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Unionport Bridge: Construction of Twin Single-Leaf Bascules in a Constrained Urban Site

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Introduction

The Unionport Bridge design was discussed at the 2016 HMS Symposium. The current paper provides an update on the construction of this challenging project which was built in a constrained urban site over an industrial waterway in New York City. The double-leaf bascule bridge was originally constructed in the 1950's. Over time, as navigational and roadway traffic demands continued to grow, it became apparent that taking the bridge out of service for an extended period of time to perform major rehabilitation work would not be feasible. As a result, the bridge continued to deteriorate through the years.

For roughly 20 years, there were a pair of double-leaf bascule bridges at the site. The northerly span was removed in the late 1960's when state-owned elevated highways were built on both sides of the southerly span. At the time, the elevated highways diverted much of the traffic away from the lower-level bascule bridge. However, as traffic demands continued to increase, the bascule bridge remained in service for local city streets and as a connector to the Hutchinson River Parkway.

The prior bascule was built on a sloping grade such that the intersection with Brush Avenue at the east would be an at-grade intersection and the roadway could pass above Zerega Avenue at the west. The pit pier of the new twin single-leaf bascules was built east of the existing bascule span which facilitated making the four needed highway connections at the west end of the bridge with improved alignment geometry in a tight space. The resulting twin bascules will allow one span to be taken out of service if required for future maintenance or reconstruction while providing ample room for traffic on the remaining span. Elements of the existing piers are incorporated into the new bridge in order to minimize navigation restrictions and eliminate the need for channel realignment The new, wider bridge maximized use of the space between the elevated interchange structures and allowed for the addition of a shared use path.

During the design phase, a concept was developed to utilize twin fixed temporary bridges, built below adjoining interchange viaducts, to maintain traffic during the accelerated phased sequential construction of two new single-leaf bascules. The first single-leaf bascule would have been built in the open position, offset from and behind the existing bascule, which would allow maintenance of traffic on a skewed alignment across the existing bridge while the new span was being built. This was consistent with the need for navigation at that time. This approach required two temporary bridges and accelerated phased construction of the movable spans to limit the impacts on navigation while the temporary fixed bridges were in service. Temporary movable bridges were ruled out during the design phase due to their high cost and site constraints above and around the temporary bridges which made achieving adequate vertical clearance impractical.

The new bridge design was completed, and the project was bid in 2017. The contract was awarded to UCJV, a joint venture of Schiavone and Lane Construction. During construction, two factors combined to change the course of the project staging: 1) the major oil depot upstream of the bridge ceased their operations which reduced the navigation demands substantially, and 2) the contractor sought to have more time in their schedule to build the new twin bascule spans. The contractor's proposed approach would build the new twin single-leaf bascules according to the plans but changed the phasing to include twin temporary vertical lift spans to maintain traffic while the new bascules were being built.

This paper discusses not only the changes resulting from the temporary movable spans but also the overall construction challenges encountered and how the project was constructed within a constrained urban site beneath a major elevated interchange

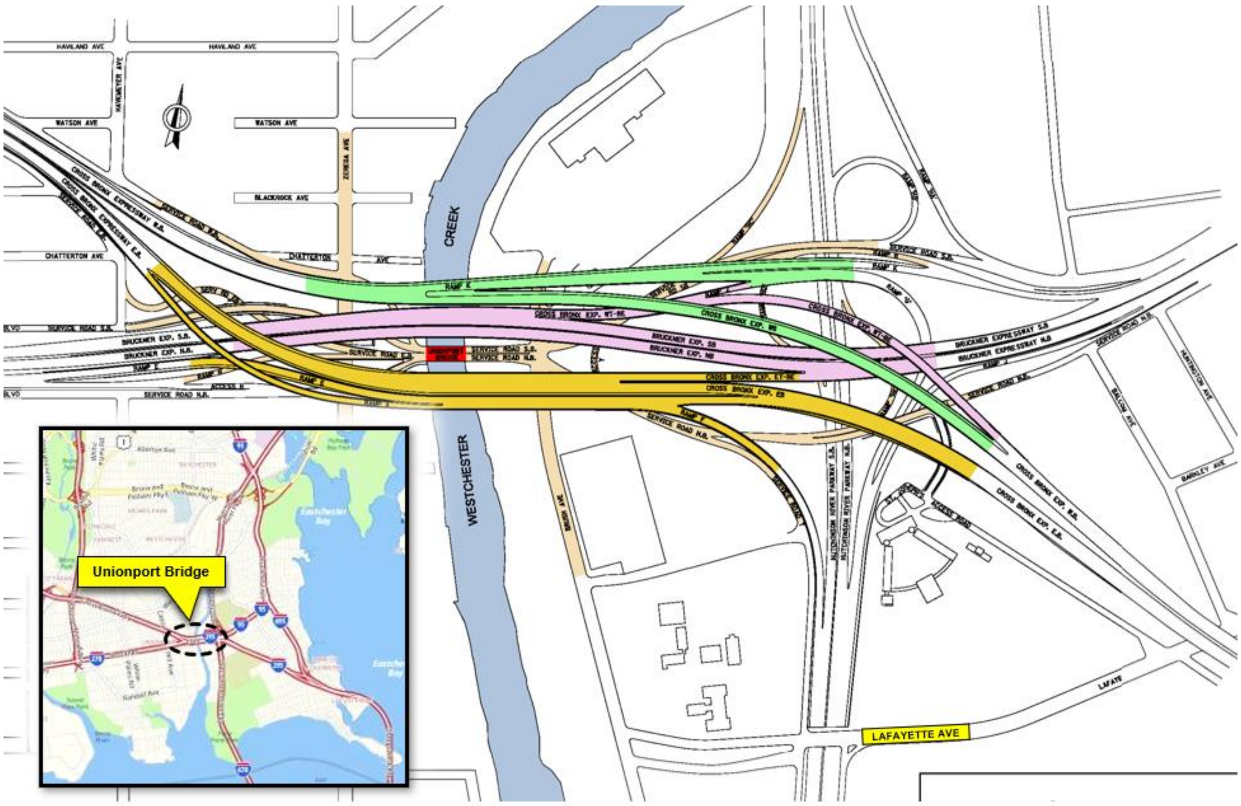
Prior Unionport Double-leaf Bascule Span

Background

Westchester Creek has been in use as an industrial waterway since the 1800's with a series of bridges crossing the Creek at the Unionport Bridge location including a swing span and several bascules. The prior, third generation Unionport Bridge was constructed in the early 1950's following design plans created in the late 1940's. It consisted of two parallel, independently operable, double-leaf trunnion bascules carrying the Bruckner Boulevard over the Westchester Creek in the Bronx. A portion of the bascule piers in the creek were constructed on foundations of an earlier bridge that had been built circa 1915.

Twin Double-Leaf Bascules Prior to Construction of the Expressway Above

In 1971, the Cross Bronx and the Bruckner Expressway structures were built above by the New York State Department of Transportation (NYSDOT). At that time the north bascule bridge superstructure and abutments were demolished to accommodate the interstate highway alignments. The approach roadways, ramp structures, and south bascule span were altered accordingly to accommodate two-way traffic. The resulting condition placed a maze of elevated highways around the legacy double-leaf bascule.



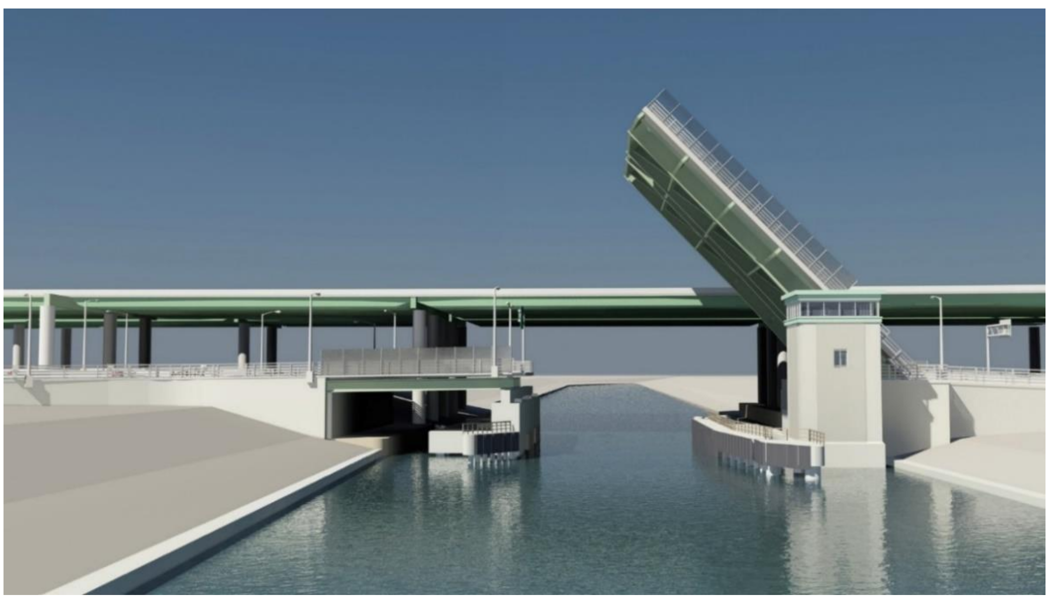
Project Location

During the initial development of bascule span rehabilitation plans in the 1990's, it became apparent that there was no easy way to maintain traffic during construction. Temporary movable bridges were considered to allow the rehabilitation work but there were no good locations for these temporary movable bridges due to the columns supporting the adjoining state-owned interchange structures and the overhead restrictions. Further, the United States Coast Guard (USCG) wanted to maintain the 52-foot vertical clearance at this location and was not in favor of the two temporary movable bridges in close proximity along the waterway. In spite of the efforts to keep the existing bridge in service, it became apparent that replacement would be needed, and traffic would have to be maintained during replacement.

Project Development

The main span of the prior Unionport Bridge was a double-leaf bascule that carried three eastbound lanes and two westbound lanes of the Bruckner Expressway Service Road vehicular traffic over the Westchester Creek. The bascule was tightly constrained and is interconnected with numerous roadways. The bridge is flanked on the north and south sides by the elevated mainline structures of the State-owned Bruckner Interchange, which serves both the Bruckner and Cross Bronx Expressways. The service roads crossing over the bascule span are relied upon to connect between the Hutchinson River Parkway and the two expressways, and also provide access to and from the local community. The bridge is the only crossing of Westchester Creek readily accessible to the local residential, industrial, and commercial areas on either side of the creek and diverting traffic to the expressway above would not have been possible.

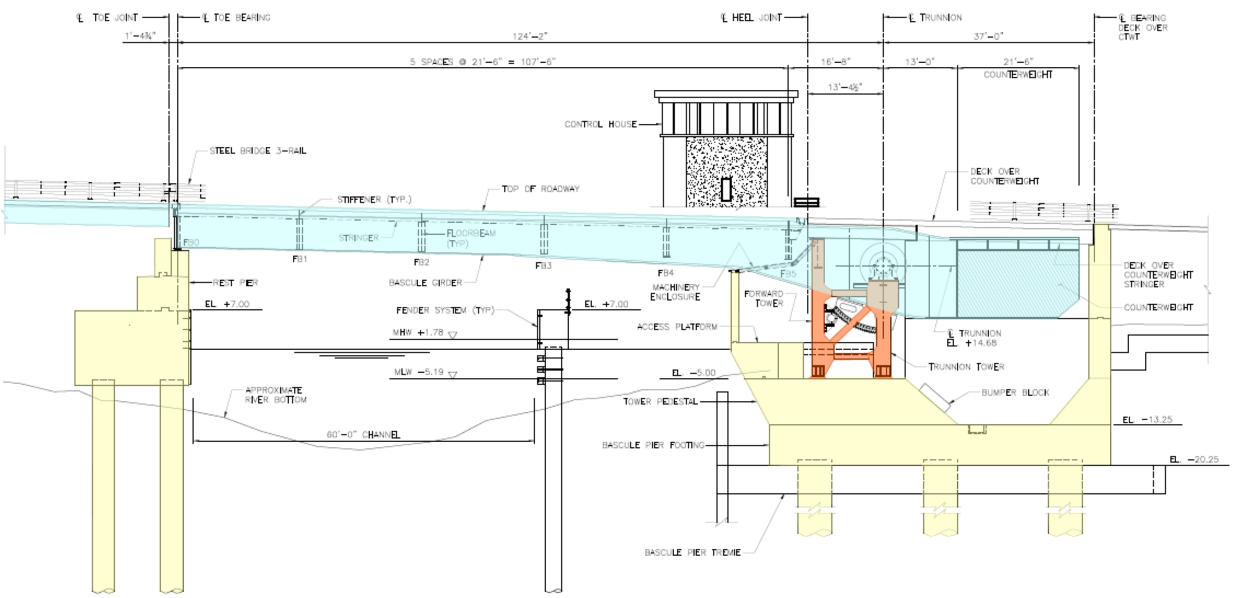
The new Unionport Bridge project includes new wider bascule spans, the addition of a bikeway, and the replacement of the associated on and off ramps. Due to overhead and lateral site constraints, other movable bridge types such as swing spans or vertical lift bridges were not deemed feasible. Two parallel single-leaf bascule spans are being constructed to replace the existing bridge. Each single-leaf bascule includes a simple trunnion bascule span with a closed pit bascule pier. The advantages and project challenges of this alternative are further described below:



New Twin Single-Leaf Bascule

The single-leaf bascule bridge was designed to provide the necessary vertical clearance within the navigable channel as required by USCG. The existing Unionport Bridge is located between two parallel elevated fixed bridge structures which define the vertical clearance requirements of the channel at this location. The bascule span was designed with approximately 45 degrees angle of opening to provide the required 52-foot minimum vertical clearance and match the clearance afforded by the adjoining NYSDOT fixed interstate structures. Limiting the angle of opening allows for a single-leaf bascule bridge with a shallower bascule pier. Due to the low opening angle, the depth of the bascule pier for the single-leaf bridge is comparable to that of a double-leaf bascule bridge designed for the same location. Limiting the depth of the pier pit was important to reduce the potential for disturbance to the foundations of the adjoining NYSDOT interchange structures.

A single-leaf bascule bridge requires fewer machinery alignment concerns as there are only half the number of moving components as compared to a double-leaf bascule bridge. The toe of the single-leaf rests on a solid pier which reduces deflections and makes maintaining alignment easier. Span operation will be more reliable than a double-leaf bascule over the life of the bridge.

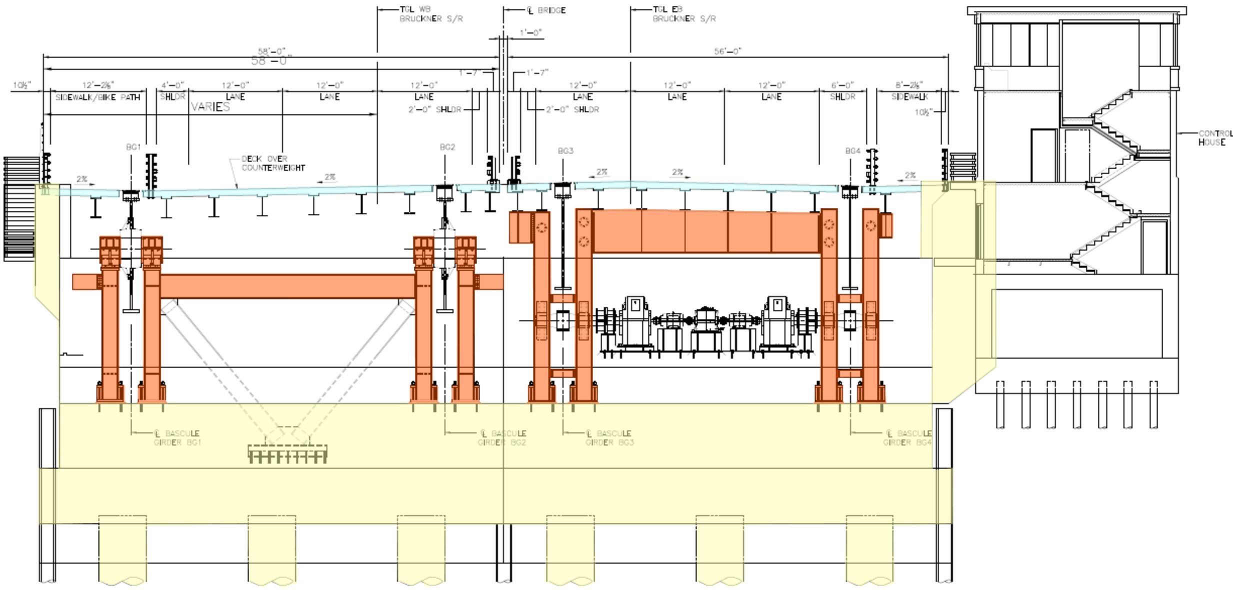


New Unionport Bridge Longitudinal Section

The proposed single-leaf bascule allows for all of the bridge operating machinery to be located in one larger, centralized location on one side of the navigable channel, as compared to a double-leaf bascule bridge which has machinery on both sides of the channel to operate multiple opposing leaves. Maintenance crews will only be required to work in one primary location. This also simplifies electrical connections and conduit routings and simplifies access for the Bridge Operator, since the Control/Operator's House will be located on the same side of the channel as the machinery room.

A single-leaf bascule bridge performs as a simple span under live load; lock machinery will not be required to provide live load shear transfer between the moving leaf and the fixed pier. However, lock bars will be used to function as a safety "hold down" mechanism, providing for a redundant system to ensure safety in the event of operating machinery limit switch failure.

Maintenance access is also improved in the vicinity of the lock bar machinery for a single-leaf bridge. The lock machinery is installed on the fixed rest pier with the lock bar driven to a receiving socket on the single-leaf toe floorbeam. This allows maintenance crews to access the lock machinery from the fixed flanking span with the movable span in the opened or closed position. Access platforms are situated outside the navigation channel with sufficient head room clearance to allow for simplified access for routine maintenance including inspection and lubrication.



New Unionport Bridge Cross Section (split section)

Overcoming Project Challenges

1.) Structural Geometry

A single-leaf bascule bridge requires a longer girder rear of the trunnion to balance the forward moment arm as compared to a double-leaf bascule bridge crossing the same navigable channel width. Since the vertical profile of the bridge is not high enough to accommodate the longer girder while remaining above the water level, a closed pit bascule pier is required. The closed pit pier for this bridge is located mostly on land and its size was controlled by limiting the span opening angle and use of a smaller, higher-density counterweight including a steel box with concrete and steel as well as some selectively placed lead blocks.

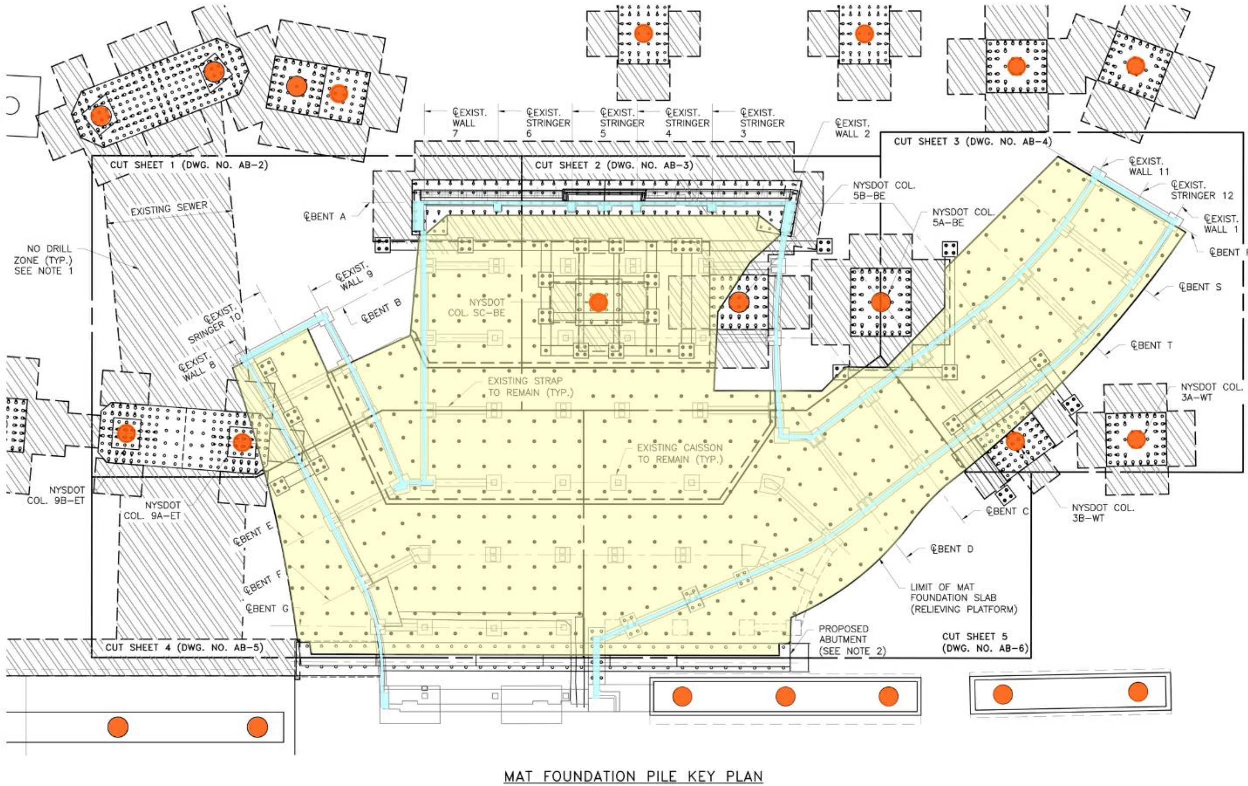
2.) Working Adjacent to Existing Foundations

Working adjacent to elevated viaducts owned by NYSDOT and carrying large traffic volumes was very challenging. Inherently, the new bridge foundations would be close to the existing foundations and a robust structural monitoring program using accelerometers and total station survey measurements was implemented to control vibrations and displacements. New foundation elements included drilled shafts and micropiles installed by rotary methods to minimize soil disturbance. One particularly challenging operation was the excavation of the pit pier. In order to do this, a secant pile isolation wall was pre-emptively constructed between the existing foundations and the cofferdam for the bascule pier. This further reduced the potential for disturbance of adjacent foundations.

Secant Pile Wall Construction

3.) Cellular Abutment Replacement

The west cellular abutment was particularly challenging to replace. The roadway geometry above this abutment was improved by flattening out the curves, and at the same time, traffic needed to be maintained along the four ramps crossing it. In order to do this, a new micropile supported mat foundation was built within the old abutment and flowable fill was placed while working from inside the abutment. This inside-out construction took advantage of the headroom within the old abutment and allowed traffic to continue to pass above.



Micropile Supported Relieving Platform Constructed Within the Existing Cellular Abutment

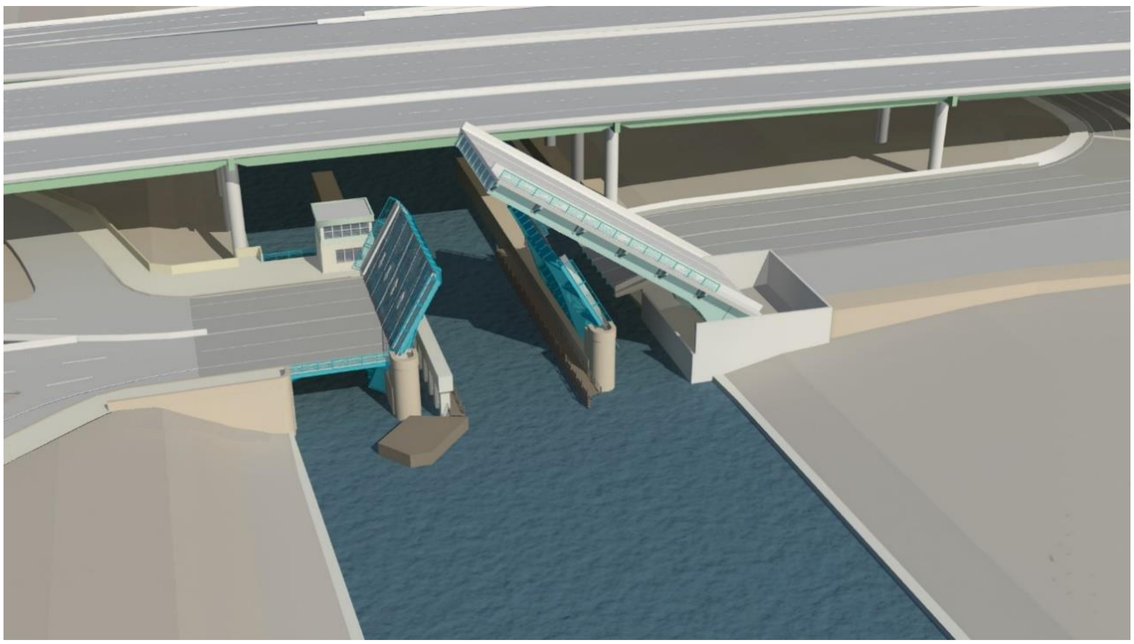
4.) Staged Construction

While the originally planned staging involved constructing the south bascule pier south and west of the existing span and initially running traffic diagonally across the existing bascule, followed by short-term use of two fixed temporary bridges as the bascule was completed, the contractor proposed an alternate staging approach. The contractor proposed using the same alignment as was planned for the twin temporary bridges but making them movable rather than fixed. This would allow the temporary bridges to remain in place longer without affecting navigation. The challenge for temporary movable bridges was the height of vessels navigating along the creek. Some thought was given to using alternate, shorter, tugboats to deliver oil to the upstream depot, but ultimately the issue was resolved when the oil depot ceased operations just as construction began. This change in the vessel fleet, resulted in USCG allowing a reduction of vertical clearance during construction. With a 35-foot vertical clearance over the channel, the contractor was able to make twin modular temporary vertical lift spans work. The temporary lift bridges vary in dimensions. The north lift bridge is 24 ft wide with 60-ft and 100-ft approaches and a 66-ft lift span. The south bridge, which is 30 ft wide, has 80 ft and 100 ft approaches with a lift span of 90 ft, as well as a 5-ft walkway off the south side of the entire 270 ft length.

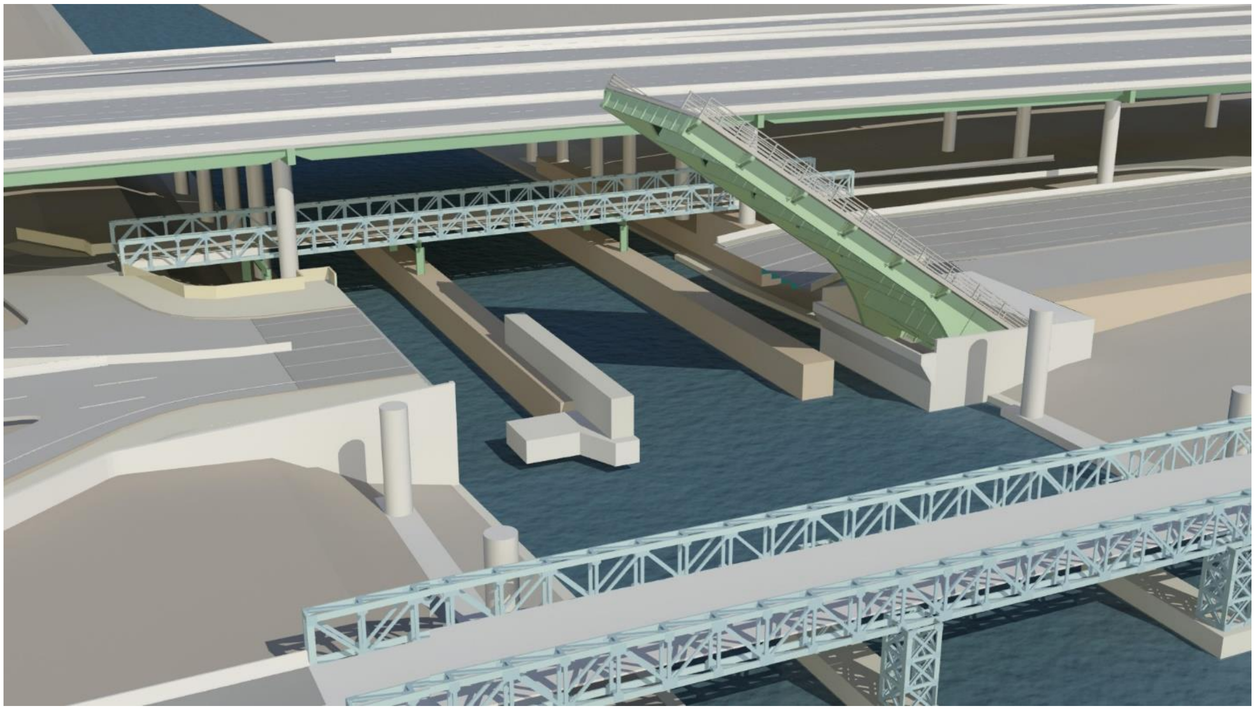
In order to maximize the height of lift below the overhead interchange structures, the lift spans were built as high as possible and hydraulic cylinders were used to pull the counterweights down and lift the span. These twin vertical lift spans would be operated infrequently, but they still required safety measures including fender systems, and traffic signals as well as warning and barrier gates.

The new rest pier was built in line with the existing west bascule pier to provide a place for the toe of the new leaf to be seated on. This avoided the need for any temporary narrowing of the navigation channel and eliminated channel dredging. However, incorporation of parts of the existing bascule piers into the new rest pier and east fender was necessary.

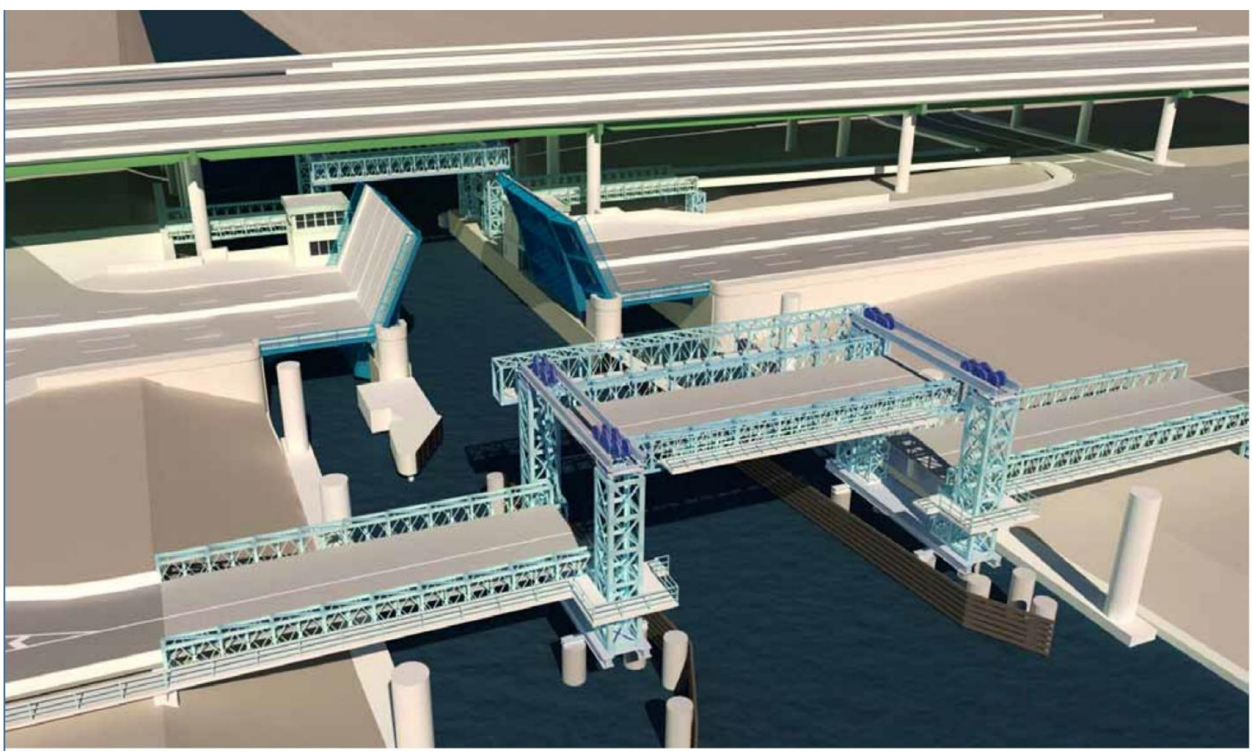
A critical step in construction is the shifting of traffic from the existing to the new bridge. Constant communication was maintained with the USCG which allowed us to erect the bascule spans in the lowered position. During a navigation height restriction, the deck infill was placed and cured. The bascule spans were erected one at a time and the south leaf was commissioned first. This allowed for traffic to be shifted to the south leaf and removal of the north temporary bridge and its supporting foundations.



Original Erection Scheme



Original Staging with Temporary Fixed Bridges



Alternate Construction Staging with Temporary Lift Bridges

The north temporary bridge was supported on the pre-existing unused bascule pier and the south temporary bridge was be supported on independent foundations. This arrangement allowed marine traffic to be undisturbed during the majority of construction.

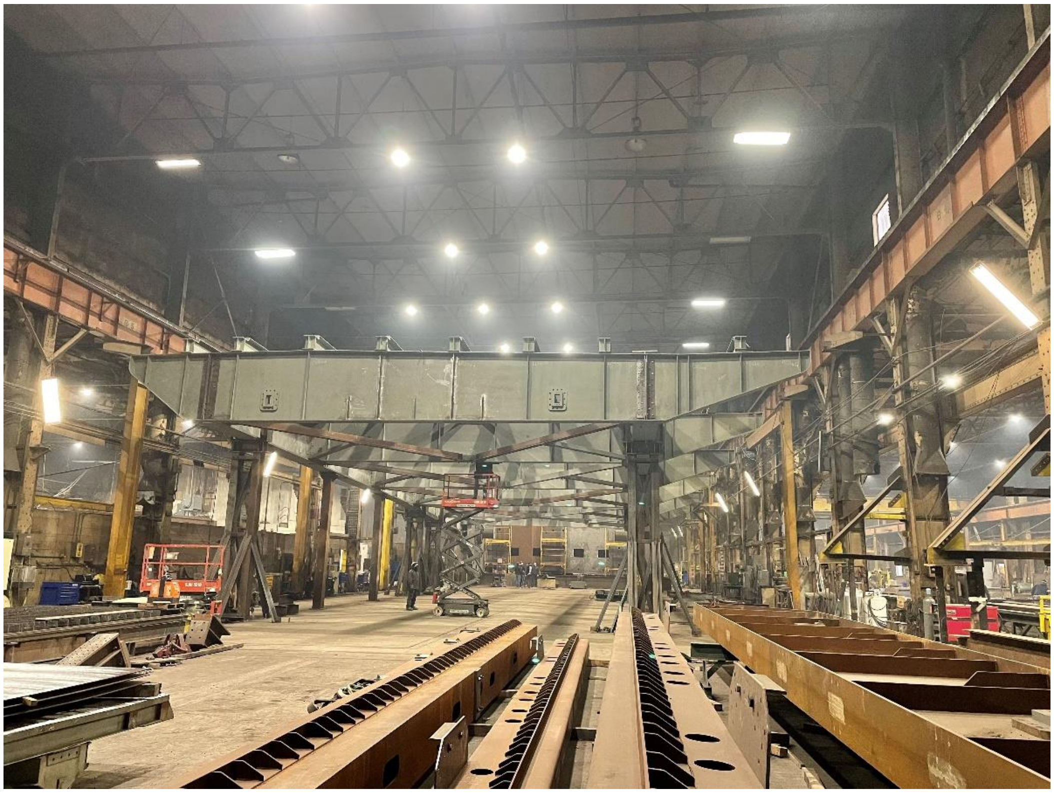
Unionport Temporary Lift Span

5.) Interim Bridge Operating Systems

In order to minimize the time needed to commission and put the new bridge into operation, an interim bridge operating system incorporating hydraulic cylinders was required. Similarly, the existing bridge was run using an interim operating system after the old electrical system was decommissioned.

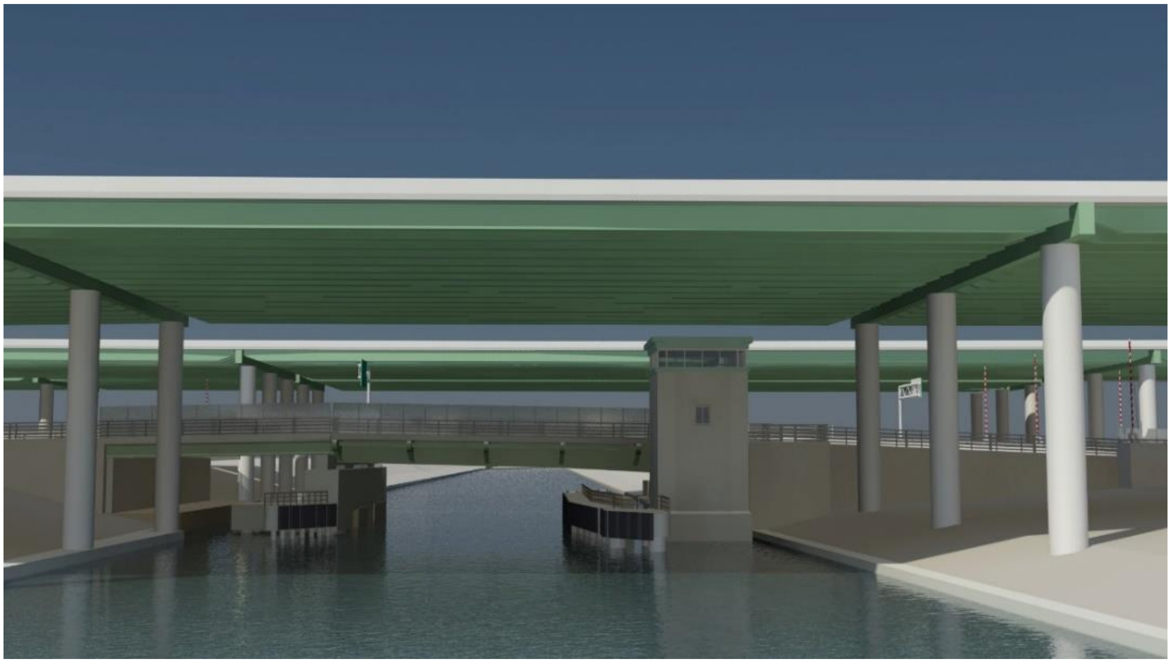
6.) Bascule Span Fabrication and Erection

The bascule girders are 159 feet long with one bolted splice to simplify shipping and erection. The new bascule span steel was fabricated, and shop assembled in Schenectady, NY before shipping to the project site where final assembly and machinery alignment was completed. The shipping route was circuitous and had to follow a route that was approved not only for the size of the components but also their weight. Due to the location of the fabricator near a canal, barge shipment was considered but trucking proved more cost effective.



Shop Assembly of New Bascule Span

Bascule Span Trunnion Bearing Installation



New Twin Single--Leaf Bascule

Conclusion

The existing Unionport Bridge needed replacement but was confined by tight site constraints. By considering all available space, innovative staging was used to replace the existing double-leaf bascule with a new twin single-leaf bascule. this allowed the project team to meet the project goals which included maintaining both marine and vehicular traffic and building a new movable span that is feasible to construct and incorporates systems and features that are easier to maintain. This project construction is scheduled to be substantially completed in late 2024.