VICTORY BRIDGE REPLACEMENT DESIGN UTILIZES HPC

Jose M. Rodriguez, PE, Figg Bridge Engineers, Inc., Tallahassee, Florida

ABSTRACT

Route 35 over the Raritan River is a vital link between Perth Amboy and Sayreville in northern New Jersey. The existing Victory Bridge is a low-level concrete and steel swing bridge that was constructed in 1927. Functionally obsolete, the bridge will be replaced with a concrete segmental bridge designed by FIGG/Vollmer Joint Venture. The new bridge will consist of two parallel structures, each 3,971' in length, with 440' precast matchcast main spans (a new U.S. record) and back spans of 330' on either side of the main channel. The bridges are to be built in balanced cantilever from barge-mounted cranes. Precast approach spans will vary in length from 132' to 150' and will be erected span-by-span with supporting trusses. In keeping with the current bridge name, the new Victory Bridge will be dedicated to the honor of World War I veterans. Bronze plaques along the pedestrian sidewalks will commemorate various aspects of the war and its heroes. The superstructure and substructure consist of High-Performance Concrete.

Keywords: Precast, Concrete, Segmental, Replacement, Span-by-Span, Balanced Cantilever, High-Performance Concrete

INTRODUCTION

The Route 35 Project consists of the replacement of the 75-year old Victory Bridge, widening of Route 35 and intersection improvements at Smith and Fayette Streets. The existing swing span Victory Bridge carries Route 35 over the Raritan River connecting the City of Perth Amboy with the Borough of Sayreville, in Middlesex County, New Jersey. The nationally registered historic bridge has reached a level of deterioration where replacement is necessary to maintain its structural serviceability. The owner, New Jersey Department of Transportation, hired the FIGG/Vollmer Joint Venture to design the Replacement Project. Figg Bridge Engineers, Inc. designed the segmental bridge.

EXISTING CONDITIONS

The existing Victory Bridge, which was constructed in 1927, is a concrete and steel low-level structure on piles with a swing span over the Raritan River channel. Route 35, constricted by the existing bridge width, has very narrow lanes. There currently are two 9'-6" lanes and 4'-6" sidewalks in each direction with no shoulders or median barrier. The restrictive 28' bridge clearance over the Raritan River requires the bridge to swing open frequently for marine traffic, which causes major delays to drivers on Route 35. Because the existing structure is currently at an advanced stage of deterioration, has substandard lane widths and operates inefficiently, the structure will be replaced.

PROPOSED CONDITIONS

Route 35 will be widened to provide two 12' lanes and a 10' outer and 3' inner shoulder in each direction. Safety improvements will be made throughout the project limits including the addition of a center median barrier, guard rail replacement and new highway lighting. A 6' wide sidewalk will be provided on the southbound side of Route 35 for pedestrian traffic. Ten-foot wide shoulders will safely accommodate bicycle traffic, along with the required AASHTO bicycle height open railing across the bridge.

BRIDGE DESCRIPTION

The proposed bridge (see Figure 1) consists of two parallel structures approximately 4000 feet long and will provide a 355 feet wide navigational channel in the Raritan River with a minimum vertical clearance 110 feet above the mean high water elevation.

Fig. 1 Rendering of Proposed Victory Replacement Bridge

The new bridge will be constructed adjacent to the existing Victory Bridge. Shifting the new alignment approximately 30 feet to the west of the existing baseline will allow the construction of water foundations without interrupting existing traffic. The bridge contains 23 spans with a record span of 440' for a precast matchcast girder in the United States.

SUPERSTRUCTURE

The superstructure consists of precast concrete segmental box girders erected by the span-by-span and balanced cantilever construction methods. The utilization of both methods will allow construction of the mainspan and approach spans to occur simultaneously. This will result in an expedited construction schedule.

Approach Spans

For the approach spans, which will be built using span-by-span erection, the typical segments are 10'-1¾" deep and 9'-4" long, with a few that are 8'-0" long (see Figure 2). These lengths, along with the varying closure joint widths, are combined to produce the different span lengths that are required to build foundations around the existing bridge. These lengths were chosen also because they can be easily transported over roadways. Each pier segment, which is heavier per foot than a typical segment because of the diaphragm, will be cast in two halves, so that the same equipment that is used for the typical segments can be used to lift and place the pier segments.

Fig. 2 Precast Approach Span Segment

Continuous units were selected to reduce the number of expansion joints and the quantity of post-tensioning required. Typically, there are 7 or 8 spans per unit; the spans with the typical length of 150' will use external longitudinal tendons. The typical span has in each web five 19 x 0.6" strand tendons. Transverse post-tensioning in the top deck will provide for a long-lasting, durable riding surface.

The bridge segments will be cast with an additional ½" of concrete on the top slab, so that when erection is complete, the riding surface can be milled to meet rideability criteria and provide superior rideability. An additional 1¼" of sacrificial concrete will also be cast into the segments to provide an integral wearing surface. No second course wearing surface will be required for the project; however, the additional 1¼" concrete can be removed in the future and replaced with an overlay, if required. The superstructure segments will be cast using a high-performance, 6000 psi (Class P-2) concrete.

Main Span

For the main span, the segments are typically 7'-9"long, with a few that are 9'-4" and 8'-0". The depth of main span segments varies from 10'-1¾" at mid-span to 21'-1¾" at the piers. The main span unit consists of 440' main span with 330' side spans, which are built in balanced-cantilever using 19 x 0.6" strand tendons for the cantilever tendons in the top slab and 19 x 0.6" strands for the continuity tendons in the bottom slab. The superstructure segments will be cast using a high-performance, 8000 psi (Class P-4) concrete.

The precast superstructure consists of the construction of Portland cement concrete with the use of High Performance Concrete (HPC). HPC is defined as concrete that meets special performance and uniformity requirements that cannot always be obtained by using conventional ingredients, normal mixing procedures and typical curing practices. Since there is an integral wearing course, it was decided that a dense mix with good resistance to freeze-thaw conditions and permeability be incorporated in the precast mix to provide long-term durability.

In order to achieve the desired resistance to chloride penetration, an appropriate pozzalonic material, such as silica fume, flyash or ground granulated blast furnace slag, will be used in the mix design.

In the development of the superstructure HPC mix design, the following performance requirements were specified (see Table 1).

Table 1

Performance Characteristic	**Standard Test Method**	**Performance Required**
Scaling Resistance (x = visual rating of the surface after 50 cycles)	ASTM C672	x = 3 maximum
Freeze-Thaw Durability (x = relative dynamic modulus of elasticity after 300 cycles)	AASHTO T 161 ASTM C 666 Proc. A	x = 80% maximum
Chloride Permeability 56 days (coulombs)	AASHTO T 277 ASTM C1202	1000 maximum
56 Day Compressive Strength (Verification Strength)	AASHTO T 22 ASTM C 39	Class P-2 7000 psi minimum Class P-4 9000 psi minimum

SUBSTRUCTURE

The substructure will consist of 22 piers and two abutments for each structure. Each pier will be constructed from precast concrete hollow box sections that will be post-tensioned together. All the piers will be 8 feet by 16 feet with chamfered corners for architectural purposes (see Figure 3). 20 feet by 16 feet precast pier caps will be placed at the top of all piers. The wall thickness of the box piers will be 12 inches except at the mainspan piers, which will be thicker. Piers within the river will have foundations consisting of footings connected to drilled shafts. The remaining piers that reside on land shall have foundations consisting of rectangular footings with steel pipe piles filled with concrete. The abutments will be conventional cast-in-place concrete on a pile foundation. Precasting the columns off-site allows for concurrent foundation installation. The precast piers can be installed at rates of 100 feet in height per day. The precast concrete is high-performance concrete with a strength of 8000 psi.

Fig. 3 Precast Column Support

Foundations

Multiple 6' and 8' diameter drilled shafts are used for the footings for the piers located in the water (see Figure 4). The footings in water are typically 28' x 96' x 10' deep. The footings on land will consist of 24" diameter concrete-filled steel pipe piles with steel conical tips. The footings are typically 40' x 28' x 8' deep.

Fig. 4 Drilled Shaft Construction

The water footings are subject to waterway abrasion, as well as chloride intrusion; therefore, high-performance concrete (HPC) was specified with these concerns in mind. Pozzalonic materials were used for chloride resistance similar to the superstructure.

In the development of the footing HPC mix design, the following performance requirements were specified (see Table 2).

Table 2

Performance Characteristic	Standard Test Method	Performance Required
Abrasion Resistance (x = average depth of wear)	ASTM C 672	x = 0.04 inches (maximum)
Freeze-Thaw Durability (x = relative dynamic modulus of elasticity after 300 cycles)	AASHTO T 161 ASTM C 666 Proc. A	x = 80% maximum
Chloride Permeability 56 days (coulombs)	AASHTO T 277 ASTM C1202	1000 maximum
56 Day Compressive Strength (Verification Strength)	AASHTO T 22 ASTM C 39	Class P-1 6500 psi minimum Class P-3 5500 psi minimum

ERECTION METHOD

The southbound structure will be constructed first while the existing Route 35 Victory Bridge remains in service. Upon the completion of the southbound structure, all traffic will be re-routed from the existing bridge to the southbound structure. This will allow for uninterrupted traffic flow while the existing Victory Bridge can be demolished. After the demolition, the northbound structure will be constructed and the traffic will be re-routed to the normal pattern for the new Victory Bridge. The estimated construction schedule is 36 months to complete the entire project.

The construction method used for the approach span bridge will be the span-by-span erection method. The design was developed based on an underslung truss system being used. With this system, the trusses are supported on the pier brackets and support the precast segments under the wings. The segments are delivered across the completed structure and placed onto the truss with a crane mounted on the newly erected bridge deck. The segments on the trusses are supported under each wing of the segment.

The main span structure will be built in balanced-cantilever by erecting the pier segment on top of the main pier and installing one segment on each side of the pier segment with the use of cantilever tendons. Once the two main pier cantilevers meet in the middle, a closure pour is installed and the continuity tendons in the bottom slab are installed to complete the cantilever unit.

UNIQUE CONTRACTING METHODS

The drawings included in the bidding documents are construction drawings. These drawings were developed to include al elements required to build the concrete structure without shop drawings. The drawings include dimensions, rebar bends, segment geometry and tendon stressing information. For the pier segments, expansion joint segments and deviation segments, electronic files of 3-D integrated color drawings are also given to the Contractor to assist him during fabrication (see Figure 5). This results in a faster construction schedule by eliminating development and review of shop drawings.

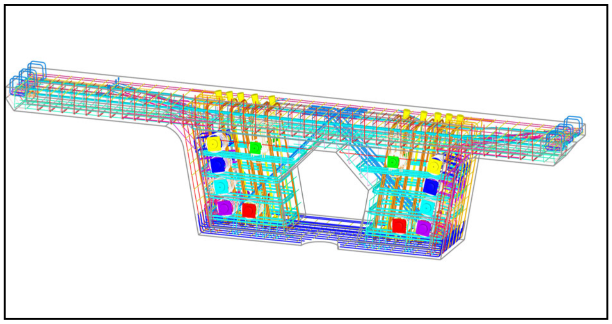

Fig. 5 Example of 3-D Integrated Color Drawing

AESTHETIC FEATURES

The theme chosen for the bridge honors the intent of the builders of the original Victory Bridge. The original bridge was erected as a memorial to those residents of New Jersey who served in World War I. The bridge's slender rectangular columns evoke the verticality that is associated with monuments. The new Victory Bridge will be a monument that will honor and memorialize those same veterans.

The light poles required every 150' will be supported on concrete pilasters, which include bronze plaques that commemorate various branches of the armed services from World War I (see Figure 6). These will form a linear library along the sidewalk so that pedestrians can view, learn and honor the war heroes.

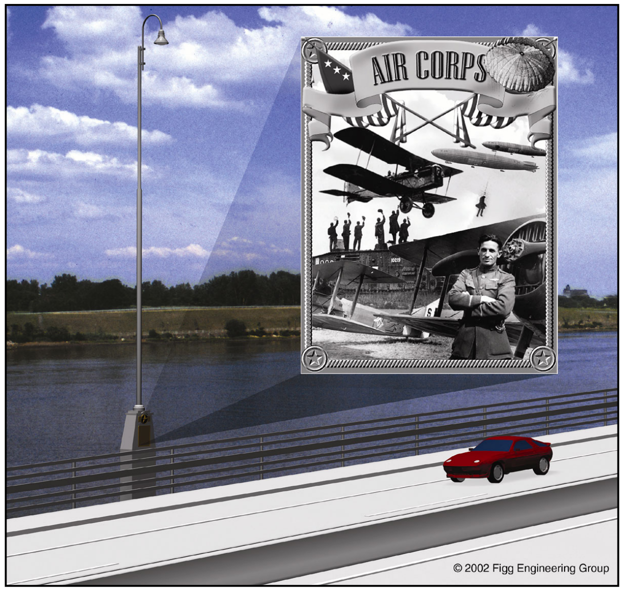

Fig. 6 Bronze Commemorative Plaques

Four memorial obelisks (see Figure 7) will be erected at the bridge abutments; two of these will incorporate original bronze plaques from the existing bridge and the other two will have new bronze plaques that rededicate the bridge to World War I veterans.

Fig. 7 Memorial Obelisks

CONCLUSIONS

The project received bids in December 2002. George C. Harms Construction Co., Inc. of Howell, New Jersey was the low bidder. The project is currently under construction. Pile driving, drilled shaft construction, precasting of superstructure and substructure segments and fabrication of erection equipment is underway for the southbound structure. The project will be completed in December 2005.

The incorporation of a high-performance concrete at different locations in the structure with different, unique requirements for that element will result in a long-term, durable structure at an economical cost with little future maintenance.