The Humpback Bridge on the George Washington Parkway near Washington, D.C., is being replaced with a precast concrete arch design that replicates the look of the original, including using some of the original stonework in the fascia. Photo: Cianbro Corp.

SEQUENCED ARCH

by Craig A. Shutt

Five-stage process keeps traffic moving during construction of precast concrete segmental arch bridge near nation's capital

Replacing the existing Humpback Bridge over the Boundary Channel on the George Washington Parkway near Washington, D.C., with a wider bridge will create efficiency and functionality, but it poses significant challenges. In addition to providing an appearance that replicates the original stone-faced arch, the work must progress with site restraints caused primarily by the need to keep two lanes of traffic open in each direction during construction.

The previous bridge consisted of a stone-faced, cast-in-place concrete arch. The 73-ft-wide structure accommodated two northbound and two southbound lanes, separated by a 4-ft median. The Mount Vernon Trail, approximately 6 ft wide, runs adjacent to the northbound lanes, with a similarly sized pedestrian walkway adjacent to the southbound lanes. Officials required the new design to incorporate features and styles of the original historic appearance while also ensuring that pedestrian traffic was segregated from vehicles. They also mandated traffic continuity during reconstruction, requiring a systematic sequencing that allowed for construction of only a few girder lines at a time.

Construction Progressing

Designers planned the new single-span bridge to reflect the arched design and stone facing of the original bridge. The new bridge comprises segmental precast concrete girders erected as half-arches, which are joined together with a cast-in-place concrete closure. The structure, to be completed in late 2010, is 244-ft long and includes underpasses at each end to aid access for pedestrians, including access to the hiking trail. The span over the channel consists of seven match-cast segments in each half-arch component, with 11 girder lines comprising the entire width for a total of 154 girder segments. A 9-in.-thick, cast-in-place high-performance concrete deck is placed for the riding surface after construction of the arches.

profile

HUMPBACK BRIDGE OVER THE BOUNDARY CHANNEL / VIRGINIA

ENGINEER: Eastern Federal Lands Highway Division of the Federal Highway Administration, Sterling, Va.

CONSULTING ENGINEER: URS Corp., Washington, D.C.

CONSULTING EXPERT: National Park Service, Washington, D.C.

PRIME CONTRACTOR: Cianbro Corp., Pittsfield, Maine

PRECASTER: Northeast Prestressed Products LLC, Cressona, Pa., a PCI-certified producer

The project adds an acceleration lane that facilitates access from southbound I-395 onto the northbound lanes of the parkway. The added width, however, is being provided on the opposite side of the bridge, with all lanes moving over, explains Doug Nair, construction operations engineer for the Eastern Federal Lands Highway Division of the Federal Highway Administration (FHWA). It also is adjusting the grade of the road to improve sight lines, as the current sight distances over the bridge are too short as cars approach. This has resulted in frequent accidents when cars come over the rise and need to stop in a short distance.

The precast concrete segmental design minimized site construction, aiding traffic flow.

To replicate the look of the original cast-in-place concrete arch bridge, designers chose to use a precast concrete segmental structure, as it minimized the need for site construction, aiding traffic flow, Nair says. It also allowed the existing stonework on the structure to be saved and replaced after construction. The FHWA consulted with the engineering firm of URS Corp. and the National Park Service to achieve the final design.

Because the precast concrete arches required a depth of 20 ft, they were cast horizontally, with all seven segments for each half-arch cast in one setup. Photo: Northeast Prestressed Products LLC.

In addition to the aesthetic needs, designers wanted to ensure the bridge retained a low profile while still providing the necessary clearance over the channel. The bridge is located on the parkway near the Lincoln Memorial, and officials didn't want the structure to interfere with views, explains Hong Chen, FHWA structural engineer. "The low-profile, one-span precast concrete design helped ensure we met those goals." However, the design also needed to retain the existing clearance, as recreational boats use the boundary channel to reach the Potomac River from the Columbia Island marina located north of the site.

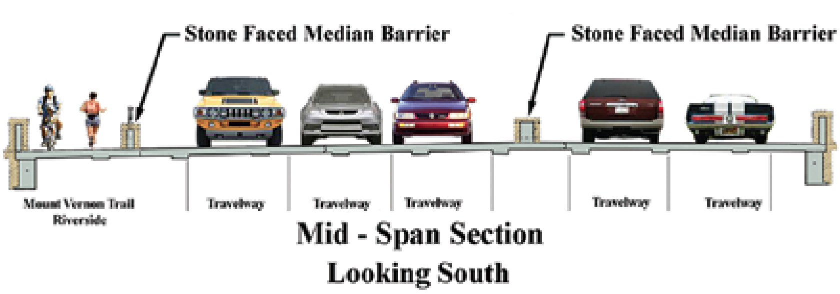
The substructure on each side of the arch consists of a 96-in.-deep pier cap supported by four 72-in.-diameter drilled shafts, each approximately 100 ft deep.

Arches Match Cast on Their Side

Casting each half-arch component created challenges, according to Troy Jenkins, chief engineer at Northeast Prestressed Products LLC. "The original assumption was that the beams would be cast vertically, in the position in which they'd be installed," he says. But some of the pieces near the piers required 20-ft depths, which could not be cast efficiently in that position. The casting also was complicated by the need to match cast each segment to ensure alignment with its adjacent segment.

The arch pieces were cast in a horizontal position, with all seven segments for each half-arch cast in one setup. The segments were cast in a sequence of sections 1, 3, 5, and 7, after which forms were removed and the segments were used to form the intervening segments (2, 4, and 6) to ensure the match cast. A complete half-arch was cast in less than 1 week, Jenkins says. "The arches were a challenge, but match casting them removed any issues that would have arisen," he notes. "That was an excellent approach to use on a project like this."

Some of the pieces also needed to have close attention paid to so that lifting devices were properly located to ensure their center



The new bridge separates vehicles on one side from pedestrian traffic on the Mount Vernon Trail on the other side. Illustration: FHWA.

SINGLE SPAN, PRECAST CONCRETE SEGMENTAL ARCH BRIDGE / NATIONAL PARK SERVICE, OWNER

POST-TENSIONING CONSULTANT: Lawrie & Associates LLC, Alexandria, Va.

POST-TENSIONING MATERIAL SUPPLIER: Dywidag-Systems International, Bolingbrook, Ill.

BRIDGE DESCRIPTION: 244-ft-long bridge with an underpass for pedestrian use on each end and an arch span consisting of 11 girder lines with 14 precast segments each and a cast-in-place closure

BRIDGE COST: $35 million

The diaphragms between beam lines used epoxy-coated reinforcement. Photo: Cianbro Corp.

of gravity remained balanced when they were erected, he notes. The lifting inserts were located in the sides of the pieces to make it easier to align the match-cast joints. This was critical because the pieces were particularly small segments, which made them awkward to handle, says Mike Manoski, senior project engineer at Cianbro Corp. Careful attention was given to rigging to ensure no handling problems arose.

The components were cast and transported to the site on an as-needed basis, where they were briefly stored until assembled during erection. The site provided key challenges due to the restraints and ongoing traffic. "Access was really tight," says Manoski. "There was not a lot of real estate to work in due to lane closures and maintaining vehicular and public access throughout the project."

According to Manoski, each half girder line has seven segments. A cast-in-place concrete closure piece ties the two half-arches together. Three segments of the seven sit on the 96-in.-deep pier cap, one segment cantilevers off the back of the pier cap, and three segments cantilever over the water. During Phase two construction, for example, in which four beam lines were set, three segments were erected for each beam line over the pier cap, and then temporary post-tensioning was applied. The beam lines then were locked together with a cast-in-place diaphragm. Then the segments that cantilever off the back of the pier caps were erected, post-tensioned with the previous segments, and another diaphragm was cast. Then three more segments in each beam were placed over the water before the final cast-in-place closure segments and diaphragms were added, completing four entire beam lines.

The initial precast arch-beam segments are shown being erected on top of the 8-ft-deep pier caps that rest on four 72-in.-diameter drilled shafts, each approximately 100 ft in depth. Photo: Cianbro Corp.

The project was broken into five phases of work to allow pedestrian access and two lanes of traffic to flow during construction.

A key challenge arose in coating the match-cast faces of the segments to protect against water penetration. An epoxy bonding agent is applied to act as a waterproof joint sealant, Manoski explains. Due to the product specifications, the crews had approximately 60 minutes from the time the epoxy is mixed until the pieces were set to the proper elevation and alignment.

Five Phases Keeps Traffic Moving

To ensure two lanes of traffic would flow in each direction at all times, and to retain accessibility to the Mount Vernon Trail, the construction team had to break the project into five phases, explains Nair. "If we had been able to close down to one lane in each direction, we could have eliminated stages and accelerated the work," he notes. But the user costs and time delays caused by the restriction on this busy artery near the nation's capital would have been too great.

The first phase of work focused on removing the median in the center of the bridge and shifting the southbound traffic to the east to open up two girder lines on the west side. Phase two involved demolishing the outside existing two girders lines on the west side and adding two additional lanes, creating four lines of new girders in this phase.

Phase three, which was completed during fall 2009, shifted southbound traffic onto the new lanes, while northbound traffic remained on the east side. This allowed for the demolition of three girder lines in the center section and rebuilding with new arch components. With traffic on both sides, this work necessitates that construction take place within a 26-ft-wide area, Manoski notes, requiring close attention to detail and careful maneuvering.

Phase four, following in 2010, will shift northbound traffic onto the center girder lines so the four remaining girder lines on the east side can be rebuilt. When this work is completed, the final phase will shift traffic back into the proper lanes, and a median wall will be built down the center. The median wall will be taller than the original, but it will be thinner as well to avoid adding unnecessary load to the bridge.

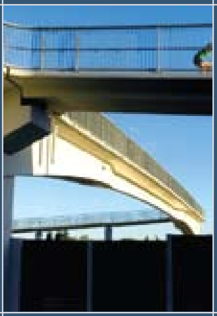
Formwork being constructed for the cast-in-place concrete deck placement. Photo: Cianbro Corp.

Original Stonework Replaced

To provide the stone facing on each side of the bridge, the original stonework was saved where possible, and new stone that matched the existing pieces closely was located. This saved considerable cost and allowed the new bridge to maintain a connection to its past. The precaster cast these final four segments with the fascia side down, to better control placement of dovetail slots in the faces. Galvanized-steel connectors were used to attach the stone to the dovetail slots in the precast panels.

The work is proceeding on schedule and is planned for completion in late 2010, Nair reports. Once completed, Washingtonians not only will have an attractive arched bridge similar in looks to the original, but they will experience a smoother, faster, and safer trip.

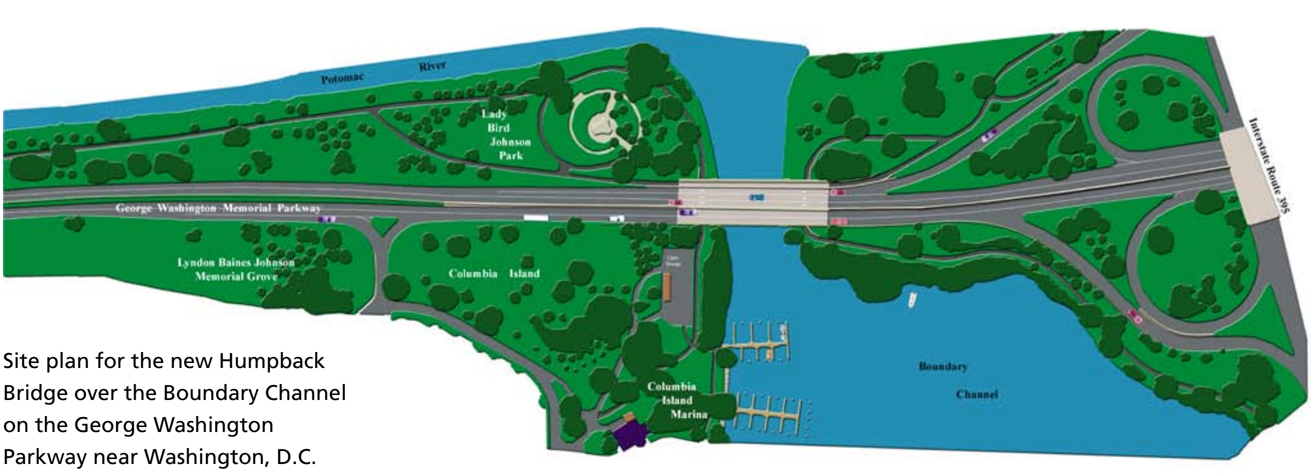
For more information on this or other projects, visit www.aspirebridge.org.



The precast concrete arches had a complicated series of temporary post-tensioning and sequenced permanent post-tensioning procedures to follow. The strand and reinforcing bar layouts within the components were complex. Photo: Northeast Prestressed Products LLC.

The arches were match cast, with odd-numbered pieces cast first. Those were then used to form the match-cast even-numbered pieces. Photo: Northeast Prestressed Products LLC.

High-performance, cast-in-place concrete is used for the bridge deck. Deck haunches over the beams range from about 2½ in. to nearly 7 in. Dowel bars will be screwed into inserts in the tops of the beams. The shallow recesses there complete the provisions for horizontal shear in the composite deck. Photo: Cianbro Corp.



Site plan for the new Humpback Bridge over the Boundary Channel on the George Washington Parkway near Washington, D.C.