HEAVY MOVABLE STRUCTURES, INC.
TWENTIETH BIENNIAL SYMPOSIUM

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Rt. 30 over Beach Thorofare - Rehabilitation of a Historic Complex Single Leaf Bascule Bridge

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Introduction and Project Scope

The original structure, built in 1941, is a 7-span, 471-foot-long bridge with 5 approach spans of concrete encased steel stringers, a single leaf, three girder, simple trunnion bascule main span with floorbeams, stringers, and purlins and a girder-floorbeam anchor span. The bascule span deck is an open steel grid deck while all approach spans have a reinforced concrete deck. The bridge carries three lanes of traffic in each direction, (2) 11'-0" lanes and (1) 12'-0" lane, divided by a concrete median barrier in the approach spans and custom aluminum barrier in the bascule span. The bridge also has a sidewalk ranging from 6'-3" to 7'-11" wide along each side. The Route 30 Bridge is a critical toll-free link to Atlantic City and is vital to its economy. Situated very close to the city's commercial corridor, the bridge also provides important access to the Atlantic Ocean for maritime traffic. This structure serves as an emergency evacuation route, and also needs to open for recreational and commercial vessels to access the Intracoastal Waterway.

Figure 1: Rt. 30 over Beach Thorofare Bridge

The bridge was determined to be eligible in the National Register of Historic Places as an intact example of an increasingly rare bridge type found in New Jersey. A bridge of this type has specific character defining features as identified by the New Jersey State Historic Preservation Office (NJHPO). The character defining features of this bridge are the original Moderne style concrete balustrade, metal balustrade, bascule leaf, faience tilework on the piers, and the gate tenders house and operator's house. All design decisions had to consider the need to preserve these features.

Advance coordination with NJDOT Traffic Operations South, Traffic Engineering, Movable Bridge Engineering and Maintenance, US Coast Guard (USCG), and Atlantic City, County, and local officials was utilized to set construction staging and navigational restrictions which can be summarized as follows.

1. All six (6) lanes had to be maintained in the summer months, and no restrictions to the navigational demands were allowed in this time frame.
2. One sidewalk had to be kept open throughout construction.

3. One lane each bound could be shut down long-term only between September 15th to May 14th and the movable span could be locked down from November 1st to the following March 31st for three seasons to complete the bascule span work.

4. One half of the navigational channel was required to be kept open throughout construction, for vessels that could use the waterway without a movable span lift.

Between September 15th and October 31st and April 1st to May 14th of each year when a lane was scheduled to be closed to traffic, but the bascule span had to remain operational, a dual faced guiderail system was designed for this purpose. The guiderail system, which met Test Level 4 (TL-4) crash test requirements, facilitated quick installation and removal, and was lightweight, which allowed continued operation of the movable span. However, during construction, the Contractor requested an extended bascule span closure from the USCG which encompassed the full duration of allowable lane closures. This extension eliminated the need for the temporary guiderail system, and instead traditional concrete construction barrier was used.

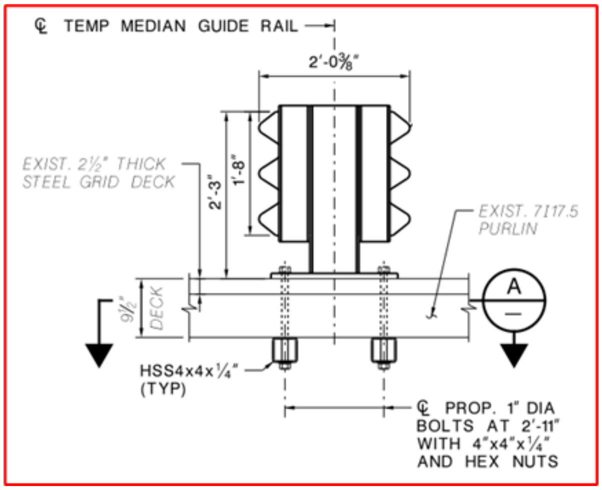

Figure 2: Temporary Dual Faced Guiderail System

Key structural scope items included complete replacement of the bascule span deck, stringers, heel/toe joints, and sidewalk, replacement of the toe floorbeam in the bascule span, rack stiffener replacement, miscellaneous steel repairs, median barrier replacement and concrete spall repairs. Safety upgrades included curb rail replacement, pedestrian railing upgrades and the replacement of movable span safety devices such as resistance barrier gates, warning gates, and traffic signals. The site-specific design of barrier gates was another complex feature. Site-specific wind gust resistance and an infinite fatigue life design required a high strength, stiff design, while energy absorption requirements for the crash loads per AASHTO MASH required flexibility of the gate system.

Mechanical upgrades included replacement of the live load shoes, span locks, primary reducer, auxiliary diesel drive, motor and machinery brakes and air buffers. Electrical upgrades included updating the Programmable Logic Controllers (PLCs), and replacement of service lines, limit switches, safety interlocking, and redundancy of operation via a generator. A new sidewalk was also added connecting the southeastern corner of the bridge, to Gramercy Avenue, providing a new pedestrian connection to a community previously cut off without this pedestrian access.

A key challenge of a movable bridge rehabilitation is maintaining the delicate balance of the movable span throughout construction and at completion. As a result, each pound added or subtracted from the span had to be accounted for in detail throughout the design. Every design decision made on the bascule span had to be carefully vetted in order to maintain the span balance, as the original machinery will be retained.

Bascule Span Upgrades

Bascule Span Deck and Superstructure

Total replacement of the bascule span deck and supporting stringers was necessary to increase the load carrying capacity to HL-93 live load. The existing framing in the bascule span, shown in Figure 3 below, consists of a 2.5” thick riveted steel grid deck, closely spaced transverse purlins, support stringers, floorbeams, and girders. The replacement consists of a 5” thick heavy-duty welded rectangular steel grid deck supported by steel stringers, shown in Figure 4. The thicker deck eliminates the need for purlins and provides a reduction to the overall weight imposed on the leaf.

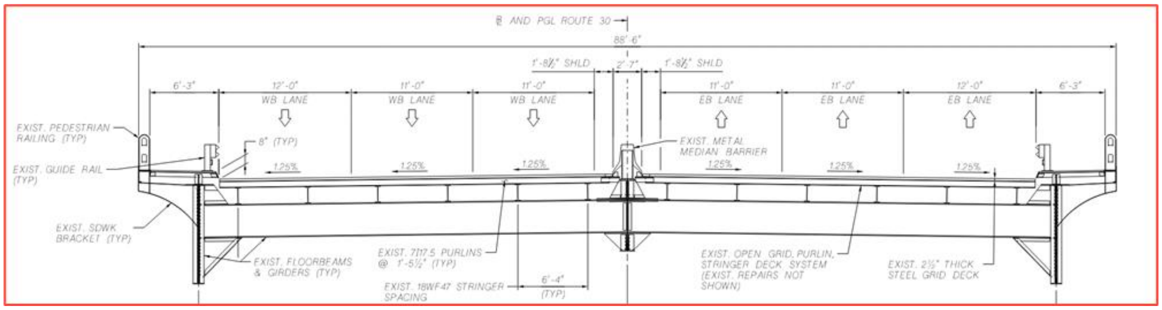

Figure 3: Existing Typical Cross Section, Bascule Span

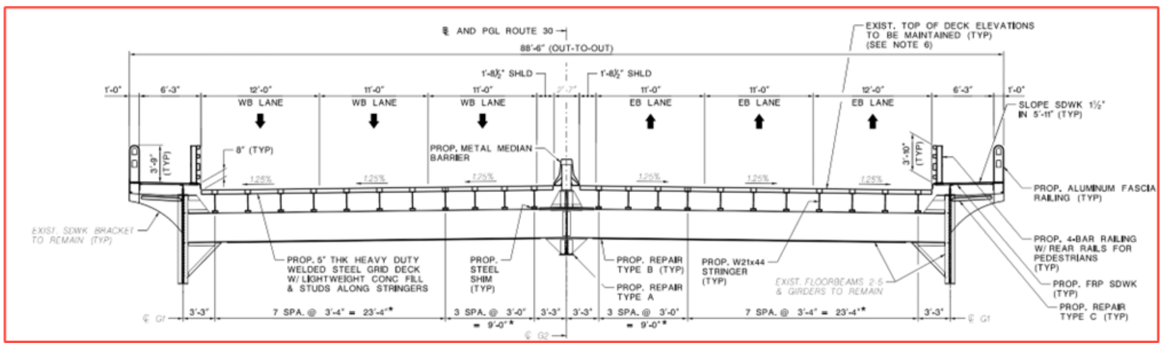

Figure 4: Proposed Typical Cross Section, Bascule Span

The deck to stringer connection includes shear studs field welded to the top flange of the stringers spaced at 4” and lightweight concrete fill poured over the width of the flange to protect the stringers from deterioration as done successfully elsewhere in New Jersey. This detail also eliminates the need for time-consuming field welding. At stage lines, this connection detail included temporary hold down plates where the concrete could not be poured until a later stage, as seen in Figure 5 below.

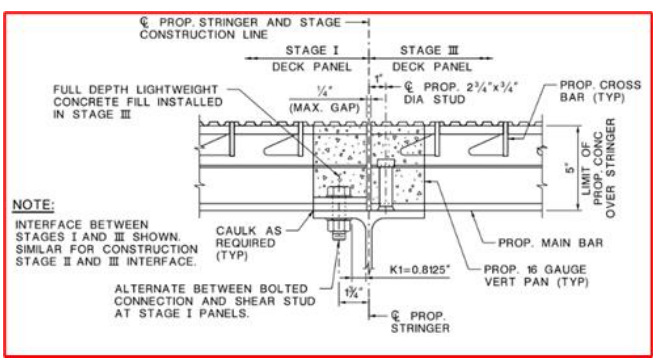

Figure 5: Detail of Concrete Fill, Shear Studs, and Hold Downs at Stagelines

A deck type study and cost benefit analysis were completed considering cost, efficiency, speed of construction, weight implications, span balancing requirements, maintenance and material type. This matrix analysis favored the use of a welded steel grid deck system. The counterweight pockets are full, leaving no room to add additional weight to the span, so retaining or lessening the leaf load was a critical factor in the choice. A 5" thick heavy duty welded rectangular steel grid deck with main bar spacing at 6" was selected. The grid deck system consists of the 5" main bearing bars, transverse cross/distribution bars, and supplemental bars, shown in Figure 6.

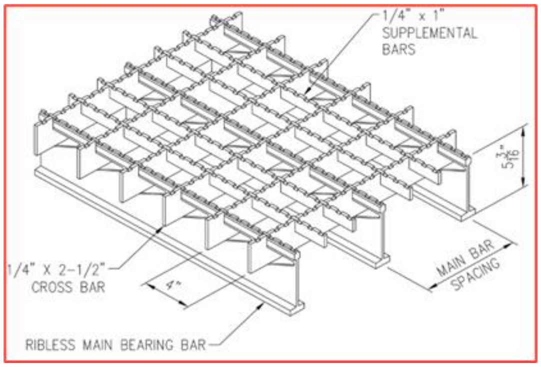

Figure 6: 5" Rectangular Steel Open Grid Deck

A 2D model with an equivalent moving wheel point load was used for the analysis, considering equivalent strip widths per Section 4 of AASHTO. The grid deck and stringer system was designed as a non-composite section, conservatively not accounting for the stiffness provided by the lightweight concrete fill and grid deck over the stringers.

Fatigue resistance governed the grid deck design. AASHTO classifies the main bar weld connection to the secondary bars as a Category E detail, unless evidence for a lesser Category is provided. Coordination with manufacturers, review of past performance testing and research on open grid decks has demonstrated that a higher threshold than a Category E is allowable. The team justified using a Category C detail per AASHTO (Category C is 10 ksi as opposed to the Category E, which is 4.5 ksi). Further, past manufacturer product data, long-term use and performance history on similar clear deck spans of 3' to 5' has been satisfactory. Based on these factors, manufacturers indicated that considering fatigue as part of the open grid design is not necessarily a deterrent for product use, and a specific verification check was included in the analysis. Had this increase in allowable fatigue stress not been allowed, it is likely that the stringer spacing would have been significantly tighter, leading to increased weight in the bascule span.

Figure 7: Stage 1 Finished Steel Open Grid Deck

The stringers in the bascule span were chosen to create the most efficient framing system with the removal of the existing purlins. Spacing was dictated by construction staging and the allowable grid deck span, and the height was dictated by the available space between top of floorbeam and bottom of deck. Within this envelope, the most efficient section was selected. The toe floorbeam was also in need of replacement, which required complex staging considerations given that the floorbeam is framed into the center girder, but construction staging split the bridge into thirds. The floorbeam removal cut line therefore did not correspond to the deck removal cut line. In order to solve this problem, a temporary support system for the stringers and deck was designed for the time during which the floorbeam was removed and live load was still travelling over the area of removal. The floorbeam was originally designed as continuous with strap plates connecting the top and bottom flange through the center bascule girder. This design approach was used again during the rehabilitation, in all staging conditions. During construction, the contractor requested to remove the strap plates to simplify the replacement and then install new strap plates in the final condition, resulting in a simply supported condition during periods of construction. Following a detailed submittal of their procedure and discussion with NJDOT Structures, the contractor's proposal was accepted.

Bascule Span Sidewalk

Other important weight considerations for the span included replacing the concrete-filled grating sidewalk, steel pedestrian railings (a character defining element per NJHPO), curb guiderails, and sidewalk supporting steel members.

A large weight savings was achieved by using lightweight yet strong fiber-reinforced polymer (FRP) panels for the sidewalks. This helped compensate for the weight added by an NJDOT standard crashworthy railing separating vehicular traffic from the pedestrians.

FRP sidewalk panels provided an excellent option for weight reduction, which was pivotal as there was no room left in the counterweight pockets. After evaluating several options, a 1-¾" thick panel was chosen, which provided sufficient strength, service, and deflection properties. The supporting steel was also lightened and placed transverse to the direction of traffic, allowing a thinner and lighter FRP panel to be used. It was estimated that the existing sidewalk weighed approximately 36,000 pounds, and the curb railing and all supporting steel added an additional 9,500 pounds, totaling 45,500 lbs. The estimated weight of the proposed sidewalk panels and supporting steel was 24,500 pounds, cutting the weight of each sidewalk roughly in half. The reduced weight offset the additional weight of the proposed steel 4-bar rail, which required MASH TL-4 crashworthiness in replacing the existing curb guiderail. The switch to a MASH approved TL-4 railing required the custom design of the connection directly to the top flange of the bascule girder in order to maintain the TL-4 rating. At the time of Final Design, the NJDOT Standard steel 4-bar open railing system was an approved system.

In total, these modifications theoretically accounted for a reduction of 3,600 pounds in the bascule span.

Bascule Span Median Barrier

The proposed aluminum median barrier on the bascule span had four major conditions that needed to be met: satisfy geometric constraints and compatibility with the approach median, sustain collision loads, achieve a constructible connection to the existing girder, and add no additional weight to the bascule span.

A detailed investigation into crashworthy barrier options led to numerous barriers found on the FHWA longitudinal barrier website, but none were deemed suitable due to either geometric or weight limitations. An alternative NCHRP TL-4 compliant aluminum median barrier from a local fabricator was considered, but this barrier could not connect directly to the existing bascule girder and was approximately twice as heavy as the existing lightweight aluminum median barrier. An alternative movable type barrier, designed to meet AASHTO MASH TL-4, was considered. However, it was not geometrically compatible with the approach median, and was also twice as heavy as the existing median. Ultimately, the team received approval to replace the existing aluminum median in-kind. While the existing aluminum median barrier has not been crash tested for the MASH TL-4 level, our calculations have verified that the barrier can develop the same capacity as the NJDOT Standard Concrete Median Barrier. Additionally, the median has experienced at least one previous vehicular impact and remained intact, showing its ability to provide resistance, albeit details of the prior collision are not available (Figure 8).

Figure 8: Impacted Aluminum Median Barrier

The subsequent challenge was to find an aluminum fabricator to fabricate this custom aluminum barrier based on the existing design. Many aluminum fabricators only create standard members, and the original fabricator of the existing custom aluminum barrier is no longer in business. The aluminum median barrier is made of three elements – the two outer rails and the cap placed on top. These elements are mechanically connected together and attached to a steel post. This detail is shown in Figure 9.

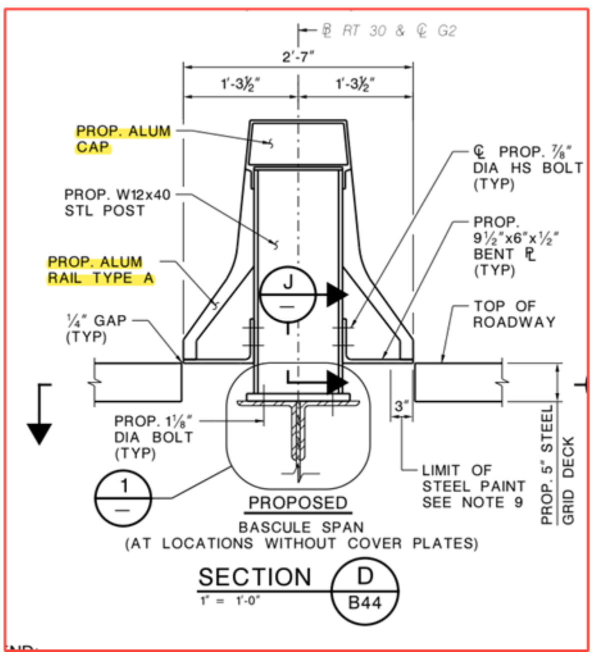

Figure 9: Bascule Span Aluminum Median Barrier Section

Due to the complexity of the rail elements (Figure 10) these segments of the median barrier need to be extruded in one piece. Although some aluminum fabricators considered extruding the railing in 2 pieces and welding the sections together, this option was eliminated early in the process. This option was eliminated because either the large voids create thin metal sections that would lose strength if welded together, or the thin metal sections were too thin to weld to.

Aluminum fabricators are limited in extrusion size based on their press and dies available. Many presses are limited to 22" or less.

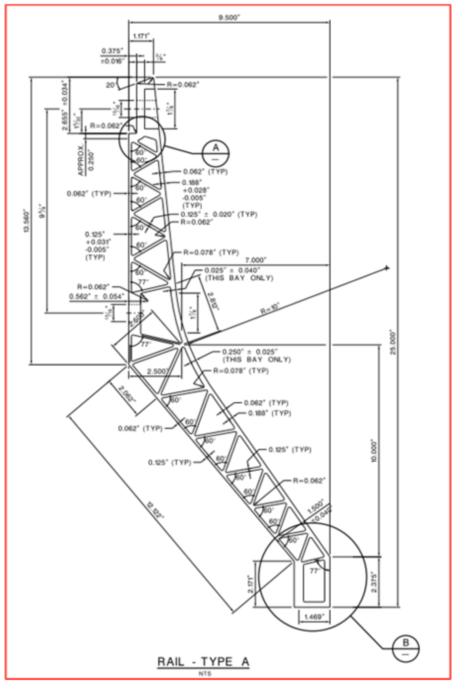

Figure 10: Bascule Span Aluminum Median Rail Detail

After extensive research, a fabricator was found to be one of the few, if not only, custom aluminum manufacturers in the country that was able to custom create this aluminum median barrier. With this confirmation, the team detailed the aluminum barrier to be replaced in-kind to keep the weight the same. The existing barrier was also mandated to be stored at the NJDOT yard after construction as a spare for future use.

Approach Span Upgrades

In the approach spans, the majority of the work consisted of various safety improvements. The existing curb guiderail was substandard and had to be replaced with a TL-4 rated steel 4-bar railing, that matched the railing used on the bascule span. The existing concrete, historic, fascia pedestrian rail was not compliant with current OSHA standards for height and needed to be replaced or modified. The existing resistance barrier gates, warning gates and traffic signals for the movable span did not meet MUTCD, AASHTO nor MASH requirements and had to be replaced to meet these codes. The wind at this site is known to be much stronger than other inland areas and the excessive wind gusts was a key consideration in the site-specific gate design, see trailing section for site specific requirements. Lastly, the existing highway lighting had to be replaced to meet current standard lighting requirements.

Historic Considerations

The historic and character defining concrete fascia pedestrian railings were affected by the bridge lighting replacement (existing and new standards were placed on the railing pylons), the upgrade of the fascia railing to meet OSHA requirements (the height was to be increased), and the replacement of the gates (the gates physically conflicted with the existing railing). All of these items had to be completed while preserving the fascia railing. A Historic Bridge Alternatives Analysis was performed in order to present options for NJHPO to approve the recommended alternative so that the project can meet the Secretary of the Interior's Standard for the Treatment of Historic Properties. This resulted in a Memorandum of Agreement (MOA), which accepted the project's proposed treatments of all historic elements.

A portion of the railing post pylon was planned to be demolished and rebuilt to accommodate lighting replacement. Embedded in these pylons was decorative faience tilework, and at the bridge corners, the date and route identification tiles. Ultimately, the MOA stipulated that all tilework must be carefully removed, cleaned and reset in the same place as the original construction, embedded in new concrete. The new concrete at this location must match the color, texture, quality and exposed aggregate finish of the existing concrete. A test panel was required to be provided to SHPO for approval.

During construction, rather than demolish a portion of the pylon and cast the lighting standard anchors in new concrete, the contractor requested to utilize post-installed anchors at these locations. This was originally considered and not pursued during design in order to maintain the standard NJDOT anchor bolt detail. Following coordination between the contractor, NJHPO, and NJDOT, the request was accepted and post installed anchors were used, maintaining all existing concrete.

The existing fascia railings were inadequate in height to meet current OSHA code. Options considered to comply with OSHA were to replace the railing in its entirety with a new, taller railing of the same appearance, adding a top rail by drilling and grouting into existing, or to leave the railing as is and provide a new aluminum open railing system in front of it while not obscuring the original rails. Ultimately the third option, shown in Figure 11 was preferred and an aluminum railing with the least impact to views of the existing railing was selected.

Figure 11: New Aluminum Railing in Front of Existing – Note the original concrete railings are visible

In order to accommodate the new resistance barrier and warning gates, cantilevered platforms on the fascia needed to be constructed. This meant that sections of existing railing had be removed to allow the operation of the drop-arm gates. Under a previous rehab contract, at the location of existing gates, sections of railing had already been removed from the bridge. In order to limit the impact of this project, the MOA stipulated that the sections of railing removed for the new gates shall be salvaged and moved to replace the rails that had been previously removed, shown in Figure 12.

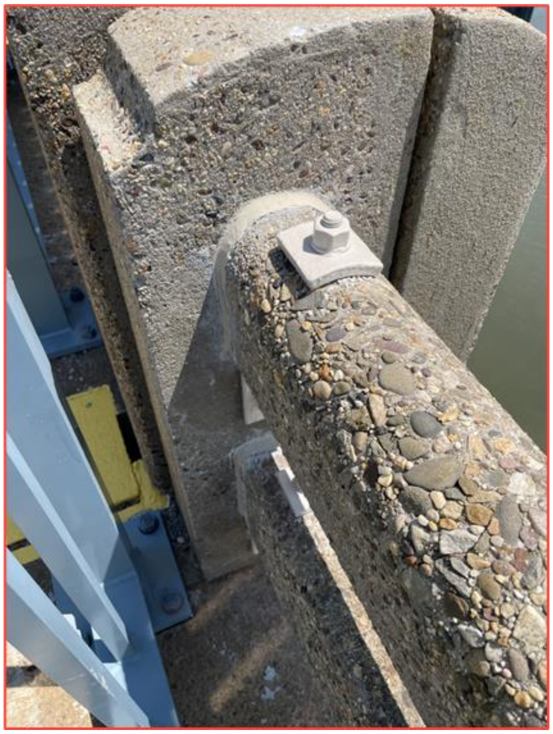

Figure 12: Salvaged Rails at Existing Gates

In the bascule span, the original fascia railing consisted of a steel railing, matching the architectural features of the concrete railings in the approach spans. Due to the same OSHA upgrades, this railing also needed to be modified or replaced. Due to the fact that the adjacent sidewalk and some supporting elements were being replaced, it was determined that replacement was the best option. Again, to save weight, a custom aluminum railing, of the same architectural features but meeting the taller OSHA requirement was designed. This switch from steel to aluminum, though the railing was taller, resulted in a net reduction in bascule span weight of approximately 5 kips.

At the operator's house and gate house, prior to starting work on concrete repairs to the houses, the paint color was submitted and approved and test panels of the architectural concrete styling were required to be submitted and approved by SHPO.

Resistance Barrier Gate Design and 3D Simulation Analysis

The existing resistance barrier gates fouled the sidewalk width, did not meet current MUTCD, AASHTO, and MASH standards and did not satisfy NEC working clearances around the equipment at the platforms. Furthermore, the current barrier gate design has been reported to have not sustained high winds during Superstorm Sandy in 2012 and another such hurricane in 2016 while in their vertically stowed position.

NJDOT tasked the team with updating the gate design to meet not only current criteria, but a much higher wind speed (125 mph gust per current AASHTO maps), infinite fatigue life, and also MASH Test Level-2 (TL-2) criteria. To comply with MASH TL-2, the gates were each required to function as a non-redirective crash cushion capable of resisting the 1100C (Small Vehicle) and the 2270P (Pickup Truck) test vehicles impacting head-on at 44 mph. NJDOT mandated a 125 mph wind speed design, much larger than what had been used in earlier designs (70-90 mph). In summary, the design requirements were as follows:

1) Shall be resistance type, of tubular construction, using non-spliced tubes
2) Shall resist the 125-mph gust wind speed in any position
3) Shall meet MASH TL-2 performance requirements when deployed
4) Shall meet AASHTO Fatigue design for infinite life
5) Shall cut time of gate operation

The team had previously completed a similar design to these requirements, which at the time was the first of its kind in NJ for a resistance barrier gate. and. The gate design criteria is, to an extent, at the discretion of the Owner. NJDOT has elected to utilize these stringent requirements above and beyond the requirements of the code as a standard for all future gate replacements. Though a design of this type has been completed in the past, each site presents a unique geometry, and a new design and crash testing program is mandated for each new structure when significant variations exist in the drop arm length. In this case the parameters required a unique design. WSP and NJDOT teamed with the Texas A&M Transportation Institute (TTI) and B&B Roadway to develop a theoretical prototype during Final Design and completed analytical 3D Simulation models to verify theoretical viability and to give a high level of confidence of success during future physical crash testing by the Contractor. It is noted that the earlier project's simulation analysis versus actual crash tests were in excellent correlation, leading to this effort for simulation verification.

The initial design coordination with B&B Roadway resulted in the prototype, seen in Figure 13, a vertical to horizontal articulating resistance barrier gate. It would be stowed in the vertical position on a platform outside the bridge fascia. When fully deployed, the gate tip will lock into an anchor assembly embedded in the median barrier. Geometric constraints required the two arms of the gate to be longitudinally offset from each other with independent far side receivers. The existing gates lock into each other, creating one long gate. This was considered initially but not selected due to the flexibility of the system and the risk in having difficulty passing crash tests.

The gates are typically composed of three aluminum tubes (trichords), arranged such that the front two tubes are parallel, co-planar and facing traffic, with the third tube offset horizontally and set midway between the front tubes. Energy absorbing, high strength annealed steel cables are placed inside the two front tubes and one cable between the front tubes. The main tubes are connected by aluminum tube braces of different diameters, varying in size from the base region towards the tip region, based on demand. The barrier arm length was custom designed for 44'-4" based on the deck geometry.

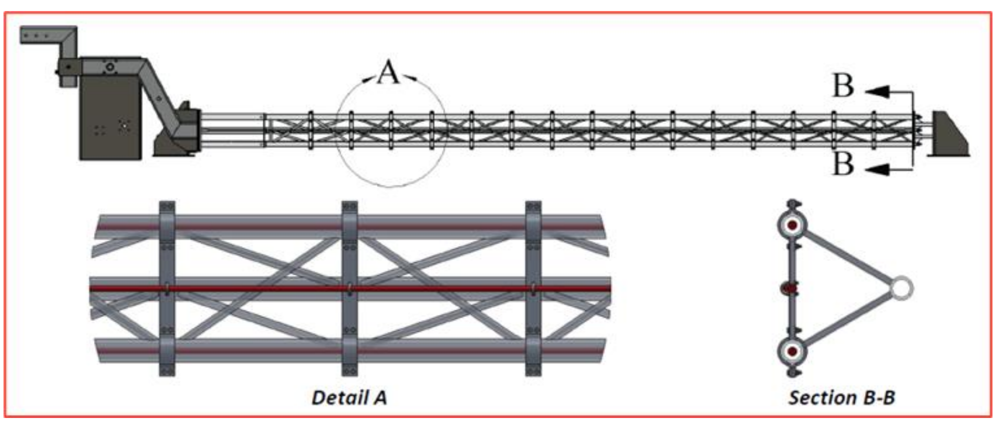

Figure 13: Resistance Barrier Gate Prototype

The wind load was applied to all components and attachments including flashing lights, support brackets, exposed cable and delineators. Three critical positions within the range of gate movements were chosen for analysis; deployed horizontal (Position 1), stowed vertical (Position 3) and midway between extremes at 45 degrees (Position 2) to capture the range of motion. All positions were modelled as free cantilevers, considering the horizontal position just prior to locking at the tip (Figure 14). Applying wind load along the bridges' longitudinal axis (normal to the gate arm) produced the maximum stress conditions.

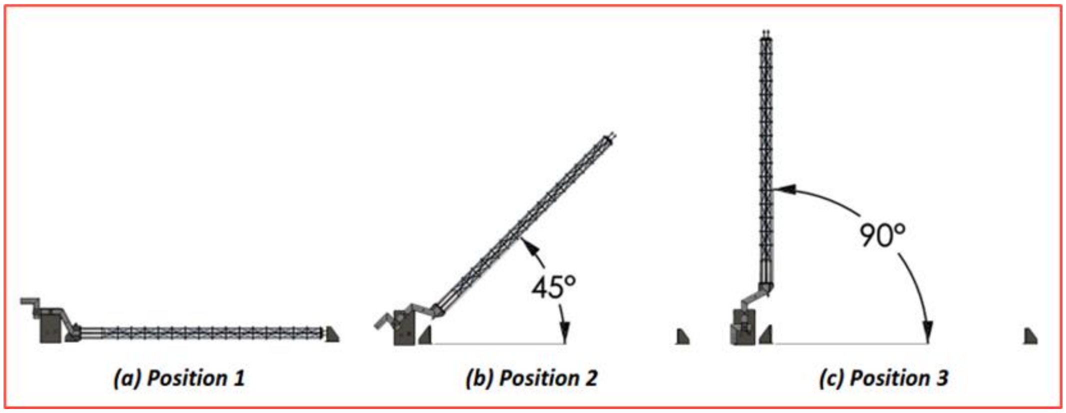

Figure 14: Range of Gate Motion used for Wing Load Simulation Analysis

The fatigue design utilized a Constant Amplitude Fatigue Threshold design per the 2015 AASHTO LRFD LTS-1 Specifications, with 2020 Interims. Conservatively, the gate arm was analyzed as a Category I Sign Structure. Galloping and natural wind gusts were applied in separate models. The initial model indicated higher than allowable stresses for two diagonal truss cross members in fatigue. The abrupt change in chord member size used in the first iteration concentrated stress at this location. A more gradual reduction in chord size was used in the second iteration to reduce the stress ratio for fatigue.

Finite Element crash analysis simulations and responses of the prototype were performed by TTI using LS-DYNA software, a finite element (FE) program used by the automobile industry to solve non-linear, dynamic response and load-time history response of a vehicle impacting a barrier system.

A highly refined mesh was developed for the FE analysis. The cables, bolts, bracing, tubes, plates and receivers were all explicitly modelled, and the refinement was highly iterative (Figure 15). B&B Roadway shared material samples with TTI so that the TTI model could closely represent the prototype.

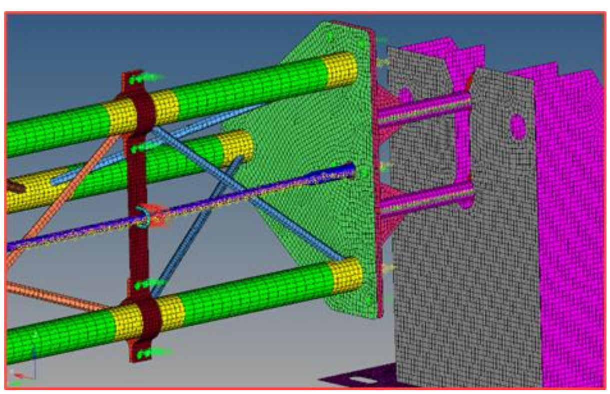

Figure 15: Typical Screenshot of FE Mesh used in the Simulation Analysis

MASH performance criteria was utilized in the simulation analysis. The simulation included verification of head-on impact of the two recommended test vehicles at a speed of 44 mph, for the following criteria:

1) Structural Adequacy and
2) Occupant risk
    a. Detached elements not to penetrate passenger compartment, limitations on deformation of vehicle components
    b. Vehicle to remain upright during/after collision, roll and pitch angles
    c. Occupant Impact Velocity (OIV)
    d. Occupant ride-down acceleration

Simulation results were expected to closely correlate with actual crash test results, based on prior experience. Simulation results, actual crash test results, and comparison to MASH performance criteria are tabulated in Figure 16. For both the small vehicle and pickup truck, the impacts at both quarter points and the mid-point of the gate arm were modelled. The actual crash tests consisted of one impact point for each vehicle – the quarter point closest to the nearside receiver for the small vehicle and the quarter point closest to the farside receiver for the pickup truck. The results shown in Figure 16 compare the simulation results and actual crash test results at the same impact location.

PARAMETER EVALUATED	SMALL VEHICLE 1100C		PICKUP TRUCK 2270P		MASH ALLOWABLE
	FE RESULTS	ACTUAL CRASH TEST RESULTS	FE RESULTS	ACTUAL CRASH TEST RESULTS	
Occupant Impact Velocity-Longitudinal	35.4 fps	33.7 fps	30.3 fps	26.7 fps	30 fps preferred 40 fps maximum
Occupant Impact Velocity-Transverse	0.1 fps	2.0 fps	2.4 fps	2.6 fps	30 fps preferred 40 fps maximum
Ride-down Acceleration-Longitudinal.	-15.1 G's	-11.3 G's	-15.2 G's	-9.7 G's	15G's preferred 20G's maximum
Ride-down Acceleration-Transverse	-2.5 G's	-2.5 G's	-5.5 G's	-1.8 G's	15G's preferred 20G's maximum
Roll angle	2.7 deg	7.3 deg	2.9 deg	3.5 deg	75 deg max.
Pitch angle	1.1 deg	6.4 deg	12.7 deg	5.2 deg	75 deg max.

Figure 16: Comparison of FE Simulation Results versus Actual Crash Test Results

The staging of barrier gate replacement also presents significant challenges to the designer. At all times when the bascule span is operable, a gate system must be in place. This means that the existing gates cannot be removed until the new gates are installed, tested, and accepted. Further, due to the use of construction barrier in order to separate bi-directional traffic, accommodate construction staging and lane shifts, custom barrier details must be utilized to accommodate the barrier gate arms during all stages of construction. Similar interim conditions at the curb railing must be designed to accommodate all interim gate conditions throughout construction.

Mechanical and Electrical Rehabilitation

In order to take advantage of the span outages required throughout construction, a significant mechanical electrical rehabilitation was pursued as part of this work. During the Final Design inspection, unexplained damage was found on the gear teeth of the enclosed primary reducer. When compared to past inspection reports, it was determined that the damage had occurred recently. The cause was not found, and due to the fact that a significant rehabilitation was planned, a full replacement of the primary enclosed reducer was added to the contract. Similarly, because the machinery room enclosure was due to be replaced as a result of deterioration, the project team understood that this was an opportunity to replace large items in the machinery room which could only be replaced while the enclosure was removed. This allowed the auxiliary diesel direct drive system (engine and reducer) to be replaced while the enclosure was removed. Other mechanical work included span lock replacement, buffer replacement, live load shoe replacement and trunnion/trunnion cap rehabilitation.

In order to continue to provide redundancy in addition to the diesel direct drive, NJDOT utilizes backup generator power. The existing generator was within the operator house and did not meet current NEC clearance requirements. As a result, the generator was moved out of the house, onto available space adjacent to the approach roadway. This allowed the generator size to be increased to support longer backup runtime while meeting all NEC code requirements. Much of the electrical rehabilitation focused on providing modern systems to replace old and obsolete systems for which replacement parts are hard to procure. This included conduit and wiring replacement, service and meter replacement, CCTV system replacement, MCC system replacement, and PLC system updates. The updated PLC system was upgraded to modern standards as well as to support the new and upgraded warning and barrier gate system being installed.

Construction Status

At bid, construction was planned to occur over 3 winter seasons, when permanent lane closures were allowed based on seasonal traffic demand, with final acceptance in August 2023. Each winter season, the bascule span would also be locked in the closed position to complete the work, per coordination with the USCG and in accordance with Local Notice to Mariners by the USCG. The final winter construction season was planned to end in the spring of 2023, with punch list work occurring through the summer of 2023. Due to unforeseen circumstances, the barrier gates were delayed, necessitating an extension to the original contract schedule with completion moving to the summer of 2024. Only barrier and warning gate work, along with associated components were extended into the winter of 2023-2024. All other main contract work including deck replacement, railings, mechanical and electrical have been completed on the original schedule. Final Acceptance was reached August 2024.

Conclusion

In conclusion, the design of the rehabilitation of the Rt. 30 over Beach Thorofare project balanced the complex requirements of a single leaf bascule span with historical considerations while upgrading the safety features, load carrying capacity and life cycle of the structure. Strategies utilized on this project such as the use of FRP, and custom aluminum shapes may be used for future movable bridge rehabilitations where weight and historic concerns are common constraints. It is anticipated that the industry will continue to move towards MASH compliance with barrier gate systems and similar challenges as presented here will be seen on many movable bridge rehabilitations in the future. These complex requirements were met in a fast-tracked design environment (less than 10 months); the team delivered the project, considerably faster than a typical Final Design in order to utilize the 2020-2021 winter construction season while navigating the challenges of the Covid shutdowns of this period. Throughout design, coordination was required with many stakeholders including local officials, NJDOT Project Management, the USCG, SHPO and the NJDOT Movable Bridge Engineering Group. Expedited input from all parties was vital to this project's design and client satisfaction.