HEAVY MOVABLE STRUCTURES, INC.
SEVENTEENTH BIENNIAL SYMPOSIUM

October 22-25, 2018

CONSTRUCTION ENGINEERING FOR THE ADAMS STREET BASCULE BRIDGE AND VIADUCT REHABILITATION IN CHICAGO

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MARRIOTT'S RENAISSANCE HOTEL AT SEAWORLD
ORLANDO, FLORIDA

Abstract

Chicago's Adams Street Bascule Bridge over the South Branch of the Chicago River and the associated viaduct west of the River over Chicago's Union Station were built in 1927 as part of the Chicago Union Station construction. The bascule bridge is a Chicago style trunnion double leaf bascule. The last major rehabilitation of the bridge was in 1996 and performed by Chicago Department of Transportation day labor trades. The work principally focused on replacement of the roadway deck, stringers and lateral bracing as well as sidewalks and railings. In November of 2015, Walsh Construction Company of Illinois (Walsh) was awarded a $33.8 million contract for the replacement of the viaduct over Chicago Union Station and repairs to the movable bridge. Milhouse Engineering & Construction (Milhouse) was retained by Walsh to provide construction engineering services in support of the work.

Most of the bascule work involved rehabilitation and replacements within the fixed span portion of the movable bridge. This included S-girder repairs and live load bearing replacements. The design plans called for the rehabilitation of the west leaf longitudinal girder which supports the bridge leaf's trunnion. The rehabilitation work was nearly impossible to perform due to limited access. Working with Walsh, Milhouse devised a procedure to temporarily support the leaf and replace the longitudinal girder in its entirety. Other challenges included raising and lowering the movable leaves without the use of the motors. Milhouse also assessed structural adequacy of the bascule bridge and viaduct during various stages of construction, much of this work for crane loadings. The analysis work conformed to the Illinois Department of Transportation's (IDOT) Guide Bridge Special Provision (GBSP) No. 67 "Structural Assessment Reports for Contractor's Means and Methods." The project is of interest due to the unusual nature of the longitudinal girder replacement and the "out of the box" solutions to some of the more challenging construction engineering problems posed by the work.

Introduction

Chicago's Adams Street Bascule Bridge over the South Branch of the Chicago River and the associated viaduct west of the River over Chicago's Union Station were built in 1927 as part of the Chicago Union Station construction. The present bridge is the fourth bridge to span the River at this location having replaced several timber and iron swing spans. The current bridge is a Chicago style trunnion double leaf bascule spanning 199'-0 between trunnions. The bridge pits are supported on hand dug

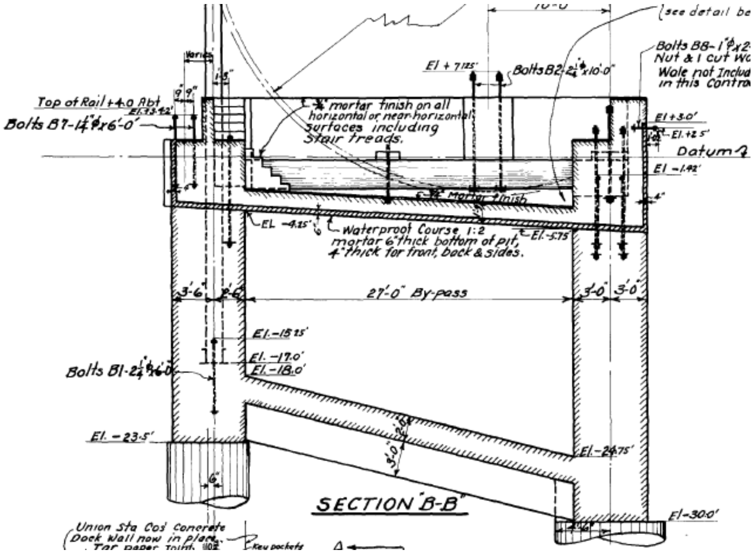

Figure 1: West Pit

caisson shafts founded on rock. Due to the proximity of the Chicago Union Station complex and the need to maximize the draw width, the west pit is smaller than the east pit and has a shallow floor two feet thick that spans between the river and back wall. It is believed that the west pit was designed this way to minimize impact to the Chicago Union Station tracks. See Figure 1.

The bascule leaf trunnions are supported by a pair of longitudinal girders that span from the river wall to the backwall and an S-girder. This arrangement allows the trunnion loads to be supported by the caissons located at the river wall and backwall of the bridge pit and eliminates the need for extensive piling and concrete substructure supports. The trunnion supported on the longitudinal girder sits on a braced pedestal mounted to the longitudinal girder. The longitudinal girder, S girder and live load bearing are supported at the river wall by a large steel built up grillage support embedded in the concrete. The longitudinal girders consist of two deep built up members tied together with heavy cover plates. See Figures 2 and 3 for the S-Girder and Longitudinal Girder details respectively.

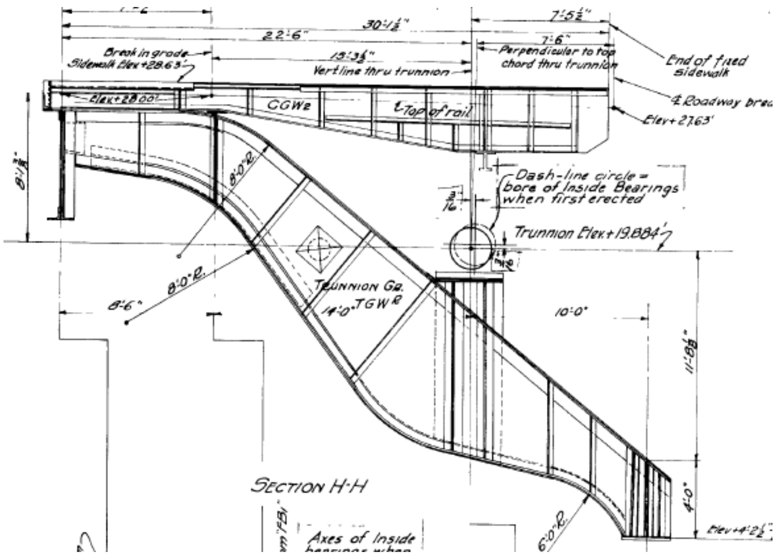

Figure 2: S-Girder

The City has performed many rehabilitations of the Adams Street Bascule Bridge including a rehabilitation in the mid-1960's. It is believed that the work performed at this time included at least a partial replacement of the northwest longitudinal girder, the same longitudinal girder discussed in this report. The last major rehabilitation of the bridge was in 1996 and performed by Chicago Department of Transportation (CDOT) day labor trades. The work at that time principally focused on replacement of the roadway deck, stringers and lateral bracing as well as sidewalks and railings.

In the early 2000's, CDOT engaged the consulting firm CMT to design the replacement of the viaduct over Chicago Union Station and to address areas of deterioration on the bascule bridge. The bascule bridge rehabilitation design was entrusted to Collins Engineers of Chicago. The scope of the bascule bridge rehabilitation included replacement of the deteriorated floorbeams at the center break, replacing the west fixed span, new protective pile clusters, replacement of the live load bearings, repairs to the S-girders and trunnion girders, repair to the northwest longitudinal girder, electric motor rewiring, new control systems and rehabilitation of the historic bridge house. During inspections performed during the design, it was found that the northwest longitudinal girder of the west pit was severely deteriorated. Most of this deterioration was found on the north girder nearest to the pit wall. It is believed that road salt run off from the fixed approach through openings in the deck contributed to the heavy corrosion found on the north portion of the longitudinal girder. The plans called for the replacement in kind of the flange angles, cover plates and stiffener angles in place.

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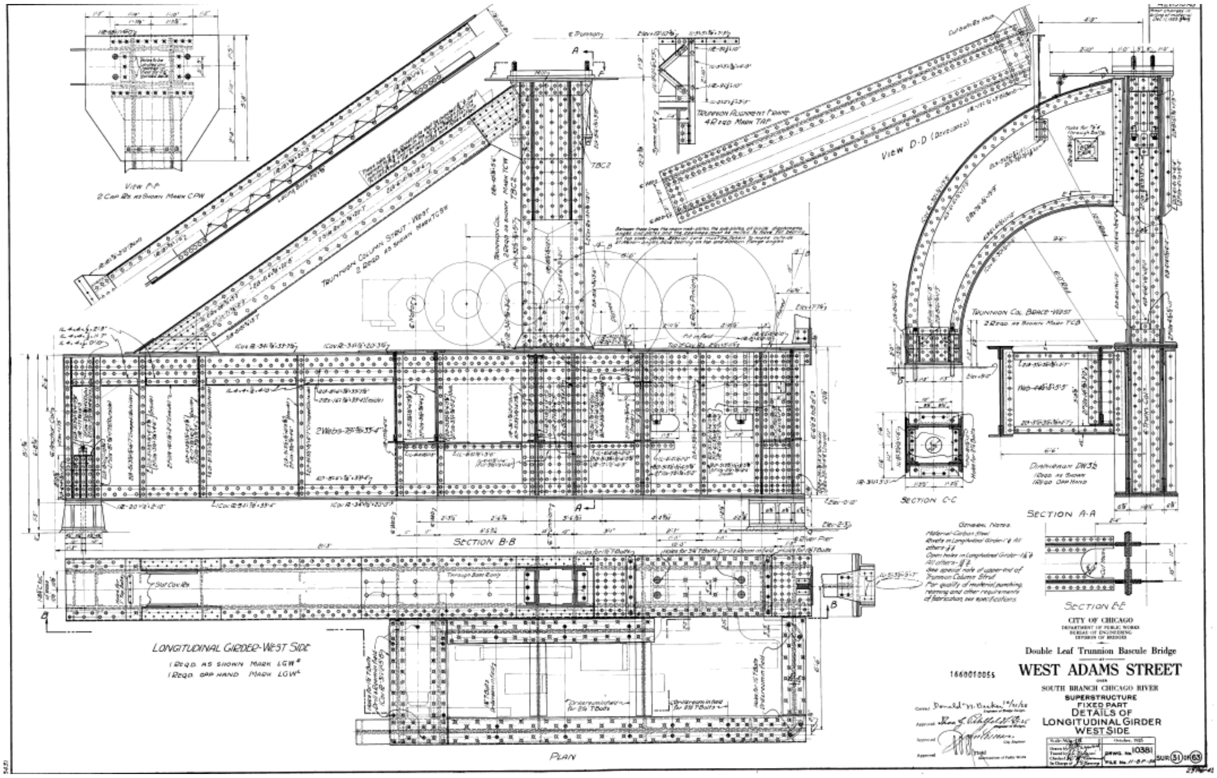

Figure 3: Longitudinal Girder with Trunnion Column and Brace

Longitudinal Girder Replacement

CDOT's plans called for the rehabilitation of the northwest longitudinal girder in place. The longitudinal girders consist of two 78 inch deep built up plate girders with exterior pairs of 8 by 6 by 7/8 inch angles, web doubler plates, cover plates and stiffeners. The girders are spaced 20- inches apart to form a stiffened box that supports the trunnion column and a portion of the machinery girder. In the intervening 50 years since the last work on longitudinal girder, roadway salts and poor drainage conspired to cause severe corrosion of both girders with the interior girder more severely deteriorated. CDOT's design called for the rehabilitation of the interior girder in place with the replacement of the top and bottom flanges and the top plate. This was to be accomplished between the pit wall and girder with less than 24 inches of space and about equal space under the girder. See Figure 4.

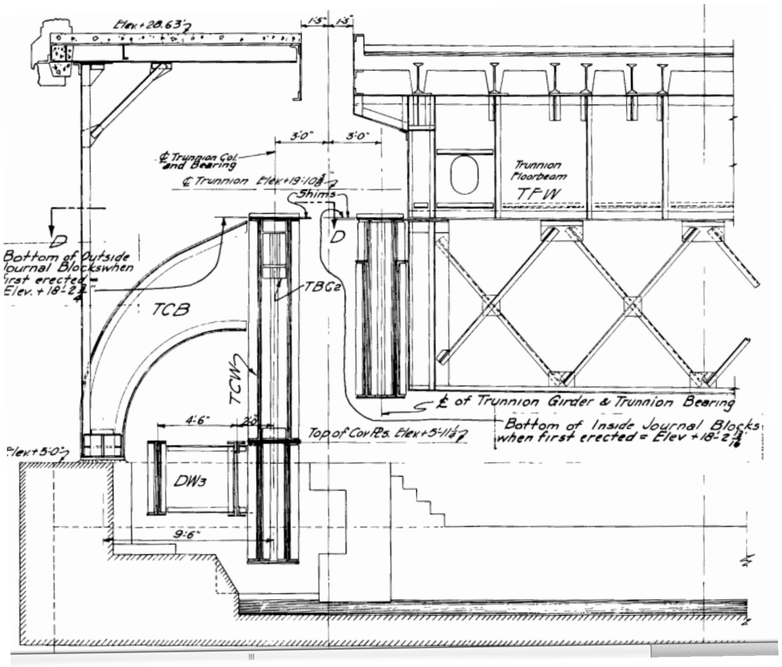

Figure 4: Section thru Pit shown Longitudinal Girder and clearances

After bid, Walsh expressed an interest in looking to more feasible options to rehabilitating the longitudinal girder due to issues with accessibility. Walsh was concerned that the access issues almost precluded the ability to rehabilitate the longitudinal girder as depicted on the plans. Walsh engaged Milhouse to review options for consideration. Milhouse's review of the plans indicated that the City in the 1960's may have replaced the northwest longitudinal girder rather than rehabilitate the girders. Based on this knowledge, it was decided to move forward with the replacement rather than rehabilitation of the northwest longitudinal girder pair.

The existing bridge plans indicated that there was a built up steel grillage embedded in the river wall of the pit that supported the S-Girder, live load bearing and longitudinal girder. See Figure 5. Based on a review of the plans, it was not known whether the grillage had been modified as part of the work performed in the 1960's.

The Illinois Department of Transportation (IDOT) requires that the contractor engage a State of Illinois Structural Engineer to evaluate existing and proposed bridge for stability and the ability to sustain construction loads as part of the contractor's means and methods. IDOT Guide Bridge Special Provision No. 67 "Structural Assessment Reports for Contractor's Means and Methods." covers the requirements for the contractor's engineer's reviews. All construction engineering performed by Milhouse was done in accordance with this Special Provision. The analysis work included evaluating the superstructure for loads associated with storing materials on the bridge and truck and crane loads. The Structural Assessment Report for the longitudinal girder replacement included all analysis of the structure associated with the work and the procedures used to accomplish the work.

Longitudinal Girder Replacement Approach

Whether the longitudinal girder was to be rehabilitated in place or replaced in kind, it was necessary to unload the longitudinal girder of the leaf's dead load. Typically, shoring towers are located on the pit floor to allow the jacking of the counterweight to ensure that the trunnions are unloaded. The west pit of the Adams Street Bascule Bridge had a shallow, relatively thin floor that could not be relied upon to support the load of the counterweight. As such, the jacking

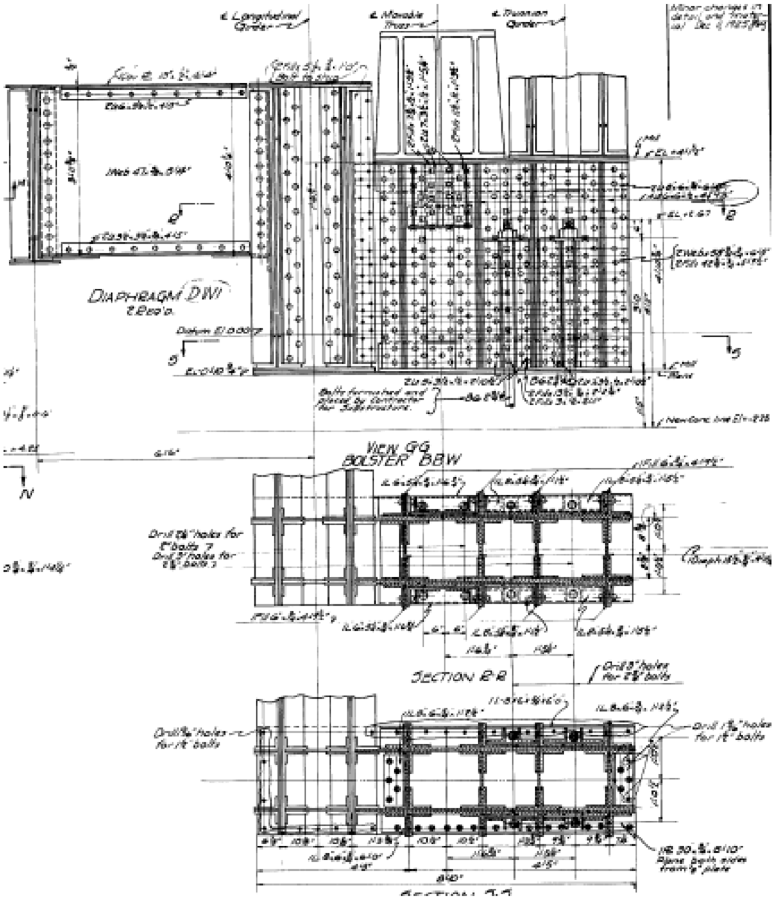

Figure 5: Live Load Grillage

towers needed to be placed on the pit backwall where the concrete was more substantial and able to support the loads needed to lift the counterweight.

Milhouse's approach to replacing the northwest longitudinal girder pair was to pivot the movable leaf about the live load bearings and the jacking towers supporting the counterweight box. Milhouse developed a STAAD model of the movable leaf in order to evaluate the existing dead loads and the loads that would be developed with pivoting the leaf about the live load bearings. Working with Walsh, Milhouse developed the following approach to removing the load from the longitudinal girder:

1. Install shear locks at center breaks so that bridge centerlocks can be removed. The centerlock removal must be completed before jacking of the counterweight.
2. Erect counterweight shoring.
   a. Clean and prepare west pit walkway to accept shoring towers
   b. Locate jacking beam to ensure that there is full engagement of the counterweight box when the support column is installed
   c. Set and level jacking beam on a 1 inch think minimum non-shrink grout leveling pad.
   d. Install support columns and shim to jacking beams at seats. Install hardwood shims between top of support column and underside of counterweight box. See Figure 6.
   e. Remove at least three inches of shimming from anchor columns to allow for movement of counterweight.
   f. Loosen trunnion cap bolts to allow at least ¼ inch of raise.
   g. Using centrally ported jack system, install 250 ton pancake jacks under support columns. Jack load into support columns until trunnion shafts are measured to have lifted off the bottoms of the trunnion bearings. Counterweight jacking load is estimated at 1102 kips or 275,500 pounds per jack. Closely monitor lift off of trunnion shafts at bearings. When lift off occurs, between 0.003 and 0.005 inches, lock off jacks and shim support column tight to jacking beam.
   h. Shim anchor column tight against counterweight bumper.

Figure 5: Shoring Towers for Counterweight Box

3. With counterweight jacked and load off the trunnion bearings, perform repairs to the S-girders, trunnion column and brace, truss lower chord and longitudinal girder replacement.

Unloading of the trunnions was assured when grease started to squeeze out the top of the trunnion caps. The load on the live load bearings and support grillage was over 2,000 kips. The shoring towers consisted of HP 14x89 shapes designed to be easily removed when not needed for shoring. With the transfer of the load off the trunnions to the live load bearings and shoring, Walsh was now able to rehabilitate the S-Girders as well as start mining out the concrete that encased the steel grillage below the live load bearings. The bottom of the longitudinal girder is located only about one foot above normal level of the Chicago River. See Figure 6.

Figure 6: Mined out River Wall with Longitudinal Girder, Live Load Bearing and Bridge House Column

As noted above, the machinery girder is partially supported by the longitudinal girder. Milhouse had to devise a means of supporting the machinery girder before the longitudinal girder could be removed. The simple solution was to erect a support girder over the gear train and the lash the gear train to the support girder so that the machinery girder could be cut free from the longitudinal girder. One of the main vertical support members of the bridge house also needed to be supported since it landed near the area where the river wall was to be mined out to allow the removal of the longitudinal girder.

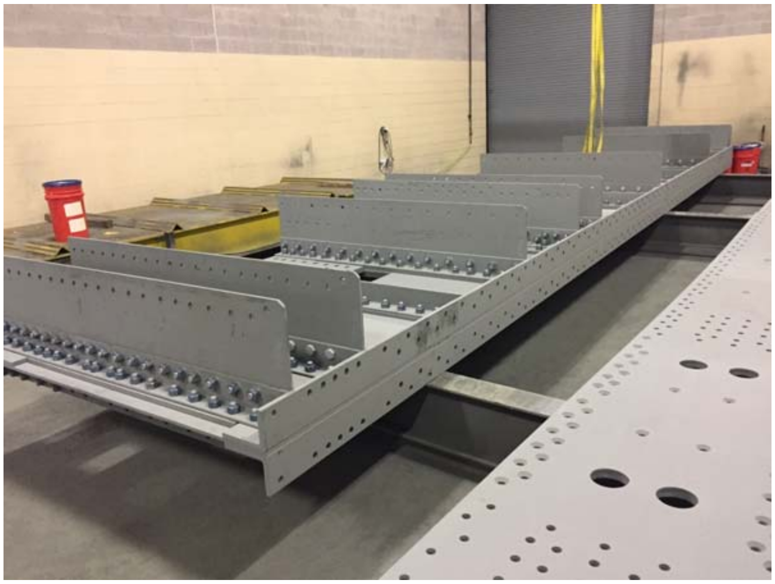

Figure 7: New Longitudinal Girder in Fabrication

It was decided to replace the longitudinal girder in-kind rather than to use a welded plate girder as a replacement. Walsh had concern that the design and approval of a new girder would delay the approval needed to begin fabrication. The only difference between the new and the existing girder was the replacement of the original rivets with high strength bolts. Once the approval of replacement of the northwest longitudinal girder was received from CDOT, work began on the fabrication of the girder. The decision to follow the original design meant the readily available angles and plates could be used in lieu of specially rolled fracture critical plate members. This speeded the fabrication process and allowed a relatively fast turnaround for obtaining the new member.

Figure 8: Longitudinal Girder Removal

With the counterweight shored and the river wall mined out to expose the end of the longitudinal girder, the existing longitudinal girder pair could be removed. Rather than try to remove the longitudinal girder as a single piece, Walsh elected to burn the existing girder into smaller pieces that could be easily handled with an air tugger. See Figures 8 and 9. The girder was marked and shored to the pit floor for the dead load of the girder to maintain support during the cutting of the girder. Walsh used oxygen lances to facilitate the quick cutting of the

Figure 9: Trunnion Column and Machinery Girder

steel. The work was complicated by the need to cut through both plate girders and the top and bottom plate. Once the existing longitudinal girder was removed, the existing bearings and the grillage were prepped to receive the new longitudinal girder.

The longitudinal girder weighed nearly 55,000 pounds. Walsh elected to bring the new girder to the site on a flexifloat barge system which was designed to carry the girder on a transfer beam support by the floats. See Figure 10. The system designed by Genesis Engineering. The new girder was fabricated with no camber, similar to the original. Deflection of the new longitudinal girder was calculated at less than 1/16 inch under full bridge dead load. To ensure proper meshing of the trunnion gear with the gear train, survey points were established prior to the jacking of the counterweight so that when the leaf was lowered on to the new girder, proper meshing of the gears was ensured. The new longitudinal girder was winched into place from the flexifloat barge using Hilman Rollers on a track girder. With the girder in place, the longitudinal girder was re-attached to the steel grillage, bearings and machinery girder.

Figure 10: Flexifloat barge with Longitudinal Girder

Repair work was performed to the trunnion column and the brace. The machinery girder also received repairs as well. These repairs were completed before the new longitudinal girder was installed. With the repair completed and the longitudinal girder in place, the shoring towers holding the counterweight box were lowered and the new longitudinal girder was loaded. Survey shots verified that the new loaded longitudinal girder matched the existing girder configuration.

Conclusion

The replacement of a longitudinal girder support a movable bridge leaf is not a regular occurrence. The loads imposed on the live load bearings and the steel grillage are large and the proximity of the work to the area of concrete removal to accommodate the installation of the replacement longitudinal girder leaves little room for error. The as-designed in place rehabilitation of the existing longitudinal girder was not easily accomplished if it could be accomplished at all. The decision to replace the Adams Street Bascule Bridge northwest longitudinal girder in kind as a built up member ensured that the fabrication could be completed in a timely manner and avoided many potential problems of matching stiffness to control deflections. The replacement of the longitudinal girder coupled with reprofiling the overhead roadway and improving drainage will hopefully reduce the potential for roadway salt infiltration and the new longitudinal girder will serve the City of Chicago faithfully for many years to come.