HEAVY MOVABLE STRUCTURES, INC.
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Thames River Bridge Replacement – Amtrak Railroad

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Introduction

Original 1919 Strauss Heel Trunnion Span

The Amtrak Bridge over the Thames River in Groton CT carries 38 trains a day with an average of 1,600 to 2,000 openings a year. The bridge is part of the 156 mile electrified line between New Haven, CT and Boston, MA. Marine traffic from the Coast Guard Academy, U.S. Navy submarines from the Groton submarine base and vessels from large industrial firms pass under the bridge to reach the Long Island sound. The existing double track single leaf Strauss Heel Trunnion bridge, built in 1919, was identified to be replaced in 1996. Feasibility studies were conducted and three options were presented to Amtrak for consideration. Option 1 was to replace the counterweight trunnions and reuse the existing bascule span. Option 2 was to replace the movable span with a new bascule span. Option 3 was to replace the movable span with a new 188 foot vertical lift span that would provide a vertical clearance of 220 feet. Based on the study's results, Amtrak eliminated the first two options because neither of the options would allow for rail traffic during construction. Option 3 would allow for rail and marine traffic to continue during the erection of the new structure around the existing structure while the existing bascule bridge remained operable. Also working in favor of the vertical lift span option was the original bridge's substructure design. Not only was the substructure still in good condition, but it originally was designed for four track service, which meant the existing piers could support the new lift span towers. Another advantage of reusing the existing piers would streamline the environmental approach and eliminate the need to design and construct new river piers. The existing approach spans would not be replaced as a part of the project.

Design and Construction Challenges

Many challenges would present themselves over the course of the design and construction. To accommodate the lift span towers, the supporting piers had to be enlarged on one end by auguring 36-inch diameter pipe piles 170 feet to bedrock. The pier supporting the bascule span began to tile when piles disturbed the boulders, sand and gravel that supported the pier's caisson foundation. The solution developed by HNTB's geological group was a plan to drill and install hundreds of grout pipes into the riverbed and inject specialized permeating grout, which essentially turned the foundation sand into concrete. Another challenge was realized when the construction company began to remove the 4-million pound counterweight that hung over the track. Because of its weight, the construction company needed to cut the counterweight into smaller pieces for remove. Once this process begins, marine traffic would be required to stop and the bridge wouldn't be able to move again until the lift span was in place. When the contractor cut into the counterweight, they found it was filled with steel pellets that jammed their saws, and the time to remove it would have exceeded the contractor's promised four-day down time. With the help of HNTB, a plan was devised to support the weight for later removal so they could bring the new sift span in and minimize the marine traffic outage. With the design and locations of the new lift span towers, the current location of the control house, which was not being replaced, would conflict with new tower locations. The existing control house would need to be moved outward on the pier approximately 19 feet from the existing location. Since the original piers were built to accommodate a double bridge structure, the space available on the pier top would allow the movement of the control house early in the construction period. The movement would need to occur with minimum disruption to the operation of the bridge and to the trains that cross the bridge. This would require that the electrical cables between the bascule span and the control house would need to be "stretched" in advance of the actual movement. The contractor pre-staged the power, control, signal and communication cables on the pier and began the process of terminating each of the conductors over several days. Termination of the new cables was accomplished during the period of time between the last train in the evening around 11:15pm and the first train in the morning around 6:30am. Once all of the new conductors had been terminated, movement of the control house was made by picking the entire structure up and moving it over the required 19 feet. Relocation of the control house was accomplished without disruption to the operation of the bridge or to operation of the trains. Once the control was moved, construction of the new towers could begin.

Original location of the control house on the pier.

Control house after being moved on the pier.

In addition to the normal problems faced during construction, Amtrak had added an overhead catenaries system to the bridge which operated at a voltage potential of 25,000 volts. Extreme care would be necessary by all disciplines to prevent equipment or personnel remain clear of these high voltage lines at all times. Minimum safe clearance distances were set and followed at all times threw out the construction period.

The new lift span was erected upstream from the bridge and was erected on a barge. With all of the operating machinery and the majority of the electrical equipment being located on the lift span, this allowed the span to be pre-wired prior to the actual float in of the span.

New lift span on barge near completion

New lift span ready for float in

With the bridge located on the primary waterway to the Atlantic Ocean and the U.S. Navy's submarine base only a few miles upstream from the bridge, getting the channel open to marine traffic by the established deadline was of concern. Several things had to take place over the 96 hour period once the lift span was floated in between the towers before the span can be lifted and the channel reopened. These tasks include pouring over 1 million pounds of concrete into each of the counterweight enclosures, connection of the 64 counterweight suspension ropes, connection of the operation ropes, completing the installation of the final structural components on the lift span and lift towers, suspending the electrical cables between the towers and lift span within the cable chase on each tower and the termination of over 290 conductors necessary for the operation of the bridge from the control house on the west pier. Concern was expressed during the design that the most of the electrical work would be accomplished near the end of the 96 hour period. As a result of this concern, provisions to operate the span from the machinery room on the lift span was included as a part of the control system design. The control system was designed on the assumption that even if the primary power cables consisting of 10 #250MCM conductor's were not installed, placement a generator on the lift span and operation the bridge could be accomplished if it became necessary during the span change out. Because of good planning by the electrical contractor's team, the electrical work was completed well before the lift span was ready for movement and the electrical work never became a part of the critical path work. The contractor pre-terminated all of the conductors on the lift span and staged the cables on the lift span prior to the span change out. Once the span was set in place between the towers, the electrical contractor hung the cables within the cable chase and terminated the conductors in the cabinets

One of the two cable chases on the lift towers on the towers while the counterweight concrete was being poured and the counterweight ropes were being connected on the lift span.

The advance work accomplished with the tower to span cables allowed the electrical crew to begin the preliminary check out of the control system to insure the system was ready to move the span when it became time to actually do so. Each of the drive motors were activated and rotated. The machinery was rotated without moving the line shafts or operating drums. This allowed the rotary limit switches to be pre-adjusted and the position monitoring equipment calibrated.

Main Drive Motors and Electrical Cabinets

Auxiliary Drive Motors

Once the span was ready to moved, actual movement was restricted to periods of time when Amtrak was not running trains. The left the time between the last train at night which passed over the bridge at about 11:15pm and the first train in the morning which passed over the bridge at about 6:30am. The first movement of the span occurred at about 12:30am on the first night of scheduled movements. At the end of the first "day" of testing, the span was moving under the power of both main drive motors at the full speed of 850 rpm. The lift height was restricted to a maximum of 45 feet above seat because of structural work remaining near the top of the tower columns. This achievement met the clearance requirements set by the U.S. Navy and the USCG for the short term.

The electrical control system was designed to use a PLC for the primary control system which would control and operate two 75 horsepower, DC drives. Each DC motor was rated at 500 rpm base speed and would operate in an overspeed condition to a maximum speed of 800 rpm. Each drive motor was capable of operating the bridge in single motor mode at the maximum speed 500 rpm providing Amtrak with two redundant drive options for backup reliability. The PLC system included a redundant CPU module that was kept isolated from the control system to increase reliability and protection from power surges to give the control system an additional level of redundancy.

As a backup to the main drive motors, the design included two 40hp, 2-speed, AC auxiliary drive motors rather than a single 75hp, 2-speed, AC auxiliary drive motor. During the testing of the auxiliary drive system, it was discovered that when the motors would start in the high speed mode, the motors would appear to be slightly out of phase resulting in loud banging within the gear reducer. Further testing found that when starting in low speed or when changing from low speed to high speed, the motors would operate without problem. Discussions with the motor manufacturer concluded that there is enough of a difference in the two motors to cause a phase imbalance that attempting to go from zero to 1800 rpm under the load of the span was resulting in the motors basically fighting each other. In order for the motors to be able to start under all conditions, the motors should have been designs as a matched set of motors which would have required the windings of the motors to be exactly the same. Since the motors operated satisfactorily when starting in low speed or when changing from low speed to high speed, timing relays were added to the auxiliary drive control circuit that would always have the drive motors start in low speed and change to high speed at all times regardless of the position of the span or the direction of movement.

The first day of testing met all the requirements to have the lift span functioning to a point that the span can be lifted to clear the channel for marine traffic. With this requirement established by the U.S. Navy, a submarine was scheduled to depart the Groton Naval Station during the mid morning hours of the first day of testing. Approximately 9:15am, the Navy's submarine approached the bridge and the new lift span was raised to the mid level height without incident or delay to the Navy's embarkation schedule.

First to transit beneath the new lift span was a U.S. Naval Submarine going out on patrol.

The second "day" of start-up testing concluded with the lift span operating at full speed under two main motor operation and raising to the full lift height of 102 feet above the fully seated position. Testing continued throughout the second day with fine tuning of the control system and setting of the limit switches to provide Amtrak with the most efficient operation of the span.

Conclusion

The replacement of the single leaf bascule span with a new vertical lift span was a very successful project. It provided Amtrak with a bridge structure over an extremely important and strategic river on a very important and highly travel rail line between Boston and New York. The achievement could not have happened without the hard work and effort from many different individuals on the project team. These would include those from Amtrak's construction division, members of the Washington Group International/URS Construction Management team who were on-sight on a daily basis managing the day to day construction and the highly professional members of Cianbro Corporation who was the general contractor for the project.

Amtrak was very satisfied with the project. This was Amtrak's largest capital bridge improvement project to date. Jim Richter, Amtrak's deputy chief engineer of structures stated, "the bridge is performing smoothly, with a minimum number of gremlins and Amtrak is very pleased with how the new bridge operates".