

**HEAVY MOVABLE STRUCTURES, INC.
THIRTEENTH BIENNIAL SYMPOSIUM**

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**Removing a Bascule Counterweight
Thames River Bridge
New London, Connecticut**

Alan D. Fisher, PE
Cianbro Corporation

CARIBE ROYALE ORLANDO
ORLANDO, FLORIDA

Introduction

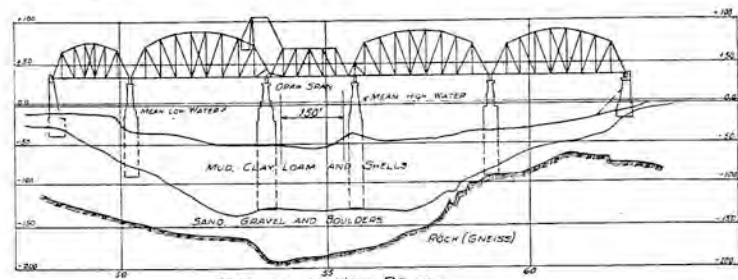
In 2005, Amtrak embarked on the replacement of the movable span at their crossing of the Thames River in New London, Connecticut. The construction of the new vertical lift span to replace the existing Strauss “Heel Trunnion” bascule span was to be a complex project. Construction of the new bridge on the existing railroad alignment required that the new towers straddle the existing span. The new tower on Pier 3, the existing rest pier, could be constructed in its entirety without impacting the operation of the bascule span, but the new tower on Pier 2 had to be constructed with some structural members left out so that the existing bascule could remain in operation.



Figure 1: Existing bascule during construction of the new vertical lift towers.

An outage was planned during which the old bascule would be removed and the new vertical lift span installed. It was recognized that this outage period needed to be as short as possible to minimize the impacts to both the marine and rail users at this location. The upperworks of the existing bascule had to be removed during the outage to complete of the new tower steel and to permit removal of the existing bascule span. The first plan, later to be called Plan A, was to support the counterweight on piles so that the structure connecting the counterweight to the span could be removed. This method changed when foundation problems with the existing bridge were discovered and a decision was made not to drive additional piles which might exacerbate that problem. The next method, Plan B, for removing the counterweight upperworks was to cut the counterweight into five pieces immediately prior to the rail outage. The pieces would weigh between 300 and 400 tons, and were to be removed with a 1000 ton capacity derrick barge which was being brought in to remove the 600 ton bascule span as a single unit. This method was abandoned during the marine outage shortly before the planned four day rail outage when it was found that the counterweight could not be cut up into pieces due to voids and loose heavyweight aggregate in the interior of the counterweight. The final method, Plan C, was to remove approximately one third of the weight of the counterweight using regular demolition methods and then support the remaining portion, estimated to be about 1200 tons, on top of the existing truss span, Span B.

When the project first began, several alternative methods to accomplish the counterweight removal were studied in depth. Span B was analyzed at that time and supporting the counterweight on the span was not considered further at that time because it was found that the truss could not sustain the railroad live load and the full weight of the counterweight. This prior analysis was reconsidered



Span A Span B Span C Span D Span E

Pier 1 Pier 2 Pier 3 Pier 4

Figure 2: 1917 Thames River Bridge

when Plan B stalled. Additional analysis showed that the stresses in the existing Span B would be acceptable if the weight of the counterweight was reduced to approximately two thirds of the original weight. The fact that Span B could support this large load was not surprising in that Span B already supported the full counterweight, just in a location closer to the end of the span. Upon approval of Plan C approach a structural frame was designed, fabricated and installed in seven days. As soon as the demolition of the counterweight had removed roughly a third of the total weight the counterweight was jacked, the counterweight upperworks were removed, and the rail outage began with the removal of the old bascule span, Span C. Four days later the lift span was in place and Amtrak was back in business.

Jacking the Counterweight

In a Strauss “Heel Trunnion” bascule the counterweight pivots about an upper main bearing and is connected to the bascule span with a counterweight link frame. Removal of the bascule span and counterweight upperworks required that the counterweight link frame be unloaded. The purpose of the counterweight support frame was to provide support at the rear of the counterweight so that the counterweight link frame was not required for stabilizing the counterweight. Jacking up the counterweight from the support frame would be needed to unload the counterweight link. Once unloaded, the counterweight link could be removed as well as the two operating struts. Once the counterweight link frame was removed, the front members of the upperworks were no longer loaded and could also be removed so that the Pier 2 tower could be completed.

Several drawings were obtained which gave us the idea that the counterweight could be demolished in place, providing its own structural support. One was a drawing which described the design philosophy of the counterweight load path. The text on the drawing indicated that the weight of the concrete fill was supported by girders on the bottom of the counterweight which transferred the load to the side plate assemblies. The side plate assemblies in turn carried the weight to vertical members which delivered the loads to the upperworks. As long as the sides and vertical members were kept intact the concrete fill could be removed. A second drawing indicated that the bascule leaf had been constructed as a progressive cantilever and that the steel counterweight box had been filled incrementally. We decided that this meant we could de-construct it incrementally also. A third drawing, developed as a part of a previous rehabilitation contract, gave a complete load rating of every member of Span B. We used this to compare with our analysis of the Span B truss to determine if any members might be overstressed by the load combinations that we anticipated.

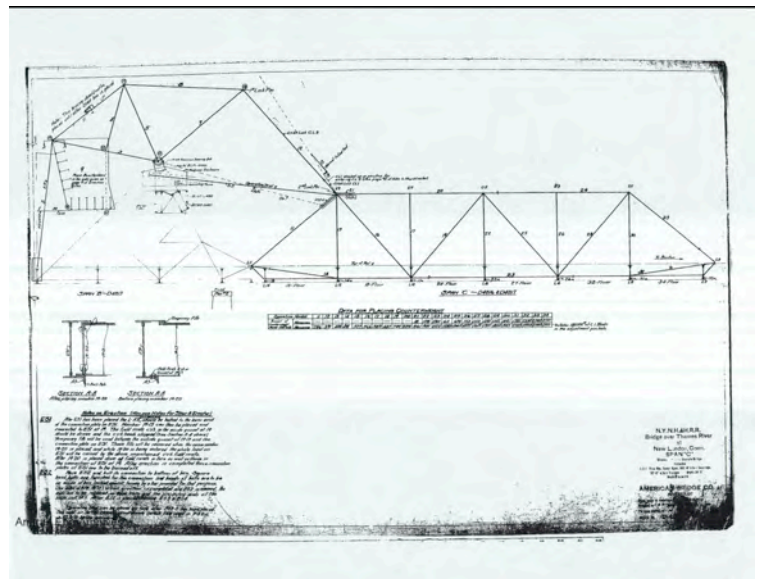


Figure 3: 1917 erection plan and sequence of assembly.

Plan C was developed in a very short period of time, as we were well into the planned outage. Plan A and Plan B had always anticipated that the counterweight could be sawn into manageable pieces using diamond wire saw technology. This is not an uncommon method and we had an excellent and experienced sub-contractor on board to do the work. The wire sawing was stymied by pockets of loose steel punchings within the body of the counterweight and by voids where concrete had failed to flow

during the original construction of the counterweight in 1917. The wire saw cut through all steel that was well bonded to concrete, but loose punchings would spin and then bind causing the wire rope to break. Similarly, the wire saw cleanly cut steel girders embedded in the concrete, but repeatedly broke where the wire had to cut through steel edges where the concrete was not in contact. The wire saw sub-contractor would have eventually cut the counterweight as required, but we did not have the time.

When we gave up on the wire sawing, we switched to modern cave man technology for removal of the counterweight and started designing the temporary support frame for the counterweight. It wasn't very fast, but it was satisfying to see that we could make the counterweight go away.

Figure 4 shows the configuration of the support frame. Its design was simplified to permit the rapid fabrication that was required. A W40x397 lifting girder was attached to the rear of the counterweight. Four 430 ton rams were positioned under the lifting girder. Each pair of rams were in turn supported on a pair of W40x397 transfer girders which spanned between two main upper chord panel points. The existing truss upper chords were stiffened at these panel points to accept the anticipated 700 kip loads and deliver them into the gusset plates at the panel points and thereby into the truss main members.

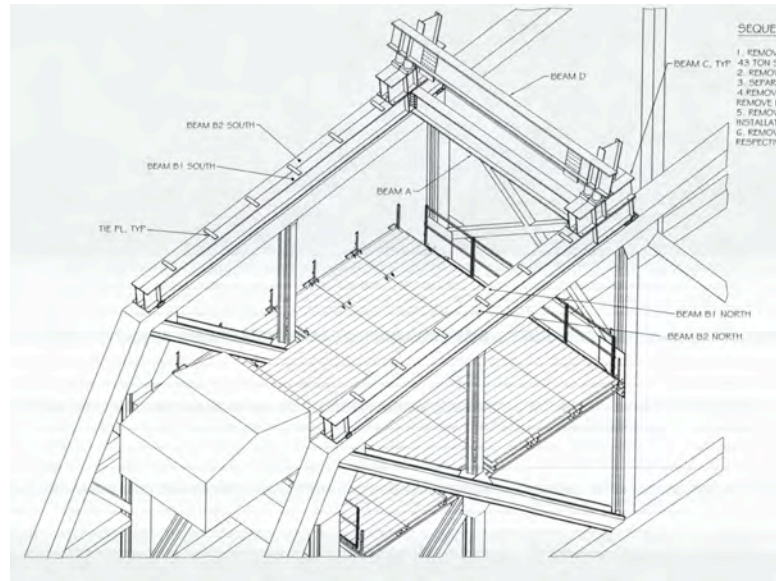


Figure 4: The temporary frame to support the counterweight.

The most difficult design issue, and the one that almost stopped our progress, was the connection between the counterweight and the lifting girder. The rear of the counterweight sloped at about a 12 degree angle to the vertical and the top chord sloped at about a 6 degree angle to the horizontal. These angles added together so that the rear plane of the counterweight was at about 18 degrees off a perpendicular to the support girders. Many different methods of attaching to the rear plates of the counterweight were considered and rejected. The final solution was to set the lifting girder web at the same angle to the vertical as the rear plates of the counterweight. The idea to address this problem resulted in the unusual application of hydraulic rams applying a significant load while in a sloped configuration. This required thoughtful detailing to consider all the forces that had to be resisted.



Figure 5: The connection of the lifting girder to the counterweight.

Once the support frame had been installed and a significant amount of concrete (and steel plates, cast iron balance blocks and lead ingots) removed from the counterweight the jacking of the support girder could

be performed. It always seems like tasks such as this get performed in the middle of the night. We monitored the jacking forces, the amount we lifted the counterweight and the amount the counterweight link frame moved relative to the bascule span. We predicted that the bearings where the counterweight links attached to the bascule span would have significant play in them and that we would know we were fully supporting the counterweight when the links moved without the addition of more load to the jacks. We were concerned that we stop jacking at that point because once the links bottomed out at the bearings we would perceive that we had not unloaded the links, when in fact we would be jacking load into the links. Not only would this lead to un-desired behavior of the links when initially cut for their removal, but the additional load of the link pushing against the bascule span would be resisted at the bascule heel trunnions which were never designed to resist loads applied in this direction. We didn't want to find out what might happen if they were.



Figure 6: The lonely job of monitoring the counterweight link at the bascule span.

As can be seen in Figure 7, the counterweight link moved very little until we reached an average ram pressure of about 4500 psi. This corresponded with our anticipated jacking load and we terminated our jacking efforts. Not much later, the steel demolition crews set to work and removed the counterweight connecting link, the operating struts and the front parts of the counterweight upperworks. With this work done the four day rail outage began the next day.

One thing we learned again, unfortunately, is that things go better, or at least more quietly, when you release the brakes before you try to jack something that has to move. Even though we were only moving the counterweight a small amount, the operating struts had to travel as well and with the brakes on there were more than a few disquieting BOOMS until one of our smarter general foremen released the brakes for us. As usual, no one of us is as smart as all of us together.

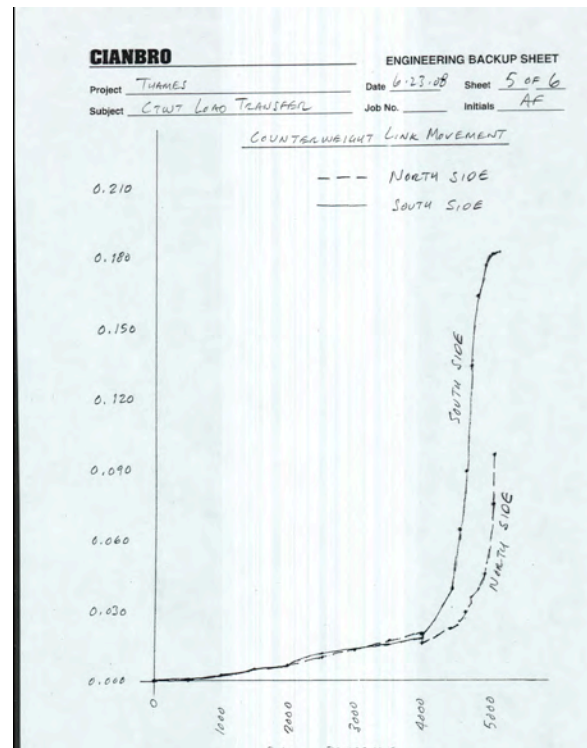


Figure 7: Link movement vs. jack pressure

Jacking Span B

Once the counterweight was supported, all attention went to the replacement of the bascule span with the vertical lift span and the restoration of rail traffic first and then marine traffic. One problem that Plan B would have permitted to be corrected during the outage that Plans A and C didn't, was the needed relocation of Span B so that it was centered on the right-of-way and positioned correctly in an east-west

orientation. Span B, a supposedly fixed span, had done a bit of moving on its own. Over the years, and more so during the duration of this project, Span B had moved west and south of its needed location. Span B, at Pier 2, needed to move north (transversely) 4 inches and east (longitudinally) 1½ inches. The need for Span B to be in a specific location came from the fact that the new lift span bearings were actually located on extensions of the Span B trusses. The new bearings had to be temporarily located out of position and the lift span centering device similarly offset until Span B could be brought to its correct location. We had moved Span D several times, including during the outage, for similar reasons. Span B, however, with the added weight of the old counterweight, was too great to permit it to be lifted so that it could be slid back to where it needed to be. We had to wait until enough of the old counterweight was removed.

By mid-August the counterweight had been reduced so that we felt we could lift Span B without damage. We had lifted one end of Span D with four 430 ton rams and moved it sideways with one 55 ton ram. Moving sideways was so easy in fact that when we jacked it sideways for the first time it almost jumped past where we wanted it to go before it stopped moving. We hoped for similar results on Span B.

The vertical jacking system for the end of Span B we needed to lift required eight 430 ton rams. We based our ram size on an estimated load-to-lift of 1600 tons which would keep jacking pressure under 5000 psi. Ram selection was also based on the availability of finding eight rams of this size available for short term rent. It required some effort to fit all the rams into places where they could direct load safely into the truss above. Jacking stiffeners were built into all jacking points using an estimated load of 400 kips per ram.

We provided three 55 ton rams for moving Span B north at Pier 2. We provided eight 50 ton rams, four at Pier 2 and four at Pier 1, to move Span B east. We provided rams at both Pier 1 and 2 since for Span B to move east, all four bearings would have to slide at the same time. Usually more is better when it comes to moving something that isn't supposed to move. We decided to perform the needed jacking over two successive weekends. In addition to lateral moving, Span B needed to be raised up about an inch so that the final rail grades would meet the lift span



Figure 8: Two 430 ton capacity rams.



Figure 9: Lateral Jacking bracket.



Figure 10: Always use plenty of lubrication.

correctly. During first weekend we lifted Span B at Pier 2, cleaned the surfaces beneath the bearings and verified what thickness shims would be needed to position Span B at the right elevation the next weekend. This operation confirmed that we could lift the bridge safely and prepared us for the lateral movements the following weekend.

The lateral jacking was a bit more eventful than desired. The fact that we had to clean under the bearings obviously didn't sink in to our planning as much as it should have. We had located our lubricated Teflon and stainless steel sliding bearing below the bridge main bearings, and as we found out, our cleaning efforts of the previous weekend had not been extensive enough. Additional grit, like we had removed the previous weekend, contaminated our sliding bearing system such that it took nearly 100% of our lateral jacking capability to get the span moved. There was so much resistance that we tore the 10 gage stainless sheets of our bearings in direct tension. Once again we learned that slide bearings don't like grit.

With Span B in its proper position, rail traffic was switched to the track which had been pre-located at the correct grade and alignment. The other track could then be rebuilt to its correct location and two track service could be restored.

Completing the Removal of the Counterweight

With the bridge in its correct position and the bridge open for double track service all that was left to do (almost) was the completion of the counterweight removal. With solid planning and good erection engineering all the rest of the counterweight disappeared in large chunks. Essential to doing that was the use of exothermic oxygen lances which can cut through steel and concrete. It was very satisfying to watch that counterweight, the removal of which had almost stopped the project at its most critical point, disappear piece by piece.



Figure 11: Cutting steel and concrete.

Overall this was a wonderful project to work on. All of the Amtrak employees we worked with, from engineering staff, to flagmen were focused on making this project happen. The construction management team were likewise focused on the job at hand. We had engineering coordination meetings on a monthly basis to address and avoid problems at the earliest possible opportunity. During the project I found a statement by James Rollins the engineer who designed the foundations for the 1917 original construction which applied to our new 21st century project as much as to his new 20th century project:

“Everybody worked for the best interest of the job: no pet schemes or new theories were tried out, for we all realized that we had a most difficult problem, which was a new one for all of us, and that it needed thought, brains and the most diligent attention, in order to be carried through with success.”



Figure 12: ALL GONE