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Navigating Mechanical Challenges During the Construction of the North Hero Movable Bridge

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Introduction to the North Hero Movable Bridge Project

Bridge Overview

The North Hero Movable Bascule Bridge, located on US Route 2, serves as the only connection between the Vermont Isles of North Hero and South Hero. This double-leaf bascule bridge, the only vehicular movable bridge in Vermont, and is the main means of road and marine traffic over Lake Champlain.

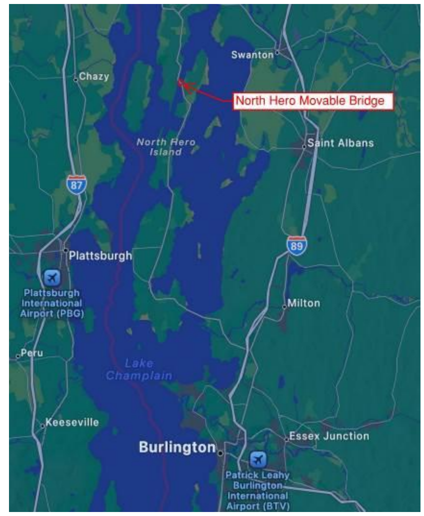

Photo No. 1: The North Hero Movable Bridge project site.

The North Hero Bridge took five years to complete. Beginning in May 2018, the construction faced numerous hurdles and delays, leading to the mechanical component starting onsite installation in January 2022. The project met its scheduled completion date in May 2023. WSP was consulted to provide onsite construction inspection services for the mechanical and electrical systems during this period, with inspectors present throughout the construction of the bascule leaves. This extended timeline highlights the complexities and challenges encountered during the project.

Once completed, the new bascule bridge would include a single lane for both northbound and southbound traffic, an 81-foot-wide channel, wireless communication between spans, and full redundancy for essential electrical and mechanical systems. It also boasts a state-of-the-art hydraulic machinery system, control house with digital touch screen displays, and highly accessible maintenance areas throughout.

However, due to the significant outage and impact on the local community, a temporary bridge was erected adjacent to the construction site. This bridge was installed before the demolition of the existing bascule bridge, constructed in 1953. The contractor maintained the temporary bridge, ensuring it met all the opening requirements established by the United States Coast Guard (USCG). These requirements posed a challenging decision to work through the winter.


Photo No. 2: The North Hero Movable Bridge Construction site with the temporary bridge adjacent to the new hydraulic bascule bridge.

Weather Impacts

The winter months of 2022 were particularly harsh, with temperatures on the jobsite reaching a low of -15.9°F, making construction extremely challenging. Despite these conditions, the bridge's construction continued to meet tight deadlines set at the end of winter. Most days began with several hours of snow and ice removal, and constant ice breaking between the piers was necessary to allow barges to maneuver the jobsite. The severe weather made daily tasks difficult for all onsite staff. Inspection and construction progress was slow, but round-the-clock heaters in the piers and the team’s hard work during the day and night shifts kept the project moving forward.

Photo No. 3: Extreme weather at the North Hero Movable Bridge during January 2022.

Mechanical Systems

The North Hero Movable Bridge in Vermont is a hydraulically operated double-leaf bascule bridge and that features two leaves supported by two main girders. These girders rest on two simply supported trunnions. The bridge is equipped with four live load shoes, four hydraulic cylinders, and two tail locks. Additionally, the two leaves share four span locks in the middle.

Timeline Situations

Schedule Requirements, Milestones, and Deadlines

The project faced tight deadlines during the winter season, requiring a creative approach during the closure window. The contractor strategically prepared the bascule leaf’s deck steel and machinery to open one-half of the bridge, allowing the waterway channel to remain 50% open and meet the Coast Guard's requirements. This construction method proved to be highly efficient.

Early delays coincided with the construction of the bascule leaves aligning with the peak boating season. To mitigate this issue, the contractor opted to accelerate work through the winter months. The contractor focused on completing the piers and scheduled the construction of the bascule leaves during an approved waterway closure. The USCG approved the channel closure for the winter months and mandated that the drawbridge must be operational from May 15th to October 15th. This created a strict deadline of May 15 for reopening the channel, requiring nonstop work throughout the winter, including night shifts. This relentless effort ensured that the project stayed on track and met the critical deadline, despite the harsh winter conditions.

Impacts of Different Schedules

The North Hero movable bridge experienced slow progress due to issues with the trunnions' steel support beams. The connections were not in full contact across the mating surfaces. This full contact is essential for properly bearing the load of the bascule bridge's weight through the trunnions. To address this, the mating steel was measured, and custom tapered shims were manufactured to fill the gaps between the trunnions' vertical steel support beams and the horizontal supporting steel beams. Additionally, shims were added between the trunnion weldments mounted on top of the horizontal support beam.

Photo No. 4: Steel gaps in the trunnion support are shown.

This delay consumed all the available float time within the schedule to complete both bascule leaves before the USCG deadline of May 15th. It became apparent to the inspection teams that the contractor would need to devise another solution. Despite this setback, the contractor continued constructing the leaves, striving to make up for the lost time.

Innovative Construction Methods for Completing the Spans

Photo No. 5: North Pier before the erection of the bascule span.

Approach of Par-Construction of South Span

To address the construction timeline delay, an innovative approach was developed to complete one span before the other. This would ensure compliance with USCG channel reopening requirements by the May 15th deadline. The solution involved partially constructing one span's bascule leaf and raising it into the open position before constructing the other leaf. This method allowed for a 50% closure that would be sufficient for most of the recreational marine traffic on Lake Champlain and the ability to raise the bridge with just a one-hour notice.

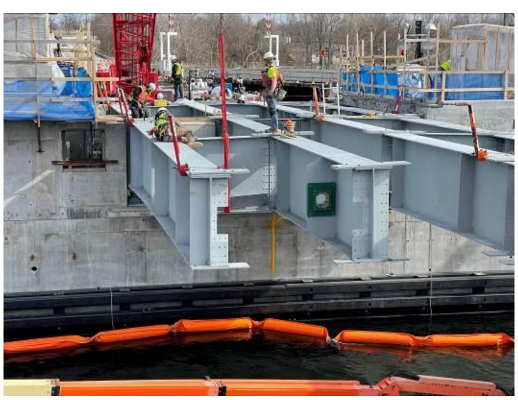

Photo No 6: Erection of the South Bascule steel.

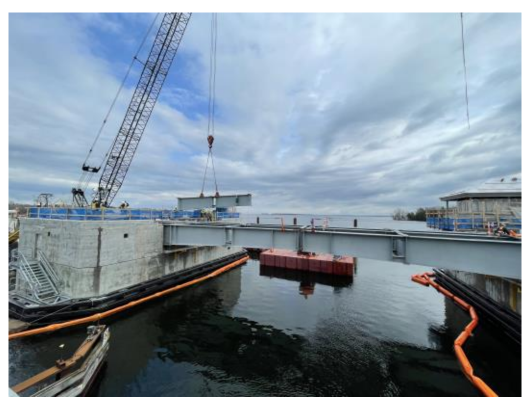

Photo No 7: Erection of the North Bascule steel.

Photo No. 8: North and South Piers bolts being snug tighten during a night shift.

Notably, the first span would open under its own power, even without a bridge deck and with some steel bolts not torqued to full specification. This strategic approach minimized disruption to the channel and adhered to the critical deadline.

Due to the contractor's efforts to complete both spans simultaneously, the deviation in work only occurred after much of the steel for both spans had been completed. At this point, the contractor shifted focus to finishing the machinery on one span to get it into the open position. This strategic decision was made to ensure at least one span was operational, allowing for partial functionality and minimizing overall project delays that would result in a daily fine from the USCG. By prioritizing the machinery on one span, the contractor aimed to meet critical deadlines and provide a functional solution while continuing work on the remaining span.

Machinery Components Installation

The installation of the mechanical components at the bridge proceeded smoothly, beginning with the simply supported trunnion bearings. These bearings were crucial as they allowed the iron workers to place the two main girder rear segments, with the trunnions inserted into the trunnion hubs and preinstalled onto the girders. The girders were divided into two segments: one extended from the rear of the counterweight just past the live load shoe and the edge of the pier wall, and the other used a web plate to join the segments, forming the main girder that extended out to the end of the span. Once the trunnions were installed and the bearing caps bolted on, the iron workers attached all the stringers and webs to the main girders and constructed the counterweight steel box.

Photo No. 9: Installation of hydraulic cylinders installed on the North Pier.

Simultaneously, the preassembled hydraulic power unit was installed in the machinery room adjacent to the pit in the pier. Three hydraulic lines ran from the power unit along the inside of the pier wall and connecting to four hydraulic cylinders that were lowered through the erected steel of webs and stringers. Each hydraulic cylinder was connected to a girder, with two center support girders connected to the counterweight each having their own hydraulic cylinder. This setup created a rigid bridge deck and distributed the load to the four hydraulic cylinders. Live load shoes were positioned beneath each of the four girders, and the four span locks were installed with two actuators per leaf. The guides and lock bars were positioned on the leaf accordingly, and the receivers for the opposite leaf's span locks were also installed. The resulting leaf was constructed completely without a bridge deck, with all the machinery installed.

Opening of North Span


Photo No. 10: North Pier partially assembled in the open position.

Once the completed span had all the bolts in place and snug tight, and all the machinery was installed, the contractor placed a generator capable on top of the pier towers. The generator would power the hydraulic power units by connected it to the electrical mains at the PLCs. The span's balance was confirmed using pressure sensors at all supporters. These sensors were at all supporting points forward of the trunnions and the counterweight support steel aft of the trunnions. After final checks, the counterweight support steel was removed and the power turned on. This caused the bascule span to raise into the upright position without incident. Once fully raised, steel beams were used to secure the counterweight in the upright position. The beams held the top of the counterweight pinned against the back of the pier pit wall preventing unwanted movement.

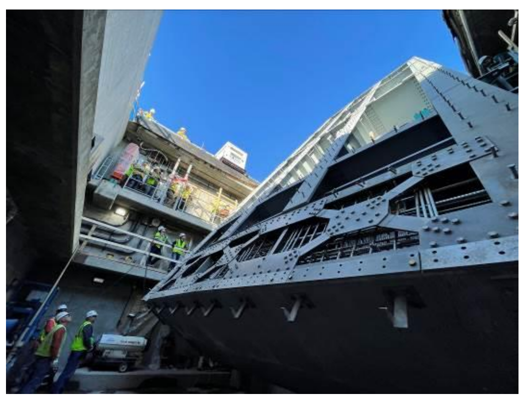
Photo No. 11: North Pier partial assembled view from pit.


Photo No. 12: North Pier hydraulic cylinders fully extended.

This meticulous process ensured the stability and functionality of the bascule span. The use of pressure sensors and careful balance checks were crucial in confirming the span's readiness. The seamless operation of the hydraulic power units, powered by the large generator, demonstrated the efficiency of the installation. Securing the counterweight with steel beams provided additional safety, ensuring that the span remained in the upright position as intended. This successful operation marked a significant milestone in the project's progress. This was completed just before the May 15th deadline, on May 11th, allowing the channel to be open for vessel traffic.

Process of Fully Constructing the South Span

With one leaf pinned in the open position, the contractor was able to shift focus to the other leaf and replicate much of the work already completed. The primary distinction in this phase was that the snug tight bolts for the steel structure would be fully torqued down. Which would ensure a secure and stable assembly. Additionally, the bridge deck was set to be completed and poured, a crucial step that included filling the counterweight with concrete. This meticulous process ensured that both leaves of the bridge were structurally sound and ready for the final stages of construction.

Photo No. 13: Completed steel and deck on the South Bascule Span with leaf in the lowered position.

Photo No. 14: Completed South Bascule Span in the upright position with the incomplete North Bascule Span open in the background.

The Final Steps in Assembling Span One

After the second span installation was complete, it was raised into the upright position and securely locked in place. Which mirrored the process used for the first span. Steel beams were used to pin the counterweight in the fully open position against the back pier pit wall, ensuring stability. Subsequently, span one was lowered using generator power, which allowed the iron crews to tighten all the bolts and pour the grid deck. Once the work on span one was fully completed, both spans were raised into the upright position. This enabled the channel to be fully open and operational. This process ensured the structural integrity and functionality of the spans, facilitating smooth and efficient operation.

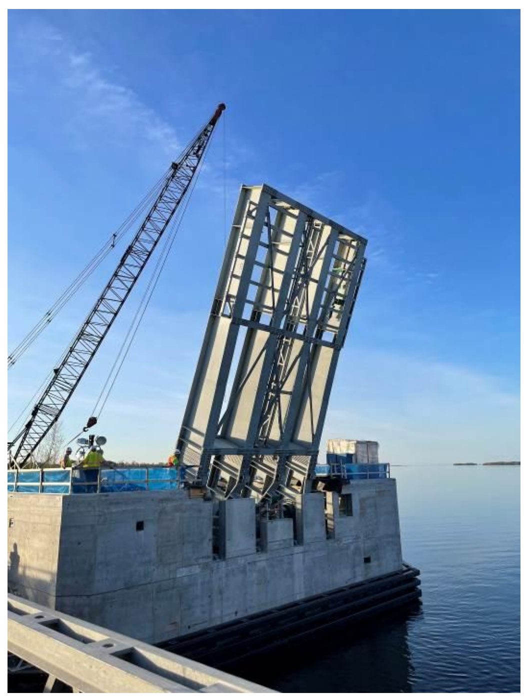

Photo No. 15: Partially completed North Bascule Span in the open position.

Span Drifting

Identifying Symptoms Related to Hydraulic Drifting

During the testing phase of the second span, an issue was discovered with the lowering cycle. While the span could be raised and stopped successfully, it could not stop during the lowering cycle. Instead, it would drift slowly and uncontrollably into the fully seated position. This problem was traced back to the third hydraulic tank line, which was designed to hold pressure during operation. However, this pressure kept the local check valves at the cylinder open during the lowering cycle due to the pressure on the rod side of the cylinder. Consequently, hydraulic fluid from the rod side would travel to the cylinder side through the orifice in the local cylinder manifolds, causing the span to drift into the lowered position.

Photo No. 16: North Hydraulic power unit in the pier's machinery room.

Modification to Resolve Drifting

The solution involved installing a new DCV1 control valve onto the hydraulic power unit and updating the bridges operation programing sequencing. This valve is normally open and only closes during

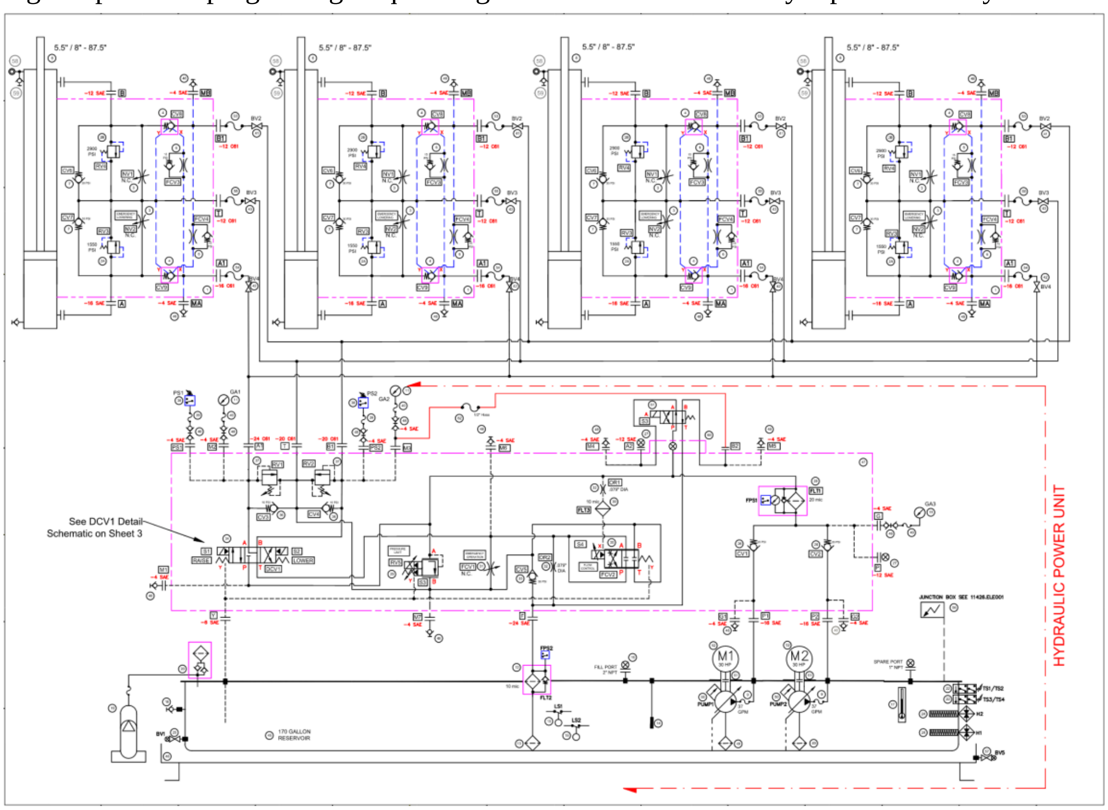

Photo No. 17: Hydraulic shop drawing schematic provided by the contractor with DCV1 valve solution that stopped the undesirable drifting.

operation. During any stop or power loss, the actuator would open, releasing pressure in the tank line. This release created a local pressure differential that locked the check valves at the cylinders. By doing so, the hydraulic fluid was prevented from traveling between the rod and cylinder sides, effectively stopping the span from drifting.

Outcomes After Implementing Modifications

As a result, the updated hydraulics allowed the span to be raised and lowered smoothly and, most importantly, stop when necessary. This improvement ensured the span could be controlled precisely, which enhanced the overall safety and reliability of the system. The new control valve mechanism provided a robust solution to the initial problem, which demonstrated the importance of thorough testing and innovative engineering in resolving complex mechanical issues.

Action	Stages of Operation	Program File	Solenoid	Reaction	Bridge Movement
During Bridge Lowering Sequence	PLC Operated	Current	Existing S1	Closes	Drifts
			New DCV1	No Reaction	Drifts
		Modified	Existing S1	Closes After Delay	Stops
			New DCV1	Opens	Stops
	Control Panel	Current	Existing S1	Closes	Drifts
			New DCV1	No Reaction	Drifts
		Modified	Existing S1	Closes After Delay	Stops
			New DCV1	Opens	Stops
	Emergency Stop	Current	Existing S1	Closes	Drifts
			New DCV1	Opens	Stops
		Modified	Existing S1	Closes	Drifts
			New DCV1	Opens	Stops
	Power Loss	Current	Existing S1	Closes	Drifts
			New DCV1	Opens	Stops
		Modified	Existing S1	Closes	Drifts
			New DCV1	Opens	Stops

Key	Green	Good Result
	Red	Undesirable Outcome

Table No. 1: The hydraulic testing results before and after implementing the DCV1 valve solution and the PLC programming modifications, which stopped the undesirable drifting.

Completion of the Project

Upon its completion in the second quarter of 2023, the North Hero Movable Bascule Bridge became fully operational and functioned seamlessly. The bridge tenders found the operations straightforward and user-friendly, while the machinery components were designed for ease of maintenance and longevity. The project culminated in a highly satisfactory outcome, with the client expressing their approval of the bridge's performance and reliability. Consequently, VTrans assumed ownership of the bridge, ensuring its continued operation and upkeep.

Photo No. 18: Completed North Hero Movable Bascule Bridge.