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Two Temporary Vertical Lift Bridges on Route 3A over the Fore River, Ma.

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The paper is a case history discussion regarding the use of a temporary movable bridge as part of the reconstruction of the Fore River Bascule Bridge located on Route 3A in Towns of Quincy and Weymouth Massachusetts. The case history will also discuss the change in design life of the temporary bridge after the award from 5 years of service to 15 – 20 years and its impact to the design and construction schedule.

Introduction:
The existing Fore River Bridge was slated for rehabilitation after serving the area for 75 years. The planned reconstruction called for the main leafs of the four leaf bascule to be completely removed. The complete removal required maintaining four lanes of traffic, two lanes north bound towards Boston and two south bound to the South Shore.

The Massachusetts Highway Department required that the temporary panel bridge bypass structure be constructed to maintain the four lanes of traffic and also provide for a moveable span that would provide the same horizontal and vertical opening clearances as the existing structure. Two consultants were retained to design the project. The primary consultant who designed the geometry and approach substructure was Fay Spofford & Thorndike, LLC. The movable portion of the project was developed by Hardesty & Hanover, LLP. The final contract documents pertaining to the temporary panel bridge were released as a performance based specification.

Design Requirements:
The temporary bridge design required maintaining four lanes of traffic for AASHTO HS20-44 design loading while accommodating vertical and horizontal curves. The temporary bypass called for two adjacent structures totaling 2740 feet of temporary panel bridge with one cantilever footwalk on the south side of the structure. There are twenty approaches spans and two main lift spans. Each main span has a Vertical Lift Bridge with a clear span of 210 feet and a roadway width of 24 feet curb to curb. When open, the bridge must allow for a vertical clearance of 175 feet above mean high water and when closed it must provide a 55 foot vertical clearance above mean high water, the minimum horizontal clearance between fenders is 175 feet 6 inches. Each movable span is designed to open in 5 minutes, 600 times annually.

The basic configuration of each temporary lift structure was to be as a vertical lift type with towers at the corners along with cross girders between the towers laterally and a gantry span between towers longitudinally. The machinery was to be centrally located and provide the area for a rope driven system with counterweights traveling in each of the towers. As shown in Figure 1.

Figure 1: View of Completed Bridge

Structural Steel Design Requirements:
The structural elements were designed to AASHTO Bridge Specifications with a 25 percent allowance for increase in stresses due to the temporary structure.

The fatigue was based on 2,000,000 cycles for the lift structure and 500,000 cycles for the approach spans.

The main lift spans were cambered for full dead load.

Mechanical Systems Design Requirements:
The mechanical and electrical systems were designed to AASHTO Movable Bridge Specifications. Allowable stresses for the machinery increased 25 percent due to the temporary nature of the bridge.

The minimum sheave diameter was also reduced below what AASHTO typically requires. The reduced sheave diameter would require the counterweight wire ropes have their size and quantity increased to counter act the smaller sheave size.

The mechanical system allowed for two drive types. A rope operating system or counterweight sheaves with a chain and sprocket or pinion drive ring gear. Acrow designed system shown in Figure 2.

The lift spans were to be counterbalanced throughout their travel with counterweights.

The weight of the counterweights ropes were to be counterbalanced through out their travel.

Figure 2: View of Winch Machinery

Electrical Systems Design Requirements:
The electrical system provided for speed monitoring throughout their travel.

The bridge was fully interlocked for sequence of operation with traffic lights, warning gates, and barrier gates. Acrow operating desk as shown in Figure 3.

The bridge operating time, raising or lowering was to be 5 minutes.

An alternate power source was also required.

A complete fully interlocked backup was required.

Each lift span was equipped with navigation equipment as dictated by the United States Coast Guard.

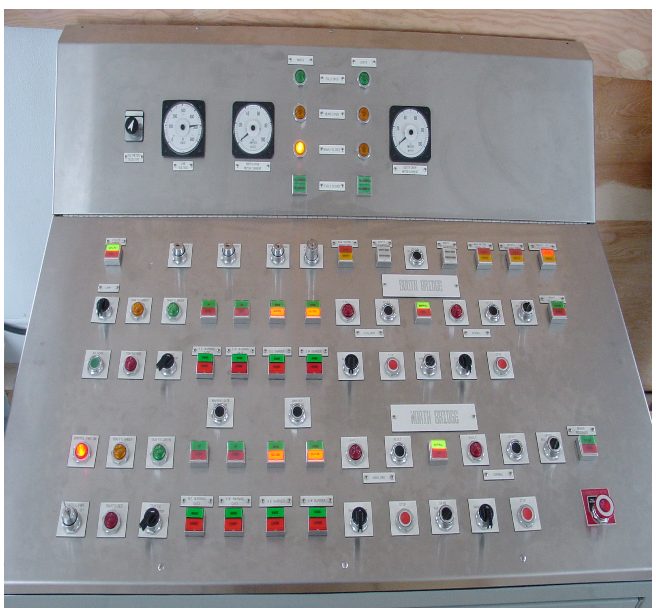

Figure 3: View of Main Control Desk

Design Challenges:
The original project was bid in Spring 1998.

The project was shelved after bidding.

In early summer 1999 the as bid project was awarded to the original low bidder.

From notice to proceed to final completed design calculations and drawings, the contract allowed for 45 days for initial submittals and an additional 115 days for final completed design drawings and calculations.

This was a relatively short time period to design a temporary structure of this magnitude. The total weight of the completed approach bridging along with the two lift bridges is 13,000 tons of steel work.

A. Taking a very conceptual design from time of bid to completion in 160 days called for a very stringent schedule of design, detailing, and submissions. To the benefit of the project, both consultants accepted partial submissions. Critical path items such as the mechanical and electrical systems were tackled first.

B. The specifications did not allow for gravity lowering of the spans. The Acrow system of lift bridge design is based on a rope driven mechanical system.

   The gravity lowering meant Acrow had to design a system of pulling the bridge down. The final design incorporated a down haul system that was operated off of the same winch which that was responsible for raising of the span.

   The uphaul and downhaul systems were wound directly over the same side of each drum. The potential rope stretch and temperature changes were all worked into the design by the use of a cantilever balance arm, which is fully adjustable. Also, incorporated into the uphaul/down haul system were additional safety features, which would reduce any potential mechanical overloads by the use of limit switches.

C. The 140-foot tall towers were uniquely designed with the use of typical panel components to achieve the proper strength towers within the allotted site geometry. The tower system is configured with four outer box type sections, while the inner towers are "T" sections. The counterweights are designed to run on the inside of the inner and outer towers.

   The bridge is guided longitudinally by rollers that run on the corners of the inner "T" towers only. The lateral guides for the spans run along the inner and outer towers. The roller running tracks are also part of the structural system of support and have been designed for the combined loads.

Project Stopped for Evaluation:
Prior to any onsite erection of the superstructure in Quincy, the job was stopped. The stoppage was in September 2000 by Massachusetts Highway Department. The existing bridge structure was being tested during the initial 12 months of the project and it was determined that the existing bridge could not be rehabilitated and would have to be replaced.

Acrow was directed to look at the design that was initially based on a life of 3 to 5 years and upgrade it for a life span of 15 to 20 years.

The redesign meant Acrow and its engineers had to evaluate where this life span change would impact the design. At this stage in the project, 16 approach spans had been assembled at Port Newark along with all of the towers and fabrication was 70% complete on the balance of the project. All fabrication and assembly was suspended.

The redesign process required a complete check of the structural, electrical, and mechanical systems. Several areas were discussed with Massachusetts Highway Department and Hardesty & Hanover as to where changes in the initial specification would occur. The result was that the approaches would be upgraded from a fatigue cycle life of 500,000 cycles to 2,000,000. The lift structure would have its 25% increase in allowable stresses removed and the additional openings would be evaluated over the extended life.

The mechanical and electrical systems were found to be acceptable for the longer life. This proved to be very beneficial since they were completed.

All of the approach trusses were upgraded.

The lift structure was also upgraded. The crosshead beams, gantries, tower bases, and counterweights were all affected by this change.

The changes also affected some of the lifting loads which also caused changes in the completed lifting scheme.

The project was stopped for 6 months while the redesign process went forward. Additional time was also consumed for fabrication of some of the newly upgraded items.

Erection Challenges:

The constructability planning also came into the project schedule as it does on many projects. The site was very constricted and did not allow adequate room to assemble spans and keep the project on schedule. To assist in the scheduling issues, all of the twenty-two approach spans, six towers, two gantries, four crosshead beams, and two main lift spans were pre-assembled in Port Newark, NJ and shipped to the site by barge as required. The offsite assembly allowed for greater flexibility onsite and better continuity of assembly in Port Newark.

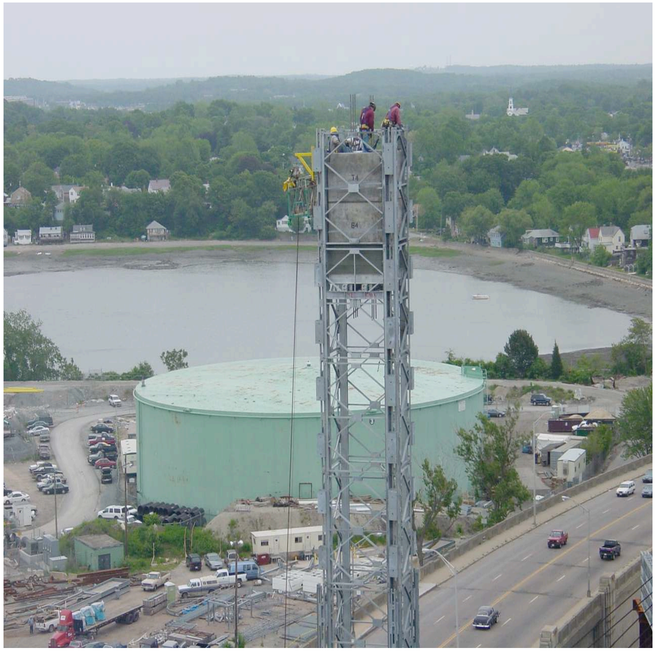

Figure 4: View of Outer Tower with Counterweight

The completed height of the top tower was 205 feet off of mean high water. As shown in Figure 4. At this height, the 65-ton counter weights had to be lifted above the top of tower. The gantry also had to be lifted above the towers. A large 650 ton water crane with 250 feet of boom was retained to make these critical lifts. The 65 ton counterweight had to be placed prior to installation of the crosshead beams and gantries. The design was checked for the temporary construction erection loads while the large counterweights sat on top of the slender outer towers that were un-braced in all directions. It was determined that the outer towers with the counterweight in position could safely experience 40-mph wind loads. The window allotted for lifting the counterweights into the outer towers was kept to just days from the time of lifting into the outer tower and placement of the crosshead beams and gantries.

Figure 5: View of North Gantry Being Lifted

The bridge system was erected from the north side moving back to the south. As shown in Figure 5. With the tight schedule of construction, the towers had to be topped out on both the north and south structures. This also meant that the north gantry had to be placed by being lifted in front of the southern towers and floated down the channel at high tide while being suspended above the high tower steel at 205 feet. The crane subcontractor limited the pick to a day when the wind would not exceed 15 mph. It was a challenge finding such a day; however, all lifts were accomplished without incident and within the allotted channel closure time.

Closing:

The overall project has been very successful. Both lift structures are completely operational and will be opened to the public this month. The overall construction schedule was lengthened by a year due to the increased service life of the structure along with the recent harsh winter.

The completed Fore River Bridge is the largest temporary movable vertical lift bridge in North America. The structure incorporates the wide range of uses of Acrow Panel Bridge components which helped facilitate the modular concept of constructing a structure of this magnitude.

ACKNOWLEDGEMENTS:

Client: Massachusetts Highway Authority

Temporary Bridge: Designed, Manufactured and Supplied By Acrow Bridge of Carlstadt, NJ

Moveable Bridge Review Consultant: Hardesty & Hanover, LLP

Approach Bridge Review Consultant: Fay Spofford & Thorndike, LLC

Contractor: The Middlesex Companies

Key Subcontractors:

BEC Electric, Inc.

Link Control Systems, Inc.

Steward Machine Company, Inc.