ALEXANDER HAMILTON BRIDGE – CONSTRUCTION CHALLENGES AND SOLUTIONS

prepared for

Transportation Research Board

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ABSTRACT

The Alexander Hamilton Bridge (AHB) Project is the largest single construction contract award by New York State Department of Transportation (NYSDOT) to-date at a cost of $407 million. Construction began in 2009 and will be completed in 2013. The project includes a new reinforced-concrete widened deck and modifications to the approach superstructure and adjacent ramps while maintaining eight lanes of traffic on a highly congested section of interstate highway in the midst of New York City. The temporary structures accounted for a key portion of the total overall project cost and posed the greatest challenges. Key innovations were the use of stainless steel rebar, elimination of approach structure deck joints, and the use of innovative temporary support structures and rail gantry installation system, thereby saving overall cost to the contractor and the owner.
INTRODUCTION
The Alexander Hamilton Bridge (AHB) carries interstate highway I-95 over the Harlem River in New York City. It funnels all truck traffic that enters upper Manhattan via the George Washington Bridge to the Cross-Bronx Expressway in the Bronx and to points throughout New England. It is a major thoroughfare, with eight traffic lanes and average daily traffic (ADT) of 189,598 vehicles (2008). The bridge includes ramps connecting with the Major Deegan Expressway (I-87) and also crosses the Harlem River Drive.

The bridge opened to traffic in 1963 as a component of the construction of the Cross-Bronx Expressway and consists of a 555-ft (169-m) steel arch span with clearance of 135 ft (41 m) above the Harlem River. The approaches comprise separate viaducts for northbound (NB) and southbound (SB) traffic.

The original approach span superstructure uses simple spans that consist of a pair of girders framed with floorbeams and cantilever floorbeam brackets, all supporting a multi-stringer system. The west approach is approximately 190 ft (58 m) and the east approach is approximately 827 ft (253 m).

In its long-range planning, the New York State Department of Transportation (NYSDOT) decided to provide redundancy for the two-girder approach spans, and also to widen the bridge and approach viaducts to create room for staged construction while maintaining all traffic lanes during peak traffic volume. Also included in the project scope is a reconstruction of the interconnector ramps to/from the Major Deegan Expressway and the Harlem River Drive. With the requirement of maintaining traffic on the crossing and interconnectors for the duration of the multi-year construction schedule, complex traffic staging and temporary ramps were required. The $407 million project cost is the largest contract award in NYSDOT’s history. The joint venture of China Construction America and Halmar International (CCA/Halmar) is currently contracted with NYSDOT to carry out the reconstruction, which is on-schedule and is due to be completed by the end of 2013.

The design for the approach reconstruction involved providing redundancy through the addition of girders, as shown in the final condition in Figure 2, and making the girders continuous. New plate girders, with section properties similar to those of the existing girders, are placed outboard of the existing fascia girders on each approach span with new outboard cantilever floorbeam brackets. The contract includes truss girders installed midway between each pair of existing plate girders, and the NB and SB approach spans are tied together by replacing the inboard cantilever floorbeam brackets from each separate span with a continuous replacement floorbeam. While the new outboard plate girders are set on widened piers and do not interfere with the existing superstructure, the new truss girders were designed to be built around, and frame into, the existing floorbeam system, thus avoiding disturbance of the inboard floorbeam system.

The project involved 7.98 million lbs (3.62 million kg) of fabricated steel; 483,500 CF (13,700 CM) of concrete, 23,300 CF (700 CM) of which was temporary construction; the use of stainless steel reinforcing bar in the new deck; elimination of deck joints by revising simple spans on the approaches to be two-span continuous; a very aggressive construction schedule; hefty incentive/disincentive clauses with liquidated damages; and extensive interagency coordination among New York State Department of Transportation, New York City Department of Transportation, The Port Authority of New York and New Jersey, New York City Parks Department, Metro North Railroad, and CCA/Halmar.
The major design challenge was to develop a construction scheme that would maintain the entire interchange traffic volume all throughout the construction. This required widening and removal of piers of the two overhead bridges to create room for work zone and traffic lanes. Removal of piers required complete replacement of these two bridges that were above the approaches on either side of the AHB.

Some innovations on this project were the use of self-consolidating concrete for certain applications; also the use of stainless steel reinforcement allowed lower clear cover and thus reducing the over deck thickness and will also help prolong deck life. Reduction in the superstructure dead load, achieved by reducing deck thickness, was helpful in optimizing the superstructure and to reduce the seismic responses.

The major issues involved in successfully completing this major reconstruction effort, the largest contract award in NYSDOT history, are discussed below.

TEMPORARY STRUCTURES
Although this project was a traditional design-bid-build project, it is noteworthy that CCA/Halmar engaged in a major re-engineering of the contract temporary structures during construction in order to reduce cost and expedite the construction schedule. The entire temporary support system of the lifting operations for the main bridge and all ramp bridges, as well as the entire superstructure and substructure of four temporary ramp bridges was re-engineered, including significant modifications to the jacking operations.

In recent years, bridge jacking technology has reached a higher level of sophistication, and a series of bridge jacking methods have been developed and implemented in the construction field, including (a) the flat jack method using a low profile hydraulic jack placed between the bridge girder and the concrete cap beam; (b) the saddle beam method, which uses the existing pier cap to support the jacking system; and (c) the independent jacking system such as the MABEY system. As for the shoring system, traditional method is to use the independent shoring structure such as the DOKA system to support the platform to pour the new concrete. All these traditional methods can only serve one purpose, either for the jacking, or the shoring. The system assumed during the constructability phase of design was the MABEY system to perform the bridge lifting. The original designer also used the DOKA system to serve the purpose of shoring for the widening and strengthening of the existing cap beam. These two systems are independent, time-consuming, and expensive.
Instead of using the traditional massive shoring towers, an integrated jacking and shoring support system was developed to not only act as temporary support for jacking up existing girders but also act as the shoring for support of the pier cap wet concrete pours. This alternative system included three integrated parts: (a) tie-rod suspended platform girders; (b) vertical steel pipes; (c) and a horizontal self-balanced tie-rod collar system. The pier shoring system was composed of two horizontal steel support girders positioned transversely near the top of the piers. These support girders supported the combination of work platform/formwork/shield. The support girders were connected to vertical steel pipe columns installed adjacent to the existing concrete piers and extended down to the existing concrete footings. The steel pipe columns were braced to the existing concrete piers approximately every 20 feet (6.1 m) by steel slip collars with tie-rods. Since the steel columns were supported by the existing footing, the new footing required for the MABEY system and the DOKA system was also eliminated.

The 92 ft (28 m) high pipe columns were located under the existing bridge girders and were offset from the existing bearings of approximately 5 feet (1.5 m) to allow room for construction work at the pier cap locations. The collar braces consisted of tie-rods between adjacent piers and provided both lateral and longitudinal restraint, with some collar braces providing only longitudinal restraint. Seismic loads were not accounted for in the analysis, and wind loads were typically the governing factor due to the height of the structure and relative slenderness of the shoring system. This integrated jacking and shoring support system has been successfully conducted in the field with high construction cost savings and can be re-used for other similar bridge construction, reconstruction, and rehabilitation projects in the future. This comprehensive integrated jacking and shoring system is shown below in

![General arrangement of lifting support system.](image)

The self balanced tie-rods collar system was used to provide the needed lateral stability to the slender steel support columns. Although the steel columns used for this project reached 30 in (762 mm) outside diameter and the column pipe wall thickness also reached 7/8 in (22 mm), the steel columns were still too slender, considering the unsupported length of the column was as much as 92 ft (28 m). Therefore, the lateral bracing was necessary to provide stability to the support columns. The collar was tightened to be in full direct contact with the existing concrete column, and then the tie rods were used to tie the steel column to the existing concrete column through the collars. The "Parallel-Type" and the "X-Type" tie rods were used to tie the collars together in order to prevent the
collar self-rotation about the existing concrete columns; the key attached to the steel column was also locked to prevent the steel column rotation and lateral movement (see Figure 4). This self-locking mechanism provided the lateral stability to the whole support system in the bridge transverse direction. It can be clearly seen that this system is also self-balanced as three types of the tie rods are preventing the movement and rotation of the steel columns and the collars from all directions.

![Collar System Diagram]

FIGURE 4 Self-balanced tie-rods collar system.

As shown in Figure 4, for example, if only one of the collars rotates about the concrete column, the "X-Type" tie-rods and the "Parallel-Type" tie-rods will limit this rotational movement. If these two collars rotate together at the same time in the same direction, the "X-Type" tie-rods will resist this rotational movement as the "X-Type" tie-rods have no place to go but to push the collar move back to its original position. If both collars rotate at the same time but in opposite direction, the "Parallel-Type" tie-rods will be in direct tension or compression so as to prevent this kind of movements. With the lock-in key and the "V-Type" tie rods and based on the same principle, the steel columns will not be able to move or rotate in any direction.

The construction sequence using the integrated jacking and shoring support system followed a simplified format. First, using the jacking system to lift the upper deck steel girder and transfer the superstructure loads from the existing bearings to the temporary supports; then replace all unloaded existing bearings. Second, while maintaining the traffic flow, the existing pier cap was widened and strengthened by using the shoring system as the platform to pour the concrete for the pier cap. The originally simply supported girders were also spliced together to become the continuous girder. Finally, the girders were lifted again by using the jacking system and the temporary supports could be replaced by the new permanent bearings.

The combined steel weight for the MABEY and DOKA system was estimated at approximately 4.4 million lbs (2,000 metric tons) compared to the roughly 2.2 million lbs (1,000 metric tons) of steel required for the integrated jacking and shoring system. In addition, new concrete footings needed to be designed and constructed to support the traditional MABEY and DOKA system, which were eliminated. The temporary integrated system,
MAINTENANCE OF TRAFFIC/WORK ZONE TRAFFIC CONTROL
Due to the ADT of 189,598 (2008), construction staging on this heavily-used bridge involved six major stages and several sub-stages. The AHB was widened by 11 ft (3.3 m) on both sides. This widening, completed in the earlier stages, provided room to maintain all traffic lanes during the peak traffic periods. For the ramps to and from the Major Deegan Expressway (I-87), independent temporary bridge structures were constructed adjacent and parallel to the existing ramp structures to allow uninterrupted use of ramps all throughout the construction. Part of the staging challenge was the channeling of traffic over the adjacent George Washington Bridge’s (GWB’s) upper and lower levels. All trucking on the GWB is required to use the bridge’s upper roadway. The upper roadway lanes from the GWB are channeled to the central lanes on the Cross Bronx Expressway adjacent to Alexander Hamilton Bridge.

The six stages of construction required retaining all four lanes of traffic in each direction at all times, except for some off-peak nighttime hours. Stage 1 involved removing the central median barrier and safety walks and replacing them with temporary roadway deck to increase the flexibility and availability of roadway deck for future stages. In construction Stages 2 and 3, the new fascia girders were erected outboard the existing girders and the roadway width was increased. This allowed traffic to be transferred to the newly-placed roadway deck. New plate girders were installed in Stages 4 and 5, located inboard of the existing girders and new fascia girders. Stage 6 involved removing the temporary roadway deck placed in Stage 1 and constructing the new central median barrier.

TRUSS GIRDER VALUE ENGINEERING ALTERNATE
NYSDOT had originally considered providing for plate girders between each pair of existing girders. However, due to difficult access and the complexity of staged construction, as well as the uncertainty of the eventual contractor’s proficiency for various types of construction methods, NYSDOT decided that a truss girder would be easier to construct and more suitable for presenting in the design documents. During construction, CCA/Halmar proposed to NYSDOT to replace the truss girders with plate girders. This was proposed as a Value Engineering (VE) Proposal, a contractual mechanism whereby there is incentive for the contractor to propose design changes that will reduce construction cost and/or schedule duration, and to share in those savings with NYSDOT.

CCA/Halmar retained Parsons Brinckerhoff to design the plate girders (VE girders) and reconfirm the potential cost savings of replacing the two truss girders with plate girders. NYSDOT reviewed and approved the VE proposal in six (6) weeks. There are numerous advantages of the VE girder: (a) the weight of the VE girder is approximately half the weight of the truss girder; (b) the VE girder’s section properties are very similar to the existing plate girders and other new plate girders; (c) the VE girder was easier to install and will be easier to maintain. In its study, Parsons Brinckerhoff was also able to realize additional savings by eliminating the existing lower lateral bracing on the bridge by taking advantage of the sequence of construction and by virtue of the composite action of the new deck. The VE girder proposal resulted in $3 million in cost savings, shared equally by NYSDOT and CCA/Halmar. The VE plate girder that was installed is compared to the originally-proposed truss girder in Figure 5.

CONSTRUCTION TECHNIQUES
Access constraints on the Bronx approach included the sprawling geometry of the spaghetti-like ramp interchange on each side of the structure, complicated by interstate and railway easements beneath the structure. On the Manhattan approach, steep topography permitted limited access below-deck. In addition, lay-down area in this congested section of New York City was virtually non-existent.

During the design phases, NYSDOT studied various possible construction schemes as part of the constructability review. One of the schemes involved the use of Platform Twinring Containerized (PTC) cranes. The PTC crane was expected to be installed near the bank of Harlem River. This crane had capability of lifting steel from the barge to and placing it on the bridge. The crane’s position would allow it to remove massive concrete
columns of the Ramp TE. Another scheme, which the CCA/Halmar elected to use, was the track mounted gantry crane.

For installation of the VE girders, Parsons Brinckerhoff designed a rail system for tandem gantry cranes to off-load girder sections from delivery trucks from within the closed work zone and ride them through the closed work zone corridor to the installation location, where they were lowered into place for bolt-up. This construction technique was envisioned by NYSDOT during its internal constructability review of the project. CCA/Halmar had bid the project based upon using a rubber tire gantry that was intended to be driven directly on the edges of the roadway deck, straddling the deck opening at the work zone. However, subsequent to field survey, constrictions between the barrier and cut lines in the deck were discovered to be as little as nine inches (230 mm), too narrow for the rubber tire gantry to navigate safely. A gantry with steel wheels meant to ride on temporary rails installed on the edge of deck was then investigated and ultimately determined to be the safest choice, since the gantry wheels would be guided by the rail, thereby significantly lowering the risk of operator error in areas of tight clearance. The rail gantry system (one of two cranes used in tandem) is shown in Figure 6.

FIGURE 5 – Comparison of Value Engineering Girder (replacement design) versus Truss Girder (original design).
Special attention was given to coordinating theoretical cut lines plotted by Parsons Brinckerhoff, and survey information from CCA/Halmar, with the gantry crane manufacturer. This ensured that the trolley systems would be able to negotiate the anticipated longitudinal and transverse grades. Coordination with the manufacturer also ensured that modular components such as access ladders and operator booths were positioned so that no components encroached into traffic, and positioning of fuel tanks optimized loading. Two 20-ton gantry cranes were used in tandem for VE girder installation. The benefit of a tandem crane arrangement was that for the larger girder picks, the load could be spread out by more points of contact.

OUTREACH
To keep the travelling public informed, at the start of every construction stage, a radio ad campaign was arranged. Extensive Multi-Agency coordination took place and an effective traffic mitigation plan was put into place, including signing numerous alternate routes, programming VMS signs and providing Highway Advisory Radio announcements, alerting NYSDOT’s 511 system, updating the project website with appropriate rerouting information, providing information to rest areas and EZ Pass customers. In addition, travel advisories and information packets were given to the trucking industry and multi-trip generators, and additional outreach to appropriate newspapers, radio and Television stations was undertaken. All of these strategies helped contribute in diverting traffic to alternate routes and thus reduced traffic congestion during the most critical construction stages. The project team also developed modifications to the Work Zone Traffic Control patterns to improve through-traffic movements based on minor restaging and available space not envisioned during the design phase.

CONCLUSIONS
This project is the largest contract awarded in NYSDOT history. With high traffic volume on the crossing, multiple construction stages, and major temporary works required, the project was highly complex. Close coordination among all stakeholders was essential for project success. The use of innovative design solutions, value engineering proposals to reduce construction time, and proactive communication with the traveling public all combined to achieve a positive synergistic effect on the final project outcome, and saved money for NYSDOT as well as for the contractor.

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