McClugage Bridge Tied Arch Span Construction and Float-In

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ABSTRACT: Construction of the new McClugage Bridge tied-arch span was planned strategically to allow for simultaneous construction activities on the arch unit and the adjacent composite steel girder units. The tied-arch span was erected adjacent to the permanent bridge on temporary falsework structures and then transported to the permanent location through a complex float-in operation on deck barges. The float-in operation successfully moved the steel arch span from the temporary erection position to the permanent position.

INTRODUCTION

The McClugage Bridge carries US Highway 150 over the Illinois River between Peoria and East Peoria, Illinois.

Figure 1 – Project Location

The McClugage Bridge is a vital transportation link that connects Peoria and East Peoria, Illinois. The original bridge carrying eastbound traffic was replaced in the recently-completed project with a complete new bridge structure featuring a 652’ tied arch span over the navigation channel of the Illinois River.

Figure 2 – Site Location

BRIDGE HISTORY

The bridge was named in honor of David H. McClugage who served as the mayor of Peoria from 1937 to 1941. The original bridge was designed in 1939 but construction was delayed several years due to World War II.

Figure 3 – Original Bridge Construction

Figure 4 – Original Bridge Construction

Construction was completed in 1948 and the single bridge remained in-service until and a second similar parallel bridge was constructed in 1982. Following construction of the second bridge, the original bridge carried eastbound traffic and the newer bridge carried westbound traffic. Over the years, the bridge has undergone several rehabilitation projects.

GENERAL BRIDGE ERECTION PLAN

The new McClugage bridge includes 23 spans arranged in eight units extending from the West Abutment on the West side of the Illinois River to the East Abutment on the East side of the Illinois River.

Figure 5 – Bridge Layout

The highlight of the bridge is Unit 5 which is the 652' tied arch span over the navigational channel of the Illinois River. The tied arch span is an orthogonal system with steel arch ribs, steel tie girders, floor beams, stringers and vertical hangers.

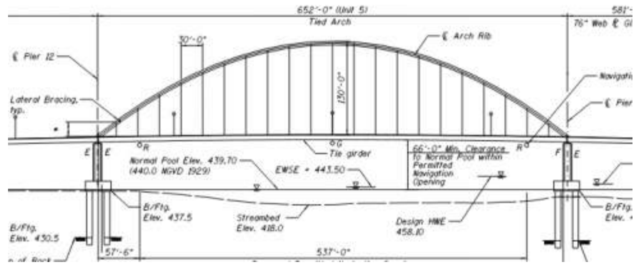

Figure 6 – Unit 5 Tied Arch Span

The overall bridge construction plan was developed to maximize operational efficiency and minimize the construction schedule. To realize high efficiency in construction operations, the various units of the bridge were planned to be constructed simultaneously with multiple overlapping activities. Utilizing this approach required that the construction of the Unit 5 tied arch span be erected simultaneously with the other bridge units.

Considering the overall construction schedule requirements and the need to maintain a clear main river channel, the Unit 5 tied arch span was planned to be constructed at an off-line location and floated-into position. This strategy de-coupled and separated the erection of the main span from the rest of the bridge, effectively creating two independent construction operations which increased efficiency and reduced the overall schedule.

Once the overall construction plan was selected, a detailed review of the construction details revealed that the approach girder Unit 4 and Unit 6 were both conflicts for a float-in operation with the span moving in the transverse direction due to the inset bearings for the approach spans. This condition required that construction of one of the flanking approach units be delayed until the arch span was installed. Ultimately the construction of Unit 6 was performed after the installation of the Unit 5 tied arch span based on this geometric restriction.

Figure 7 shows the general site layout during construction. As shown, the tied arch span was constructed just downstream of the final span position on the east side of the river.

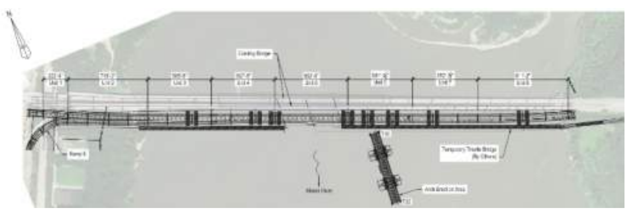

Figure 7 – Site Layout

TEMPORARY SUPPORT STRUCTURES FOR ARCH ERECTION

The temporary support structures for arch erection were carefully planned to accommodate multiple phases of construction. The temporary support structures had the following main objectives:

- Provide temporary support of individual arch span components during erection.
- Provide temporary support of the total arch span system during the float-in operation.
- Accommodate installation and interface with barges for the float-in operation.

Developing a system design that accommodated these conditions required significant upfront planning. Considering the required functionality for the span float-in operation and the transition to the float-in barges, the entire float-in operation had to be engineered upfront to define the total system layout.

MAIN SPAN SUPPORT STRUCTURES - The main span support structures were located at approximately the quarter points of the span. The general position of the main falsework structures was selected relative to the tie girder splices for steel erection planning and based on the span float-in geometry for barge positioning. The foundation and framing of the main support structures utilized heavy steel pipe pile arranged in a unique setup using "quad-pod" and "tri-pod" nodes. The foundation of the pile node systems for the pipe pile were intended to accommodate specific battered geometry which was advantageous for load resistance while also allowed for barge installation for float-in. The pipe pile systems supported a conventional steel Grillage system using existing steel material owned by the Contractor.

Figure 8 – Foundation Pile Nodes in Fabrication

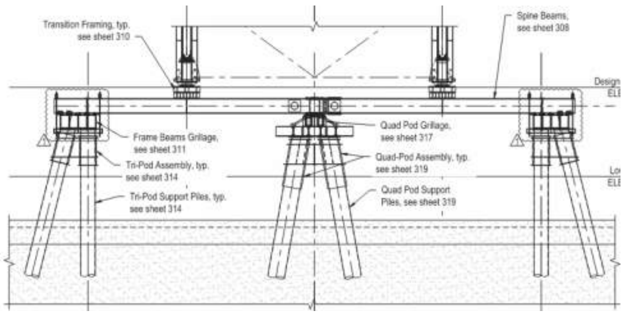

Figure 9 – Main Support Falsework Foundation


Figure 10 – Main Support Falsework Foundation

The primary tower system used in the mains supporting falsework structures was a unique historic modular falsework system owned the Contractor. The existing tower system was referred to as the "F1" tower system and was originally designed and fabricated in the 1940s. The system included various modular components including main column legs, bracing and adjustable jacking features which allowed the towers to be setup in various lengths and configurations. Use of the tower system on the project was engineered considering the applicable loads and a new extended bracing system was designed for this application.

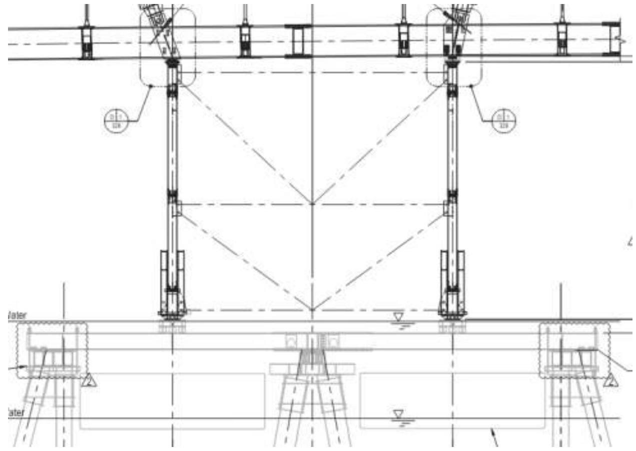
Figure 11 – F1 Tower System

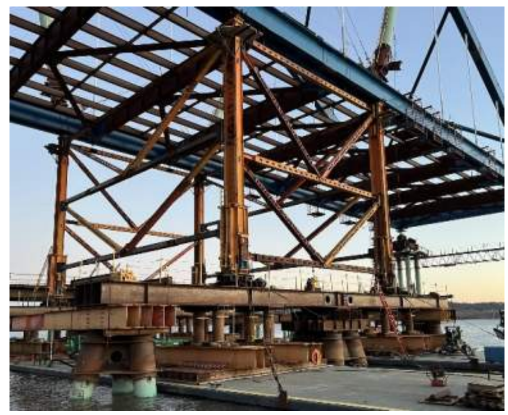
Figure 12 – F1 Tower System

The ends of the tied arch span were supported by static falsework structures comprised of steel pipe piles with an upper steel grillage system. At each arch span bearing location, a group of four piles were used to support the "knuckle" of the arch. These structures were much less complex than the main falsework because the barge interface was not a design consideration.

Figure 13 – Knuckle Falsework Structures

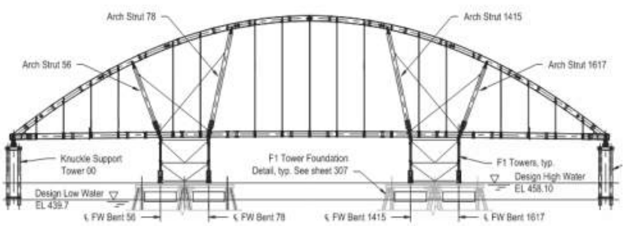

Figure 14 – Arch Span on Temporary Supports

TEMPORARY CONSTRUCTION TRESTLE AND CRANE ACCESS - Crane access for all construction operations within the river was provided by a temporary crane trestle structure extending from the limits of the main river span to the end of the bridge on each side of the river. The crane trestle bridge was a conventional system consisting of steel pipe piles with steel grillage and hardwood timber deck.

Figure 15 – Crane Trestle Structure

To facilitate crane operations for erection of the tied arch span, the main crane trestle structure was extended to the off-line erection site.

Figure 16 – Crane Trestle for Arch Span Erection

ARCH SPAN ERECTION

Erection of the arch span was generally performed first for the floor system (including tie girders, floor beams and stringers) followed by the upper arch ribs and associated bracing.

The floor system erection began at the East side of the main temporary support towers, followed by erection of the span end region on the knuckle support tower. Once the East half of the span was erected, the erection continued by erecting the floor system spanning to the opposite main temporary support tower and finally completed at the opposite knuckle support tower.

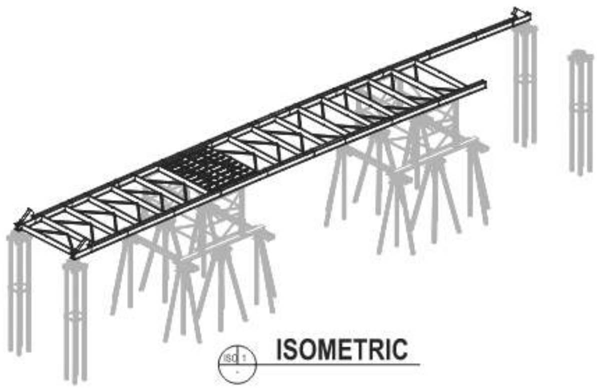

Figure 17 – Floor System Erection

Figure 18 – Floor System Erection

ADJUSTABLE ARCH STRUTS - Following completion of the erection of the floor system, preparations were made for erection of the arch system. Erection of the arch required the use of two adjustable compression struts at each quadrant. Arch struts were set for installation in preparation for the arch segments using a temporary support frame. The arch struts were heavy steel pipe and included a custom-designed telescopic end detail with dual hydraulic jacks. Utilizing the interlocking telescopic end detail and the jacks, the length of the struts could be adjusted as needed to adjust the arch system geometry during erection. The arch struts were positioned within the plane of the arch and tie girders, with bases located over the main falsework structures. This positioning resulted in a direct compression load path from the strut through the tie girder to the supporting falsework tower, minimizing local load effects on the tie girder.

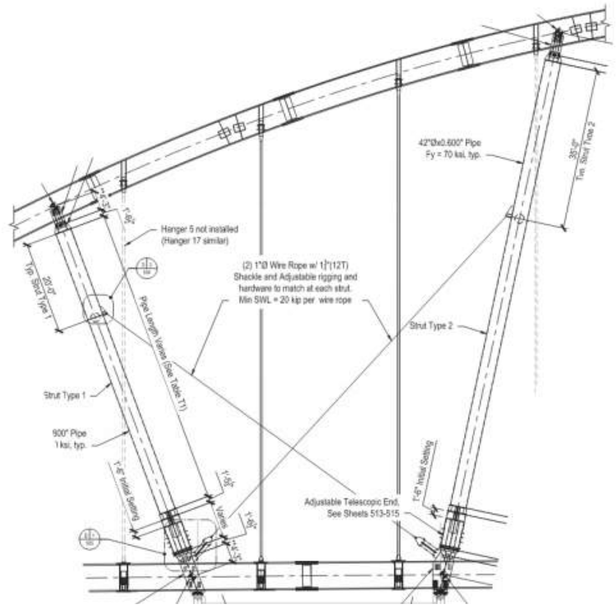

Figure 19 – Adjustable Arch Struts

Figure 20 – Adjustable Arch Struts

Figure 21 –Arch Struts Telescopic End

ARCH SYSTEM ERECTION - The arch system was erected in segments building up from each knuckle end. During temporary conditions throughout the erection process, the partially-completed arch system cantilevered from the previously-erected segments with support of the arch struts. Rigging for the arch segments was arranged to allow the segments to be lifted in their final attitude and angle which facilitated fit-up with the field splices.

Figure 22 – Arch Segment Lifting and Rigging

The arch erection progressed working from the knuckles to the center of the span. The multiple adjustable struts were used to adjust geometry during the work. In preparation for the arch keystone piece installation for closure, the interior struts were extended to open the gap for closure of the span.

Figure 23 – Arch Erection

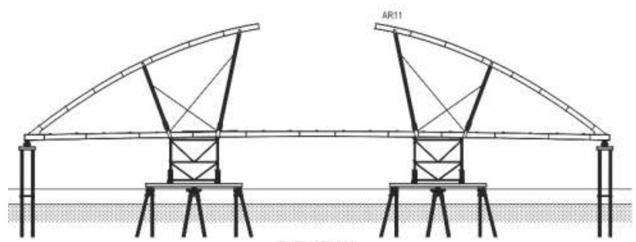

Figure 24 – Arch Erection

Figure 25 – Arch Erection

Following completion of steel arch segments, specific hangers were installed and partially tensioned. Some of hangers could not be installed at this time due to the presence of the arch struts which were in the plane of the arch and tie girders. Hangers that were installed at this stage were tensioned with an initial load in preparation for the next stages of construction.

SPAN FLOAT-IN PLANNING & OPERATION

The span float-in operation was the primary objective of the overall construction plan and all aspects of the construction engineering were planned to facilitate the span float-in.

The total weight of the lifted span was approximately 6.45 million pounds. Including the weight of the temporary works included in the float-in, access platforms and an allowance for deck forming system components (allowed for installation prior to float-in), the total floating weight was approximately 7.23 million pounds.

The span float-in was performed using four 10.5' x 35' x 200' deck barges. The supported load was distributed into the deck of the barge through a 3" compacted sand layer through a multi-layer steel grillage system.

In preparation for lifting the span off the temporary support structures, the barges were ballasted with water resulting in minimal freeboard and then moved under the support towers.

Figure 26 – Barge Grillage and Initial Setup

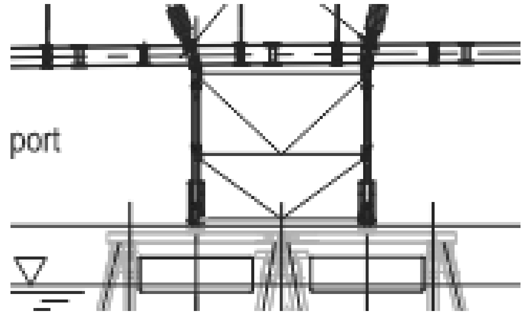

Figure 27 – Barge Installation under FW

To begin the float-in operation, the barges were then de-ballasted by pumping the initial internal water out of the barge. Pumping the internal water from the barges resulted in the floatation force required to lift the span.

During initial lifting from the temporary supports, the barges had to be raised a sufficient distance to overcome the natural deflection of the arch span at the knuckles. Due to the location of the internal support points, the ends of the span cantilevered from the support structures and had to lift off the knuckle support structures.

When the span was lifted off the temporary support structures and fully-supported on the barges, the system was ready to move upstream to the permanent bridge site.

Figure 28 – Span during Float-In

Figure 29 – Span during Float-In

The span was moved approximately 900ft upstream from the assembly location to the final location. The movement and operation control was performed with the use of three large tug boats.

Figure 30 – Span Moved Upstream

Figure 31 –Float-In Nearing Final Location

Once the span was moved alongside the new piers, the floating system had to be precisely moved in transversely over the existing piers and around the existing Unit 4 girders. At this point, a system of winch-lines was connected to the barges and was used to precisely move and manipulate the barges into final location.

Figure 32 – Preparing to Move Over Piers

Figure 33 – Moving over Piers

Figure 34 – Moving over Piers

When the span reached the final location, preparations were made to lower the system onto the permanent bearings. To do this, water was again pumped into the barges which lowered them in the water and lowered the total system. This process was continued and the adjustable falsework towers were also lowered until the barges and temporary supports lowered out completely under the span, freeing the barges from the system.

Figure 35 – Float-In Complete

The main float-in operation was performed on December 21, 2023 in a single day from initial barge de-ballasting, moving the span and set-down.

POST FLOAT-IN CONSTRUCTION

Following the float-in the final construction operations were performed to complete the project and open the bridge to traffic.

When the bridge was set on the permanent bearings, the struts were planned to unload. To accommodate this condition, the struts were restrained to the structure. One of the first operations following the float-in was to remove the struts. Hangers that were previously not installed due to the presence of the struts were installed and tensioned.

The most significant construction task following the float-in was the deck construction. Following installation of the extensive forming system, the deck was cast in multiple pours with joints located at the stringer expansion joints.

Figure 36 – Installation of Deck Forming System

Following deck construction, final hanger tensions were adjusted as required to meet the target geometry profile.

Figure 37 – Open to Traffic

ACKNOWLEDGMENTS

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