Replacing the MLK Street Bascule Bridge Toledo, Ohio

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ABSTRACT:

Faced with the decision of performing an extensive renovation or a technically challenging replacement of a deteriorated 216 foot steel girder bascule bridge while minimizing interruptions to vehicular and pedestrian traffic over the Maumee River as well as navigational traffic on the Maumee River, the City of Toledo, Ohio opted for the most cost efficient alternative; replacement of the bridge.

To replace the existing bridge would require the removal of four delicately balanced steel bascule leaves followed by the staged installation of four new steel bascule frames and counterweight concrete; all performed over the Maumee River; all planned to fit within a extremely tight 3-month time period.

This paper will present the innovative erection process developed to carefully choreograph the use of two large deck barges, eight heavy duty self-propelled modular transports (SPMT's), erection gantries, lifting towers and auxiliary counterweights. The erection process would require the equipment to lift each existing bascule leaf from its rolling track, transfer the load to mobile transports positioned on the barges, float the leaf out to a nearby staging area and move the leaf onto the shore where it would be demolished. Once two pairs of existing leaves were removed and all pier modifications were complete, the erection process would require each new pre-erected bascule leaf to be lifted onto the mobile transports, rolled onto the barge, floated to the bridge site, lowered onto new track frames and then balanced with new heavy-weight counterweight concrete.

Site Photo – Second New Bascule Leaf is Floated into Position

INTRODUCTION

Faced with the challenge of removing four 700 ton bascule leaves and replacing them with four new 1000 ton bascule leaves in a short three month time period, National Engineering and Contracting Company opted to remove and install the steel portion of the new and existing leaves in whole.

This decision came after careful consideration of the risks and time involved with removing the existing leaves in sections over the river (erecting temporary falsework under the counterweight and cutting the existing leaves apart) followed by the challenge and time of installing the new leaves in sections over the river (constructing temporary falsework in the river and counterweight pit to erect the new sections).

Time was the critical factor in many of the decisions made throughout the entire construction sequence. All repairs and modifications to the existing bascule piers and control towers that could be performed with the existing bridge in place were made months prior to the critical river outage period. In addition, steel erection for all four new bascule leaves was performed prior to the river outage at a staging yard 3 miles downstream from the bridge (see figure 1).

Figure 1 – Steel Erection in Staging Yard

Numerous hurdles had to be overcome as the erection design progressed. National's construction team faced challenges due to variability of the weather, availability of equipment and limited access time on the river.

WEATHER CHALLENGES

The three month outage would be performed from January 1 though March 30. During that period of time period, the Maumee River could experience high fluctuations in flow velocities (see figure 2), rapid changes in water elevation and could freeze over with ice 12 inches to 15 inches thick.

These variables were critical to the flexibility of the design as the barges used to float the new and existing bascule leaves in and out of the project site would be moored to the existing pier for long periods of time while maintaining a maximum range of movement horizontally up and down stream of 2 inches and vertically of +/-2 inches. The erection design called for the barges to be secured to steel cleats anchored to the piers. Multiple 2 inch diameter nylon rope lines and 1 inch diameter steel wire ropes where used to stabilize the barges global position. A tug with its props in gear was present to offset sudden changes in flow velocity and hold the barge within the tight tolerances established for position.

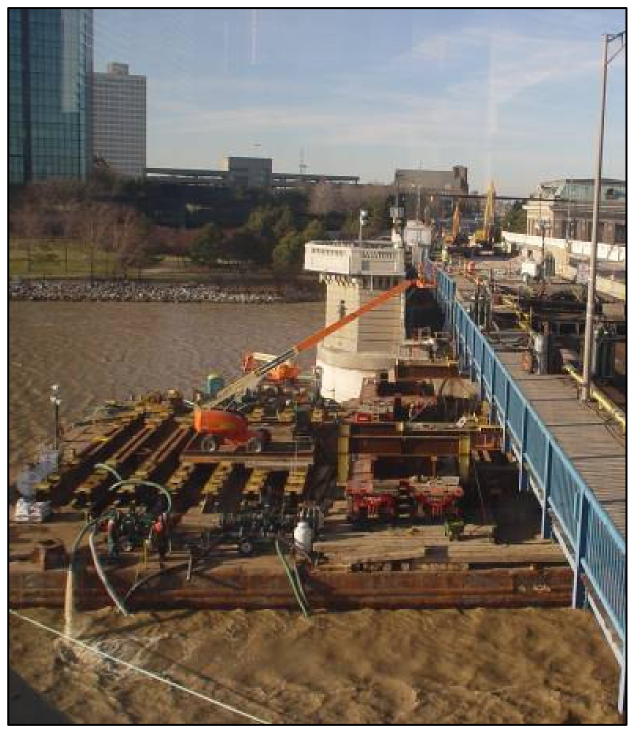

Figure 2 – High Currents on the Maumee River

The Maumee River flows directly into the Lake Erie and the water elevation depends greatly on the wind speed and direction over the lake. The rivers water elevation could fluctuate +/- 12 inches in one hour and could rise or drop over 36 inches in a 12 hour period. The entire system (barge + cribbing + SMPT's) was designed with +/- 24 inches (48 inch total range) vertical adjustment. This range was initialized by predicting the mean water elevation for a three to four day period and setting the fixed cribbing heights. Once on the water, adjustments to the vertical height of the bascule leaf could only be made by pumping water into or out of the barge for the gradual and larger adjustments and/or by raising or lowering the SMPT table heights hydraulically for the more immediate and smaller adjustments. If water elevations changed beyond the range of the system, barge operations were ceased.

Navigating through the ice was accomplished with around the clock ice breaking operations. Those areas of the river not in the main navigation channel froze to thicknesses of 12 inches to 15 inches. Even with the ice breaking operations in process, large chunks of the broken ice would accumulate at the leading edge of the barge and the barge tow would occasionally find itself locked in the ice until the breakers could work around the perimeter and free it (see figures 3 & 4).

Figure 3 – Barge Locked in Ice

Figure 4 – Ice Accumulating at Lead Edge of Barge

EQUIPMENT CHALLENGES

The equipment used to move and lift the bascule leaves was sized using the new spans as the governing design load. When combined with auxiliary counter-balance, each new leaf weighed 1000 tons. With 150 tons of falsework and cribbing used to support the leaves, the transported weight totaled 1150 tons.

Self-Propelled Modular Transports (SPMT's) provided by Fagioli PSC, Houston Texas were utilized to move the new and existing leaves on and off the barge and across the staging yard (see figure 5). 8 – six axle transports were used providing a total carrying capacity of 1600 tons. The SPMT's were grouped in four pairs and were rigged with steel falsework beams and cribbing. The transports were equipped with guidance systems that would allow for one driver control while loading and off loading the barge and for two driver control when negotiating tight corners.

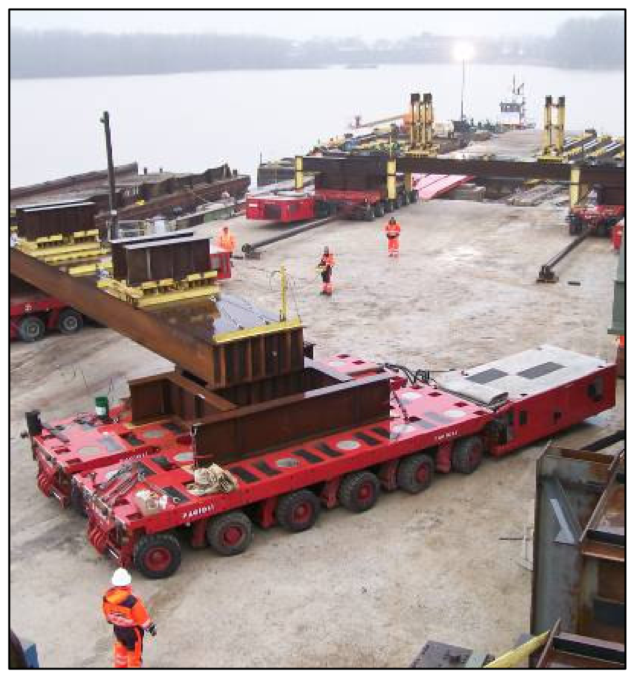

Figure 5 – Assembling SPMT's at the Staging Yard

Locating a 100 foot x 180 foot x 12 foot deep barge large enough to float 1150 tons of bridge cargo, eight SPMT's weighing 250 tons, two 60 foot JLG's, 275 tons of timber mats, two welding generators, two air compressors, two 8 foot x 20 foot crew quarters, three portable restrooms, two 500 gallon diesel tanks, twelve 2000 gpm ballast pumps, two deck winches and 24 portable heaters was not possible in the Great Lakes region. The barge was literally a floating "City" (see figure 6). Since no one barge was available, the construction team utilized two 50 x 180, 1800 ton deck barges.

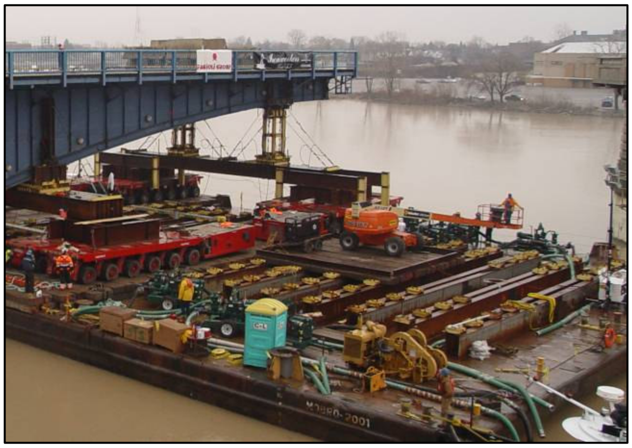

Figure 6 – The barge became a "City" on the River

Linking two barges to act as one rigid barge required the use of 36 - W36x150 (Fy=50 ksi) spine beams overlapping each barge 28 feet. Each was bolted through the deck to the main transverse trusses (see figure 7). The barge shell and internal trusses were checked using a 3D finite element model (LUSAS Bridge Plus software) and all calculations were reviewed by the U.S. Coast Guard.

In addition to the spine beams, 1 inch thick diaphragm plates were added to the bow and stern to prevent any lateral shifts between the two barges while being pushed through the ice. The spine beams effectively bridged the gap between the two barges, the 1 inch plates locked the two barges laterally and the two individual barges performed admirably as a 100 foot x 180 foot rigid barge.

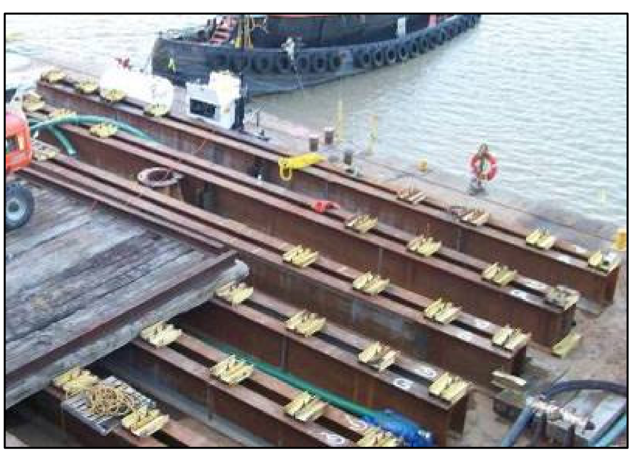

Figure 7 – W36x 150 spine beams linking barges

CONSTRUCTION SEQUENCE

The construction sequence was engineered as four distinct processes:

- Remove the existing 700 ton bascule leaves
- Disposing of the four existing leaves
- Loading the new bascule leaves onto barge
- Installing the new leaves

Removing the existing bascule leaves required the barge to be moored under the bridge while supporting the midspan "nose" of the individual leaf to be removed. The "nose" was lifted 18 inches to 24 inches to disengage the live load anchors located behind counterweight (see figure 8). This 3 inch to 4 inch gap was to be maintained until the bridge was ready to be lifted and removed from the pier. Water elevations were monitored every 15 minutes and the gap was maintained by adjusting the ballast within the barge or by adjusting the table heights of the SPMT's.

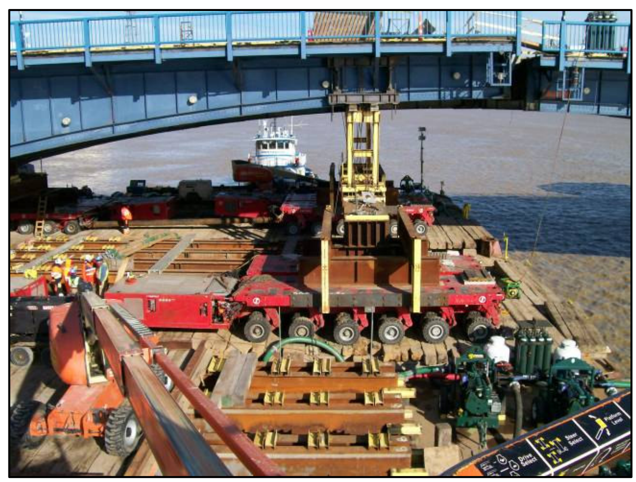

Figure 8 – "Nose" of bascule leaf lifted with barge

Removing the bascule leaf from the pier would require the demolition of the counterweight. Removal of the counterweight was dictated by the poor physical condition of the existing steel. Track hoes and excavators were used to rubbilize and remove the concrete. As counterweight concrete was removed, the "nose" reaction increased and further adjustments to the barge ballasting were made. The process to remove the counterweight concrete extended between three to four days. The construction team initially thought the entire concrete counterweight could be removed however limited positioning of the equipment affected the physical reaches and 15% (approximation) of the counterweight concrete was left to transport out with the steel (see figure 9). Additional ballasting (concrete "Jersey" barriers) would be required at the "nose" to offset the large imbalance caused by the additional weight behind the pinion.

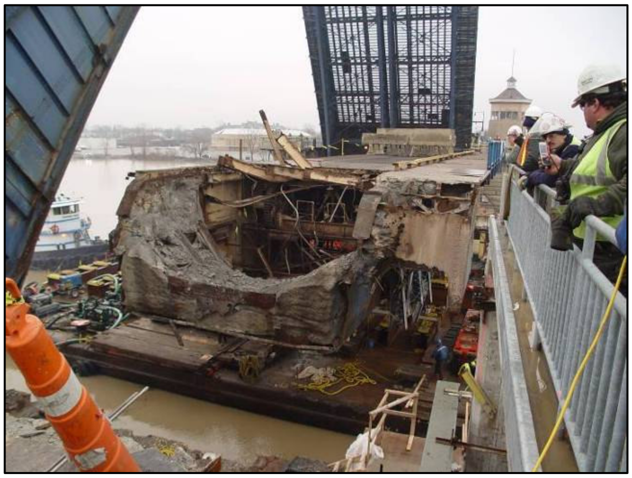

Figure 9 – 15% of the counterweight remained

Lifting brackets were added to the web to provide a level place of bearing (see figure 10). Once all miscellaneous items were cut free and clear of adjacent structures, the ballast tanks on the barge were systematically pumped dry increasing buoyancy to engage the lifting brackets and providing the lift required to raise the bascule leaf above the existing pintels and gear teeth on the rack and track. Actual time from the point where ballast removal initiated to the point where the leaf was free and clear of the existing pier averaged between four to five hours.

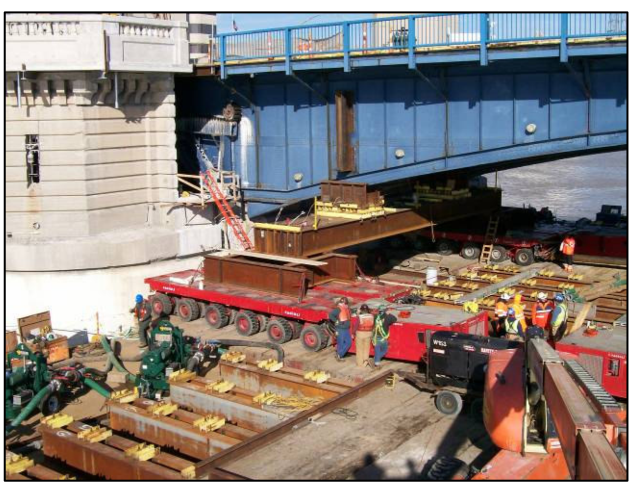

Figure 10 – Lifting brackets added to webs

Disposing of the four existing bascule leaves was performed downstream back at the staging yard using cutting torches. After a two hour trip down the Maumee River, the barge with its cargo was moored and off loaded. To off load the barge, the SPMT's were backed onto ramps while carefully staged ballasting proceeded (see figure 11). The ballasting consisted of adding or shifting water in the barge to compensate for the weight shift as the SMPT's rolled off the barge and onto the ramps. A maximum 3 inch to 6 inch list was set as the design limits for operation.

Figure 11 – SPMT's backing onto ramps

Once off the barge, the SPMT's were moved across the staging yard to a designated area set up with 12 foot stacks of oak crane mats. These would become the final resting place for the existing structure and the place where the bridges would be cut with torches and lances (see figure 12).

Figure 12 – SPMT's backing into mat cribbing

Landing the bascule leaf on the mats required synchronized shimming of the bearing points under the main girders and counterweight (see figure 13). Once seated on the mats, two 200 ton cranes were used lift the nose and allow the SPMT's to maneuver out from under the leaf. Once the SPMT's were clear, the nose was set down and secured to falsework towers. Once secure, the steel was cut using torches and lances (see figure 14). The machinery was removed first to recover all brass fittings followed by surgical removal of the steel working from the nose back towards counterweight. The remaining counterweight was rubbilized using track hoes.

Figure 13 – Timber mat cribbing under steel girders

Figure 14 – Surgical type cutting using lances

Loading the new bascule leaves onto the barge required two processes. The first step was to load the SPMT's. The second was to load the SPMT's onto the barge. All four new steel leaves were erected on falsework in the staging yard. Loading the SPMT's required the erected leaves to be lifted from the fixed falework and then lowered onto the SPMT's. The new steel leaves were lifted using two 300 ton jacks mounted to an overhead gantry over the counterweight box, two 100 ton jacks mounted to a large gantry truss over the nose and four 100 ton jacks mounted to the nose of the new leaf (see figures 15 and 16). The new leaves were lifted 12 feet to clear the SPMT's and falsework cribbing. The SPMT's were positioned below the new steel however due to geometry restrictions, the back support was located 42 inches in front of the center of gravity of the steel leaf. 350 tons of steel counterbalance was suspended below the nose to offset the imbalance. The suspended steel would also serve as the additional steel required to be installed in the new counterweight once the leaf was at the bridge site (see figure 17).

Figure 15 – SPMT's under front gantry truss

Figure 16 – SPMT's under back gantry

Figure 17 – 350 tons of counterbalance at nose

Once loaded onto the SPMT's, the new leaf was secured to the cribbing with cable rigging. After the leaf was secured, the SPMT's were moved out from under the gantries and back across the staging yard to the moored barge (see figure 18). The new leaf and counterbalance weighed 300 tons more than the old leaves and the load distribution was very different than the old leaves; therefore a new staged ballasting sequence was required. To load the new leaf, the barge was ballasted to the exact weight of the combined new leaf, counterbalance and SPMT's. The SPMT's were then moved "nose" first onto ramps (see figure 19). Ballast adjustments consisted of removing and shifting water in the barge to compensate for the additional weight as the SMPT's rolled onto and across the barge. A maximum 3 inch to 6 inch list was set as the design limits for operation.

Figure 18 – SPMT's move out from under gantries

Figure 19 – SPMT's roll "nose" first onto barge

Installing the new leaves required another trip back upstream. The new bascule leaves were heavier and the counterweight boxes were deeper than the existing leaves. One obstacle on the river (a 300 foot railroad swing span bridge with 135 foot navigation clearances) created a unique challenge as the new bridge could only pass over the existing pier when the water elevations were at normal datum or higher (see figure 20). The installation of one leaf was delayed one day due to low water elevations.

Figure 20 – Tight clearances at existing RR bridge.

Once the new bascule leaf arrived at the site, the barge was moored to another spud barge while final alignment (up and down stream) was set. Final alignment was achieved with the use of a telescoping arm that when fully extended made contact with a preset guide anchored to the face of pier. Two deck winches were used to guide the barge towards the pier. The initial fit up was made using the deck winches (see figure 21). Clearances at each side and top and bottom were tight with the largest clear gap at 3.5 inches and smallest at 1.5 inches. Final fit up with the pintels and gear teeth was made using the fine motor movements of the SPMT's (see figure 22).

Figure 21 – Initial fit up of spans

Figure 22 – Final fit up of spans

Once the bridge was aligned with the pintels and gear teeth, the new live load anchors were installed and post-tensioned (see figure 23). While the live load anchors were installed, only 20% of the load could be transferred to the pier without tipping the leaf into the river. During this period, water elevations were checked every 15 minutes and ballast adjustments were made to the barge to compensate for large changes in the water elevation or to the SPMT table height for the more immediate and smaller changes in the water elevation.

Figure 23 – Installation of live load anchors

Balancing of the bridge proceeded with the installation of the counterweight concrete, deck concrete, sidewalk concrete, steel counterweight slabs and balance blocks.

FINAL NOTES

The construction team was able to remove all four existing bascule leaves and install two of the four new leaves. Weather and the discovery of poor low strength concrete in critical areas of the existing piers delayed the project three to four weeks. Unfortunately the river closure could not be extended long enough to install all four leaves. Since the final concrete wearing surface could not be installed on the two new leaves and since a temporary barrier system would be required, a temporary balance condition was calculated using "Jersey" barriers and steel plates bolted to the deck (see figure 24). Currently the two southern leaves are operating and open to traffic (see figure 25). Installation of the two northern leaves is planned for the winter of 2008. When construction resumes,

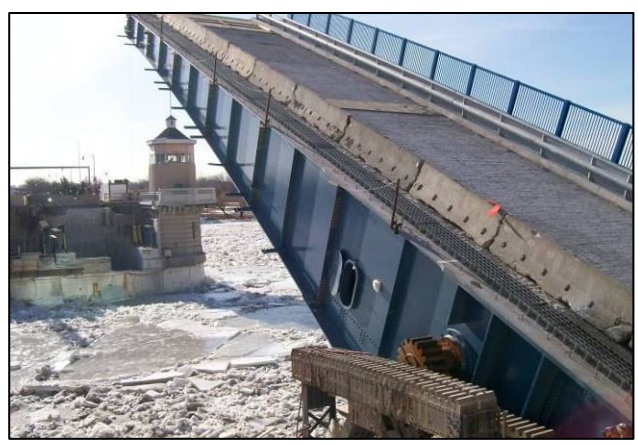

Figure 24 – Temporary balance condition

the two remaining bascule leaves will be installed and all four leaves will be locked in the down position. All temporary balance measures will be removed from the southern two leaves. All miscellaneous framing between the northern and southern halves will be installed. Final balancing will include installation of the concrete wearing surface and readjustment of the number and location of balance blocks in the counterweight.

Figure 25 – Bridge opened during machinery tests

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