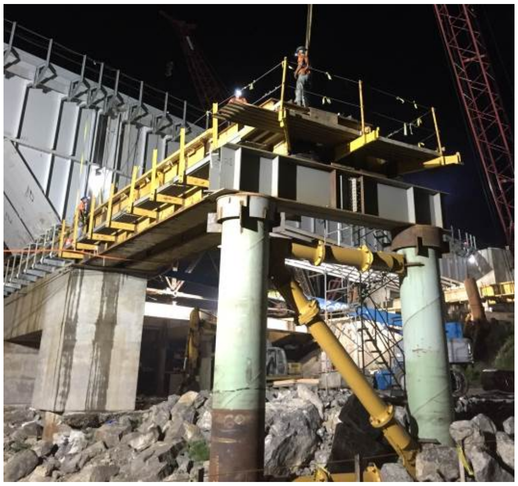

Figure 15 – Falsework Structures

Figure 16 – Pier Modification for Support of Falsework Structures

Figure 17 – Falsework Structures at Abutment

INITIAL LATERAL SLIDE FOR ERECTION – The new spans were erected starting with Span 2 and working out towards the abutments. The first four girder lines were set and then slid over approximately 16ft to their pre-outage position before the last two girder pairs were set. The approach to set-half-and-slide had several advantages 1) reduce the area that needed to be prepared for the cranes 2) eliminate the need for erection braces that may interfere with the existing truss and 3) allowed for a test of the slide system prior to the main outage.

EXISTING TRUSS SPANS

PREPARATIONS FOR REMOVAL

The existing bridge included two double-track through Pratt truss spans, each 166’ long.

Figure 18 – Existing Truss Span

Significant planning and engineering were involved prior to moving the existing truss spans. Although construction plans for the bridge were available, there was limited detail and there appeared to be significant variations from the plans. The 19˚ skew and elevated deck truss configuration presented challenges for the construction team.

The truss removal plan implemented in the field utilized temporary structures aligned with the existing piers, arranged in a similar manner as the temporary structures used for the new girder slide-in.

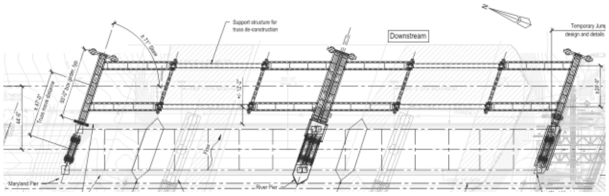

Figure 19 – Existing Truss Removal Falsework Arrangement

Existing box girders were used to support the sliding track in-line with the existing substructure such that the lifting / sliding frames could travel from the existing piers onto the temporary structures.

Bracing and temporary stability measures were implemented for the removal operation because the support conditions for the slide differed from the original support conditions. Details for temporary bracing and were implemented around the existing bridge members based on field-measured geometry.

LIFTING FRAMES FOR SLIDING – The truss was lifted at the end floorbeams using custom-designed and fabricated lifting frames, supported on a powered sliding system. The lifting frames were designed around the existing truss geometry because they had to be installed in advance of the track closure with the bridge remaining in service following installation. The lifting frames also had to accommodate the vertical jacking system and remain stable during the lateral slide.

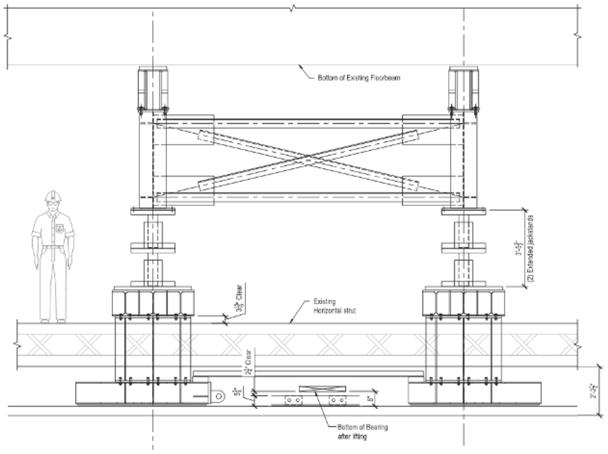

Figure 20 – Truss Lifting Frame Detail

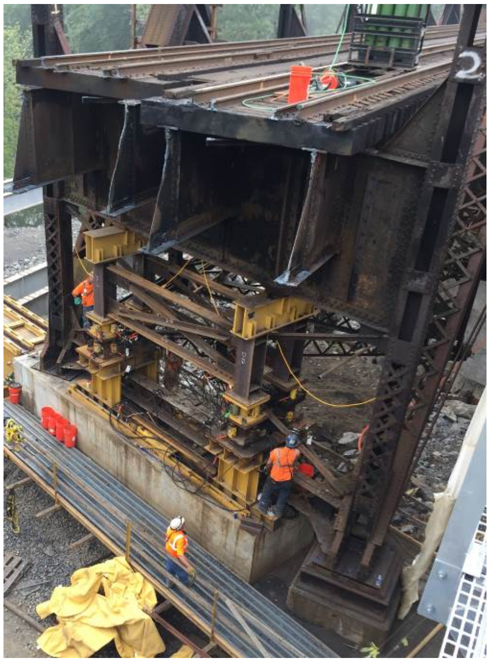

Figure 21 – Truss Lifting Frame Photo

FALSEWORK STRUCTURES FOR SLIDING – Similar to the falsework structures used for the new girder erection, significant temporary structures were designed and constructed for use in supporting the existing truss structures during the slide-out. These falsework structures were aligned with the existing bridge piers such that the lateral slide could transition along the alignment from the existing piers to the temporary structures. This activity required modifications to the existing piers which varied by location. The Maryland Pier and the River Pier required concrete in-fill achieve a sliding surface. The West Virginia abutment required low-profile profile adjustments to achieve a smooth surface.

The box girders were supported on the upstream side at the Maryland Pier in a manner similar to the support of the box girders on the new piers. Implementing a similar detail at the River Pier and the West Virginia abutment was not possible due to the pier end geometry, so an additional pile bent was required to support the box girder at these locations.

The downstream side of the box girders was supported on large pipe pile and pile caps at all locations.

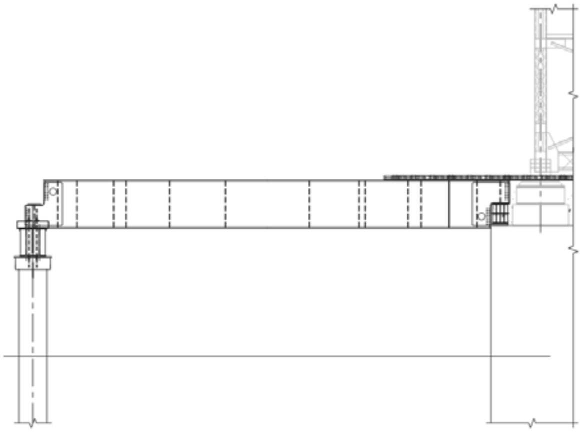

Figure 22 – Temporary Support Conditions at Maryland Pier

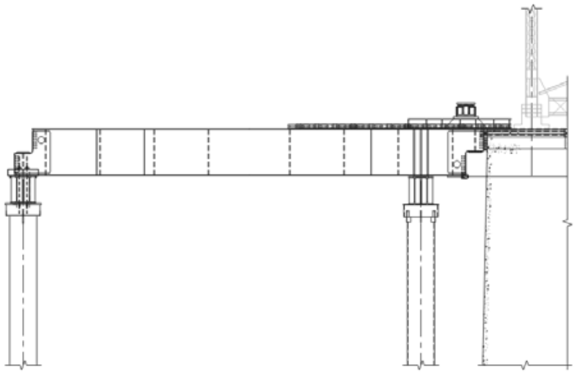

Figure 23 – Temporary Support Conditions at River Pier

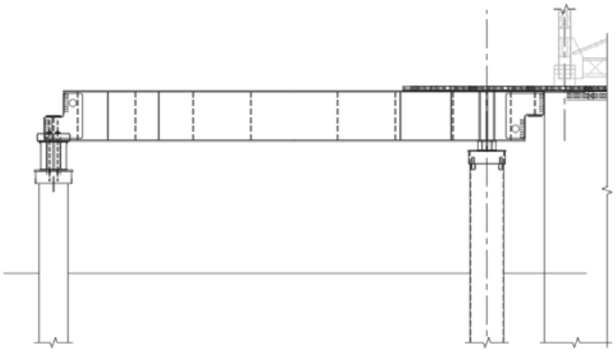

Figure 24 – Temporary Support Conditions at West Virginia Abutment

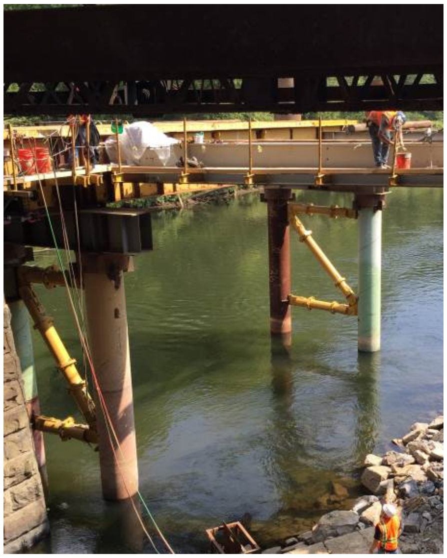

Figure 25 – Temporary Structure for Sliding Existing Truss Slide-Out

FALSEWORK STRUCTURES FOR DEMOLITION – Following the truss spans slide-out, the trusses were lowered onto a secondary static support system intended to facilitate truss disassembly and demolition. The secondary static support system consisted of longitudinal framing members which were positioned directly under the chord members of the truss in the slide-out position. The truss was supported at every panel point on the longitudinal beams through simple blocking.

The longitudinal beams were supported on spanner beams and were framed into the primary box beam members. The supporting piles for the temporary structures to facilitate truss disassembly were unbraced and therefore required to develop flexural fixity in the founding rock. As such, these pile were installed significantly deeper in the rock than most of the pipe pile on the project.

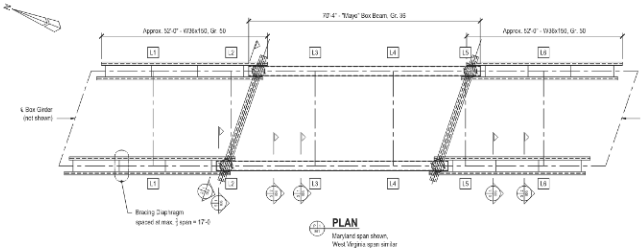

Figure 26 –Truss Disassembly System

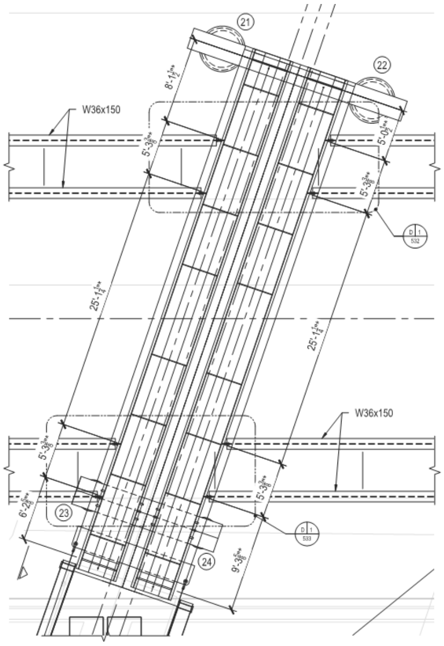

Figure 27 – Longitudinal Beams Framed into Primary Box Girders at River Pier

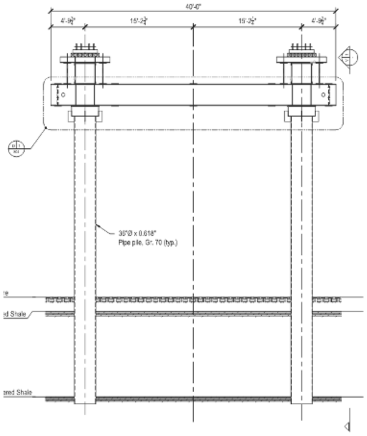

Figure 28 – Support Piers for Truss Disassembly

SPAN CHANGE-OUT DURING TRACK OUTAGE

Work on the project culminated with a 48-hour (maximum) rail closure to perform the span change-out. During this outage the existing approach spans and trusses were removed, the new spans were moved into place, and all track work was completed on the new spans.

SCHEDULE AND TIMELINE – The main track outage was scheduled for 48 hours starting the morning of September 6th, 2015. The schedule allowed 30 hours for the span change out and 18 hours for track work once the new spans were installed.

APPROACH REMOVAL – Prior to sliding out the existing truss spans the approaches had to be removed. The Maryland approach consisted of four 49ft, 44 ton open deck spans. These spans were torch-cut and lifted out with a 275tn crane.

Simultaneously on the West Virginia side, a three-span temporary approach was removed. These temporary spans had been installed during a prior outage to allow excavation for and construction of the new abutment. These spans were removed with a second 275tn crane.

EXISTING TRUSS LATERAL SLIDE-OUT – As soon as the MD approach spans that framed into the truss were removed, lifting of the existing truss began. This operation was completed with a combination of 50TN and 100TN hydraulic jacks. Total lift was 8”. Once the bearings were lifted high enough to bring in the slide track, the area under the bearing was grouted to a level condition and the slide tracks were installed. Total time from the start of lifting operations to being ready to slide out was 7.5hrs.

The Hydraulic Power Units (HPUs) were then switched over to the push cylinders of the slide system. Sliding the truss spans out was accomplished in just under two hours. Total slide distance was 47ft.

NEW SPAN LATERAL SLIDE-IN – After the existing truss was slid out the HPUs were switched over to the push cylinders for the new DPG spans. All three DPG spans were moved simultaneously 39ft into their final position. Sliding all three spans at the same time allowed for all of the walkways to be complete and for the track to be pre-installed and spliced on the deck prior to the outage. Total time to slide the new spans and align them was 3.5hrs.

Once the new DPG spans were in position, they were lifted with 150tn jacks mounted on the end jacking diaphragms so that the slide system could be removed from under the bearings.

Total time from the start of the outage to the new spans being set down was 25 hours. The entire change-out was complete 9 hours ahead of schedule. Total outage time was 32.5hours.

Figure 29 – Span Change-out

Figure 30 – New Steel Ready for Change-Out

Figure 31 – Span Change-Out

Figure 32 – Span Change-Out

Figure 33 – Span Change-Out

EXISTING TRUSS DISASSEMBLY AND REMOVAL

After the outage the old truss spans were lowered onto secondary falsework that had been erected to support the truss during demolition.

Prior to lowering the spans down onto the demo falsework, the track, ties and stringers were removed to reduce the weight to be supported. Total weight of the two trusses when it was set onto the demolition supports was 805 tons.

Demolition of the truss occurred simultaneously on both sides of the river working from the abutments towards the center pier. In order to keep the cranes close enough to the work, the demolition falsework was removed as work progressed.

Figure 34 – Beginning Truss Demolition

Figure 35 – Progressing Truss Demolition

Figure 36 – Truss Demolition Nearly Complete

SUMMARY

The project was successful in replacing an aging railroad bridge with a new structure while minimizing impact on train traffic. All construction activities were completed safely and all spans were replaced successfully within the scheduled track closure. Performing the bridge replacement during short-duration track closures required significant planning and engineering but ultimately achieved the project deliverables for the CSX Railroad.

Figure 37 – Completed New Bridge

ACKNOWLEDGMENTS

The authors would like to acknowledge the CSX Railroad and HDR Engineering, Inc. for their involvement in and contributions to the project.