The Conrail Point-No-Point Bridge Transformation: Replacing a Century-Old Swin Span with a Modern Bascule

BRIAN HILLHOUSE, Genesis Structures Inc., Kansas City, MO, DANIEL POST, George Harms Construction Inc., Newark, NJ

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ABSTRACT: The Conrail Point-No-Point Bridge is a critical freight rail crossing over the Passaic River in Newark, New Jersey. The project replaced a 125-year-old swing span with a modern bascule bridge featuring nearly six million pounds of structural steel. This paper focuses on the complex erection of the bascule span, including temporary falsework towers, driven pile supports, heavy marine crane lifts, and the challenges associated with milled-to-bear connections and tight fabrication tolerances.

INTRODUCTION AND PROJECT BACKGROUND

Constructed in 1901, the Point-No-Point (PNP) Bridge provides a critical freight rail connection through northern New Jersey into the Port of New York. At the time of its construction, the bridge consisted of a camelback Howe through-truss swing span that provided two navigable channels across the Passaic River while supporting a significant volume of rail traffic as seen in Figure 1. The structure was supported on stone abutments and piers founded on timber mats and timber piles, reflecting common construction practices of the late nineteenth and early twentieth centuries.

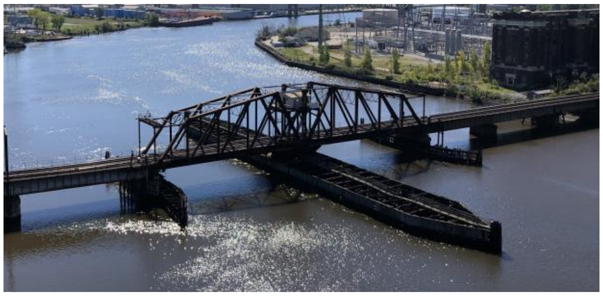

Figure 1 – Original Swing Span

Over the course of more than a century of service, the PNP Bridge underwent several modifications intended to extend its operational life. The rail line was electrified in the 1930s, and the movable span machinery was upgraded in the 1950s. Several approach spans were also replaced during this period. These improvements allowed the structure to continue serving an essential role in the regional freight rail network.

Despite these efforts, by 2016 Conrail’s engineering and operations teams determined that the bridge had reached the end of its practical service life. Persistent maintenance challenges associated with the aging substructure, combined with operational inefficiencies related to the swing span mechanism, had begun to significantly impact both rail and marine traffic. In particular, opening and closing operations for the swing span frequently exceeded five hours, resulting in delays for both vessels navigating the Passaic River and freight trains operating along the corridor.

Given the importance of this rail corridor, which carries approximately forty fully loaded freight trains per day and supports nearly two-thirds of the freight rail traffic in northern New Jersey, Conrail initiated plans to replace the bridge with a new structure designed to improve reliability, operational efficiency, and long-term serviceability.

To minimize disruption to ongoing rail operations, the replacement bridge was constructed on a new alignment adjacent to the existing structure. This approach allowed rail traffic to continue operating on the existing bridge throughout the majority of construction activities.

The new PNP Bridge consists of six fixed spans and one movable bascule span crossing the Passaic River with a total bridge length of approximately 815 ft. Spans 1 and 2 consist of multi-girder simply supported spans, while Spans 4 through 7 are simply supported through plate girder spans. Span 3 incorporates the movable bascule bridge as seen in Figure 2. The bridge substructure consists of drilled shaft piers and abutments supported on steel H-piles.

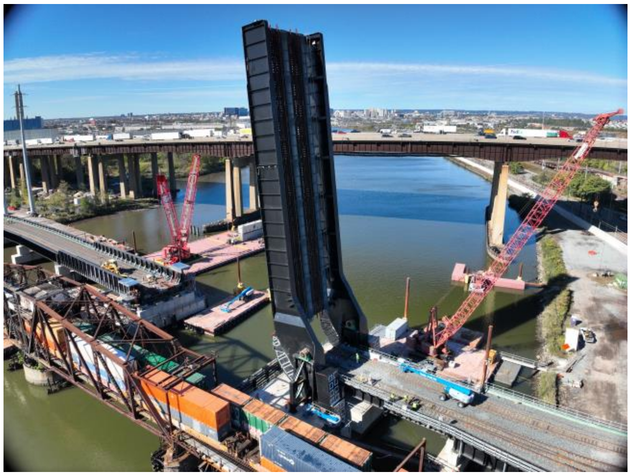

Figure 2 – Completed Bascule Span

The project includes nearly 8.5 million pounds of structural steel, of which approximately 6 million pounds are associated with the bascule span alone. The bascule bridge provides a 160-ft movable span across the navigation channel and consists of large welded plate girders with 14.5-ft deep webs fabricated from 1.5-in thick plates and flanges measuring up to 45 in wide by 3 in thick.

CONSTRUCTION METHODS OVERIVEW

Construction of the new bridge required extensive marine operations due to the bridge’s location over the Passaic River and the limited access available from adjacent land areas. A temporary trestle bridge was constructed to provide access for construction equipment and materials during early phases of the project, including installation of drilled shafts for several substructure elements.

The trestle structure ultimately played an important role during the erection of several fixed spans by providing a stable platform for crawler cranes used to place large structural steel components as seen in Figure 3.

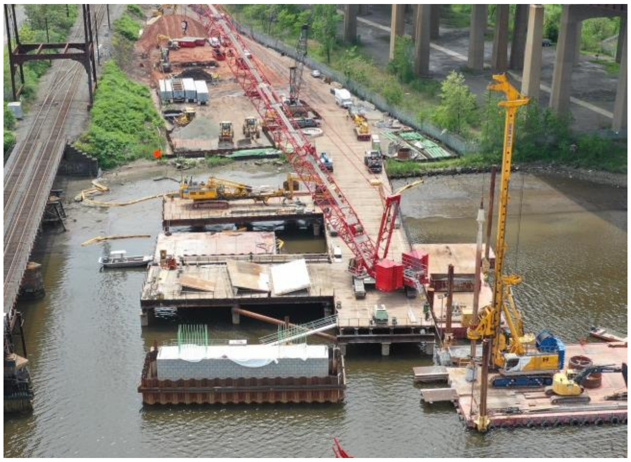

Figure 3 – Temporary Trestle Bridge

Marine crane operations were also required for multiple erection activities throughout the project. Several spans were erected using crane barges positioned within the river channel. The use of marine lifting equipment allowed the contractor to place large steel components directly from delivery barges while maintaining minimal disruption to ongoing construction activities on adjacent spans.

Alternative erection strategies were evaluated during the planning stages of the project, including land-based crane operations and temporary shoring configurations. However, site constraints, including limited staging areas and navigation requirements within the river, made marine lifting operations the most practical and efficient solution for several phases of the project.

FIXED SPAN ERECTION

The fixed spans of the new bridge were erected using conventional steel bridge construction methods. Spans 5 through 7 consist of through plate girder spans that were erected individually using crawler cranes operating from the temporary trestle bridge constructed earlier in the project.

Individual girders were lifted using bolt-on lifting lugs designed specifically for the project. Due to the large depth of the girders, approximately 15 ft, and the relatively narrow width of the supporting piers, temporary end bracing was required to stabilize each girder immediately following erection. These custom bracing assemblies provided lateral stability until floorbeams and diaphragms could be installed to complete the structural framing system. Figure 4 shows the erection of a Span 5 through girder with the temporary end bracing anchored into the side of the pier to provide stability.

Figure 4 – Span 5 Girder Erection

Once the primary girders were erected and stabilized, floorbeams and diaphragms were installed sequentially to complete each span. This process allowed the structural system to progressively achieve its final stiffness and stability as erection proceeded.

Span 4 was erected using a similar sequence, although a barge-mounted crane was used due to site access limitations that prevented crawler crane access from the trestle structure.

Spans 1 and 2, consisting of multi-girder plate girder spans with diaphragm framing, were also erected using a barge-mounted crane positioned within the river channel. Steel components were delivered by barge and lifted directly into place using conventional rigging methods.

While the erection of the fixed spans followed conventional bridge construction practices, the movable bascule span required a significantly more complex erection sequence due to its geometry, structural configuration, and extremely tight fabrication tolerances.

BASCULE SPAN ERECTION

The erection of the bascule span represented the most technically complex phase of the project. The movable span consists of two primary structural components: the rear leaf, which includes the heal girder, counterweight, and gear rack assemblies, and the forward leaf, which forms the main span of the bridge when in the closed position. Figure 5 illustrates the elevation view of the bascule system and the main member components.

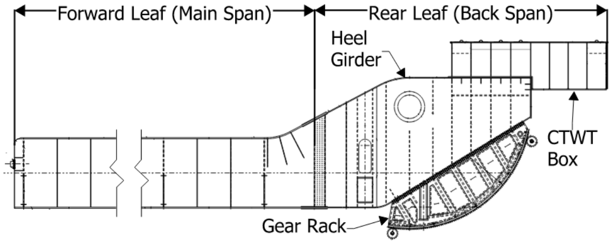

Figure 5 - Bascule Span Elevation & Main Member Components

Due to the large size of the structural components and the precision required for movable bridge operation, the bascule span was erected using a carefully controlled sequence of operations involving temporary support towers, marine heavy-lift cranes, and driven pile support systems.

REAR LEAF (BACK SPAN) ERECTION - Erection of the rear leaf began with installation of the gear rack assemblies. Each 105,000 lb gear rack was lifted from delivery trucks using a custom bolt-on lifting assembly designed to allow the component to be rotated from a horizontal shipping configuration to a vertical orientation suitable for installation. Once rotated vertical, a different set of bolt-on lifting assemblies were utilized for final erection. Figure 6 shows the many different bolt-on assemblies that were required to perform this operation.

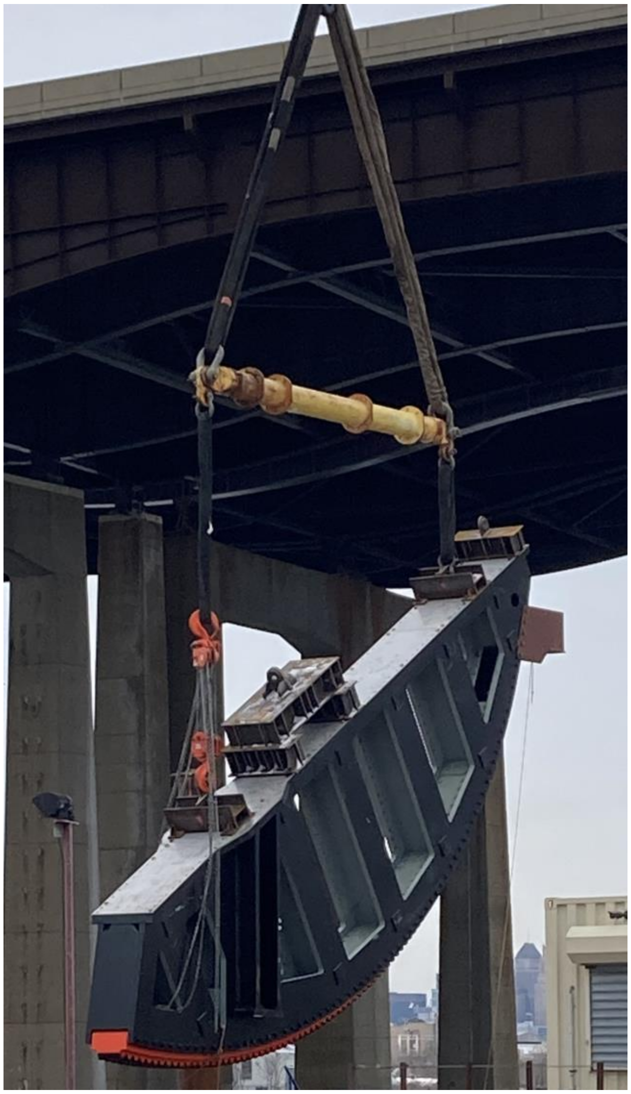

Figure 6 – Gear Rack Lifting Assemblies (vertical lifting for final erection shown)

The gear racks were erected using a Manitowoc MLC300-VPC Max S-3 crane mounted on a barge positioned adjacent to the bridge pier. Once lifted into position, the gear racks were supported temporarily on steel cribbing and a temporary support tower. Hydraulic jacks were incorporated at both support locations to allow precise vertical adjustments during alignment operations. Longitudinal positioning was adjusted using come-along assemblies as required. Figure 7 shows the positioning of the barge mounted MLC-300 just prior to gear rack installation.

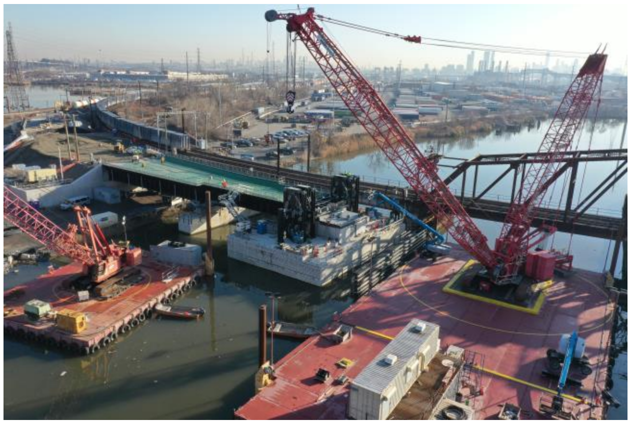

Figure 7 – MLC-300 Barge Mounted Crane

Following installation of the gear racks, the first heel girder was erected. The trunnion pin at the middle of the heel girder was supported on the permanent bascule towers, while the rear end was temporarily supported on the same support tower used for the gear rack installation. Figure 8 shows a schematic of the gear rack and heel girder supported by the temporary support tower.

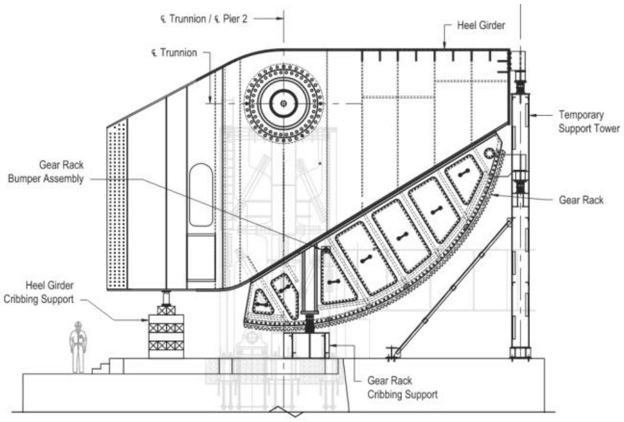

Figure 8 – Temporary Support Tower Schematic

Custom bolt-on lifting lugs and lifting beams were designed for the heel girder erection. Including rigging weight, the anticipated lifting weight of the heel girder was approximately 375 kips. Due to the proximity of the lift to the existing active rail line, Conrail requires that crane lifting operations be designed for 150 percent of the anticipated lift weight, resulting in a design lift weight of approximately 560 kips.

Few cranes were capable of performing this lift at the required radius of approximately 100 ft from a barge platform. As a result, a heavy-lift derrick barge crane was utilized for this operation. The selected crane was a Manitowoc 4600W Series 2 Ringer crane mounted on the Columbia NY heavy lift barge operated by DonJon Marine. The crane was equipped with approximately 760,000 lbs of counterweight and provided lifting capacities of up to 400 short tons over the stern and 310 short tons in revolving configuration. Figure 9 shows the position of the heavy-lift crane barge while erecting the heel girder.

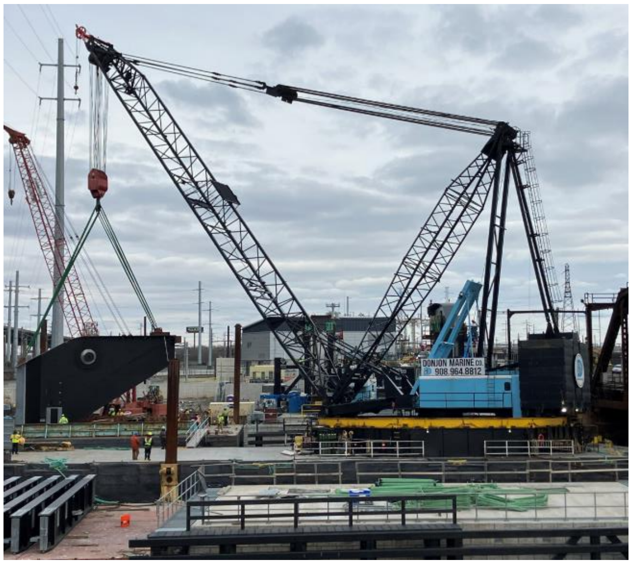

Figure 9 – Heavy Lift Crane Barge Erecting Heel Girder

Due to the extensive use of milled-to-bear connections throughout the bascule structure, erection sequencing required careful coordination to ensure proper fit-up of structural components. After the first heel girder was erected, the floorbeam between the heel girders was installed next. The floorbeam was connected to the erected heel girder and temporarily supported at its free end using steel cribbing.

The second heel girder was then erected using the same heavy lift derrick crane and supported on the same temporary support tower. Once positioned, the gear rack jacks were engaged to bring the gear rack into alignment with the heel girder connection, after which support from the gear rack cribbing was removed.

The final components installed for the rear leaf were the counterweight boxes, which were erected on top of the gear racks using bolt-on lifting lugs similar to those used for earlier lifts. Installation of the counterweight boxes completed the primary structural framing of the rear leaf.

The temporary support tower used during these operations consisted of two W24×84 vertical members with angle bracing. Due to the permanent recess within the pier required to accommodate the counterweight in the open bridge position, the tower was supported on a spanner beam that bridged this recess. The tower was required to provide both longitudinal and transverse stability for the gear rack prior to installation of the heel girders, requiring several unique connection details to ensure adequate stability during erection. Figure 10 shows the temporary support tower being utilized for temporary support of the gear rack.

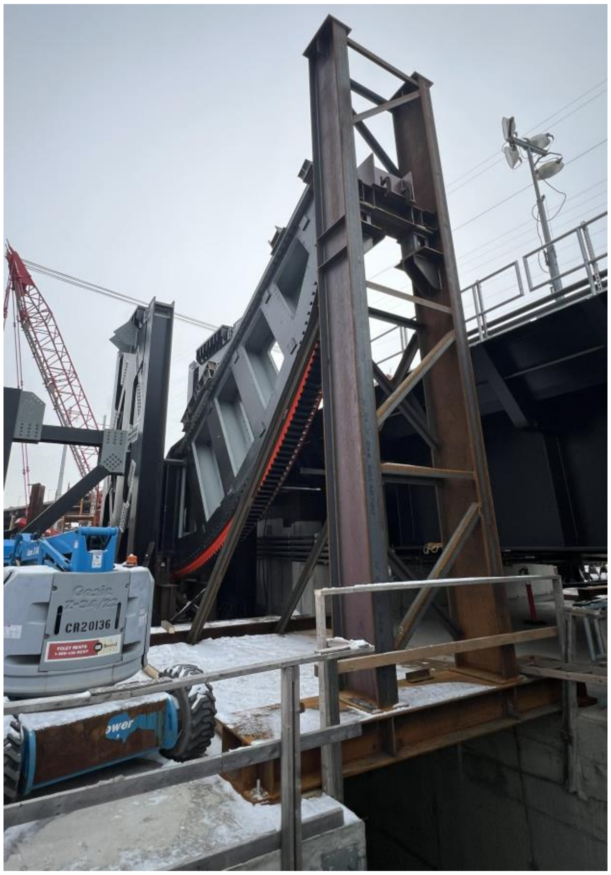

Figure 10 – Temporary Support Tower

MAIN SPAN ERECTION - The erection of the bascule main span presented additional challenges due to the extensive use of milled-to-bear floorbeam connections. These connections required extremely precise alignment between girders and floorbeams, making conventional girder-first erection methods impractical.

Instead, erection began with installation of a single main span girder connected to the previously erected heel girder. Floorbeams were then installed sequentially from this girder toward the tip of the span.

To support the free ends of the floorbeams during this process, a temporary pile-supported structure as seen in Figure 11 was constructed near the tip of the bascule span. This structure consisted of driven piles and a temporary framing system designed to support floorbeam reactions until the second main span girder could be erected.

Figure 11 – Temporary Pile-Driven Support Tower

Due to the earlier heel girder erection operations, which required the heavy lift derrick crane to occupy the space beneath the bascule span, installation of these piles could not occur until the rear leaf erection had been completed. Track stringers installed between floorbeams also utilized milled-to-bear connections, which required additional adjustments during erection. Floorbeams were initially erected slightly flared outward and longitudinally offset from their final position. Track stringers were then installed to gradually pull the floorbeams into their final alignment.

Jacking systems located at the temporary support structure allowed final adjustments to be made prior to installation of the second main span girder.

FINAL MAIN SPAN GIRDER INSTALLATION - Installation of the final main span girder presented one of the most challenging aspects of the entire erection process. The splice connection between the main span girder and the heel girder consisted of a unique configuration in which the web of the main span girder passed between the double webs of the heel girder.

This configuration required the girder to be installed using a multi-step maneuver. The girder was first erected in a longitudinally offset position. It was then shifted transversely into alignment with the floorbeam connections before finally being moved longitudinally into its final position within the heel girder splice. These movements had to be executed while floorbeams with milled-to-bear connections were already installed, resulting in extremely tight tolerances during the final alignment operations. The web splice connection alone contained approximately 220 high-strength bolts, through many plies further increasing the complexity of the installation. The heel girder to main girder field splice during erection is shown in Figure 12.

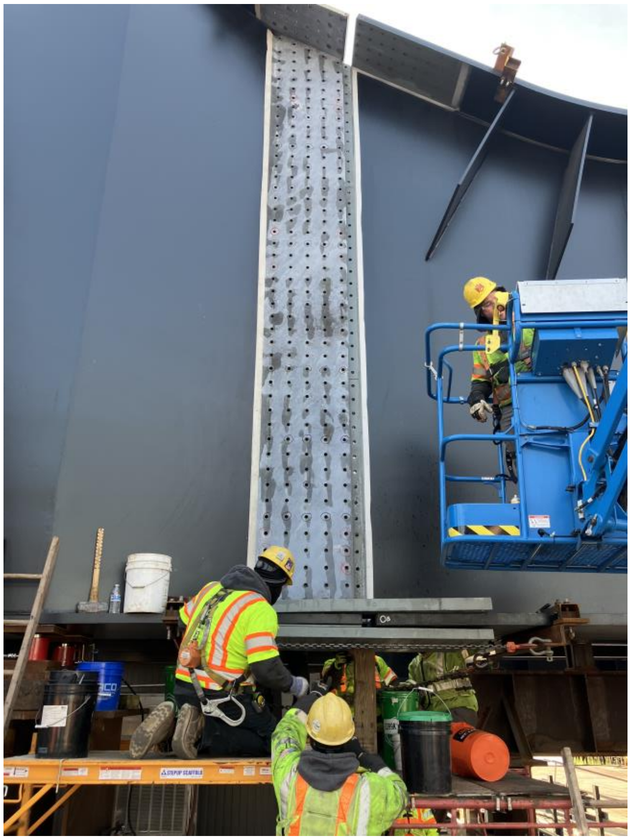

Figure 12 – Heel to Main Girder Field Splice

COUNTERWEIGHT INSTALLATION - Following erection of the rear leaf components, the structural system was temporarily unbalanced, with the majority of the structural weight located in the back span.

As additional main span steel was installed, the temporary support towers used during heel girder erection gradually disengaged from the structure as the center-of-gravity shifted to the forward span. Once the primary structural framing was complete, the lead counterweight plates were installed within the counterweight boxes to achieve the final balance condition required for bascule operation.

ALIGNMENT CONTROL AND FIT-UP - Precise alignment of the bascule structure was critical to ensure proper operation of the movable span. The extensive use of milled-to-bear connections required extremely tight fabrication and erection tolerances throughout the structure.

Thermal effects and structural flexibility presented significant challenges during alignment operations. Fabrication tolerances for many components were on the order of only a few thousandths of an inch. High precision survey measurements (laser tracker & other means) taken during erection frequently indicated that the structure would fall within acceptable tolerances at the end of a workday, only to shift outside those tolerances by the following morning due to temperature changes. To address these challenges, multiple jacking locations were incorporated throughout the temporary support systems to allow incremental adjustments during and post erection. Continuous survey monitoring was used to track alignment changes and guide the final fit-up of critical connections. Figure 13 shows one-such monitoring sensor that was used to measure the gear rack movements (radial run out, rim run out, etc.) during the operation of initially raising the structure.

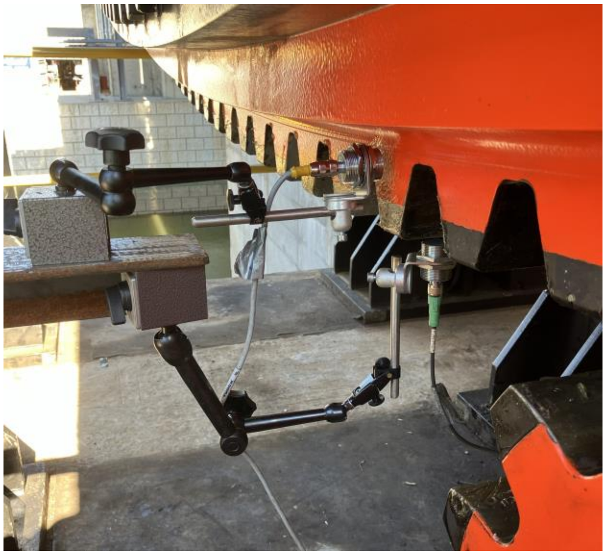

Figure 13 – Alignment Control

The completed bascule structure achieved alignment tolerances on the order of approximately 0.005 in, demonstrating the high level of precision required for successful installation of the movable bridge components.

CONSTRUCTION ENGINEERING ANALYSIS

Due to the size and complexity of the bascule span components, construction engineering analysis was performed to evaluate structural behavior during critical erection stages. Several components of the bascule structure experience loading conditions during erection that differ from those present in the completed bridge configuration. Temporary support conditions, partial framing systems, and heavy lift operations required evaluation to ensure safe and practical execution of the erection sequence.

Given the substantial size and stiffness of the bascule girders and floorbeams, global stress demands during erection were generally not governing. Conservative hand calculations were sufficient to verify that member stresses remained well within allowable limits for the majority of erection stages. As a result, the primary engineering focus shifted from strength verification to constructability, stability, and the ability to achieve and maintain required geometry throughout the erection process.

Rather than relying on comprehensive global finite element models for all erection stages, analysis efforts were targeted toward specific conditions where localized effects or stability considerations warranted additional evaluation. These included lifting operations, temporary support conditions, and connection behavior during staged assembly. For critical lifts, such as the heel girder erection, FEA shell models were created to evaluate local plate stresses and deflections due to rigging lifting forces during erection. Figure 14 shows one such shell model.

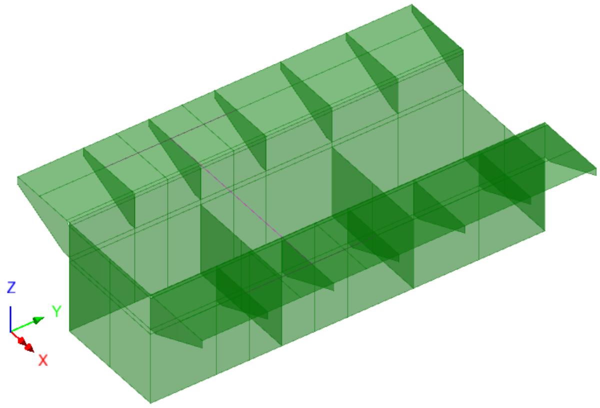

Figure 14 – FEA Shell Model of Portion of Heel Girder

Additional analysis was performed to evaluate the behavior of temporary support systems, including the rear leaf support tower and the pile-supported structure used during main span erection. These systems were designed to provide stability and controlled support reactions during intermediate stages when the structure was not yet fully self-supporting. Particular attention was given to lateral stability and load path definition, as these factors were more critical to erection feasibility than member stress capacity.

In addition to evaluating temporary support systems and lifting operations, detailed analysis was also performed to assess the behavior of the permanent bascule trunnion towers during erection of major structural components. As the bascule girders, gear racks, and counterweight elements were installed, incremental loading was introduced into the tower structure, resulting in small but measurable displacements.

A refined finite element analysis (FEA) model of the permanent bascule towers was developed to evaluate these effects and is shown in Figure 15. The study focused on both vertical and lateral movements of the tower system, including elastic shortening of the tower columns under increasing load and transverse displacements resulting from asymmetrical erection stages. Although the predicted movements were relatively small—generally on the order of thousandths of an inch—they were significant when considered in the context of the extremely tight fabrication and erection tolerances required for the bascule span.

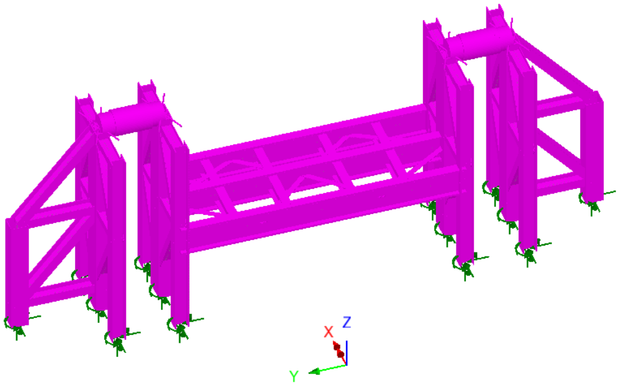

Figure 15 – FEA Model of Trunnion Tower System

Particular attention was given to the behavior of the towers during installation of the heel girders and subsequent erection of the main span components. These stages introduced eccentric loading conditions that resulted in minor but critical shifts in tower geometry. The analysis allowed the project team to quantify these movements and understand how they would influence the alignment of the trunnion assemblies and associated bearing components.

The results of these studies were used to inform field adjustment procedures, including fine tuning of trunnion bearing positions and controlled alignment of bascule components during erection. By incorporating anticipated tower movements into the erection plan, the project team was able to proactively manage cumulative tolerances and ensure that final alignment requirements were achieved.

This level of analytical refinement was essential given the reliance on milled-to-bear connections throughout the bascule structure, where even minor deviations in geometry could significantly impact fit-up and long-term performance. The integration of construction-stage FEA with field erection procedures provided a high level of confidence in the final geometry and operability of the movable span.

CONCLUSIONS

The replacement of the Point-No-Point Bridge represents a significant improvement in reliability and operational efficiency for one of the most important freight rail corridors in northern New Jersey. Construction of the new bascule bridge required careful planning and coordination between the project owner, designer, and contractor to successfully execute a complex erection sequence involving large structural components and extremely tight tolerances.

Key challenges included the use of heavy marine lifting operations, temporary support towers and pile structures, and the installation of numerous milled-to-bear connections requiring precise alignment during erection. The successful completion of the bascule span demonstrated the effectiveness of detailed construction engineering planning and close coordination among all project stakeholders. The project highlights the importance of integrating structural design, fabrication tolerances, and erection methodology during the planning of complex movable bridge structures.

ACKNOWLEDGEMENTS

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