A TALL ORDER

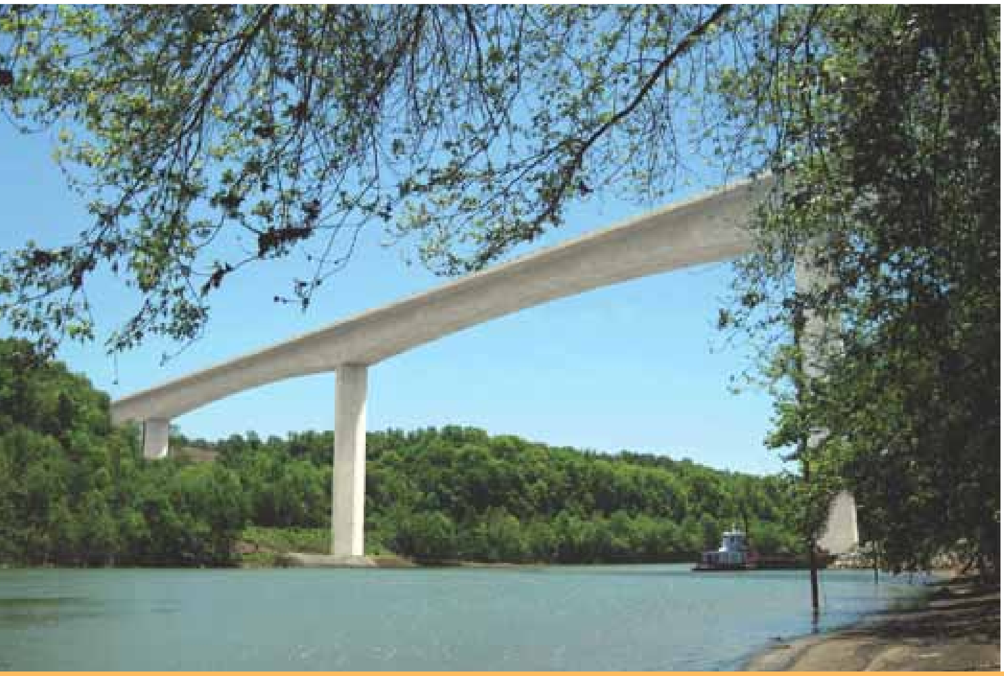
Value-engineering creates a tall, elegant concrete segmental design for the Pennsylvania Turnpike

by Brice Urquhart, FIGG, and James Stump, Pennsylvania Turnpike Commission

Long, arching spans and tall, slender piers create an elegant concrete segmental bridge across the Monongahela River near Brownsville, Pa. Value-engineering the project from a steel plate-girder design saved $8.5 million while addressing challenges in the planning and construction phases to produce a unique design.

The bridge is part of an extensive expansion to the Mon-Fayette Expressway that supports efforts by the National Road Heritage Park. The project's goal is to provide relief for Route 40, shifting it from a major transportation artery to more of a local traffic corridor and tourist destination. The bridge accomplishes this by improving access, addressing future capacity requirements and drawing traffic (especially trucks) off Route 40 and onto more modern throughways. The project closes a gap in the system between U.S. Route 119 in Uniontown and PA Route 88 in California, Pa.

Filling the gap required approximately 17 miles of new limited-access highway costing $605 million. The bridge, a major new crossing of the Monongahela River, consists of 12 major sections, with this new structure commonly referred to as Section 51H.



Value-Engineered Savings

The Pennsylvania Turnpike Commission provided the opportunity for an alternate-design concept to the original steel design. That led FIGG to team with Walsh Construction to create a segmental-concrete option that was considerably more efficient. Walsh's personnel had experience with this design type and were confident of their approach.

In part, that was due to their successful construction of a similar design, also produced by FIGG, for the nearby I-76 Allegheny River Bridge in Cheswick, Pa. (See *ASPIRE*,™ Spring 2009.) That project consisted of a 2350-ft-long structure with 100-ft-tall piers and featured the first use of balanced cantilever construction in Pennsylvania. That similarity for a recent design and local accessible expertise ensured an effective and efficient project for the new structure.

The impact of tall piers, limited access, and river, road, and railroad crossings on the construction was minimized by using balanced cantilever concrete segmental construction. To maximize savings, pier locations were adjusted to

This rendering of the Monongahela Bridge, still under construction until next spring, shows the sleek design of the superstructure that complements the piers that are up to 200 ft tall. All photos, drawings, and rendering: FIGG.

profile

MON-FAYETTE EXPRESSWAY BRIDGE / BROWNSVILLE, PENNSYLVANIA

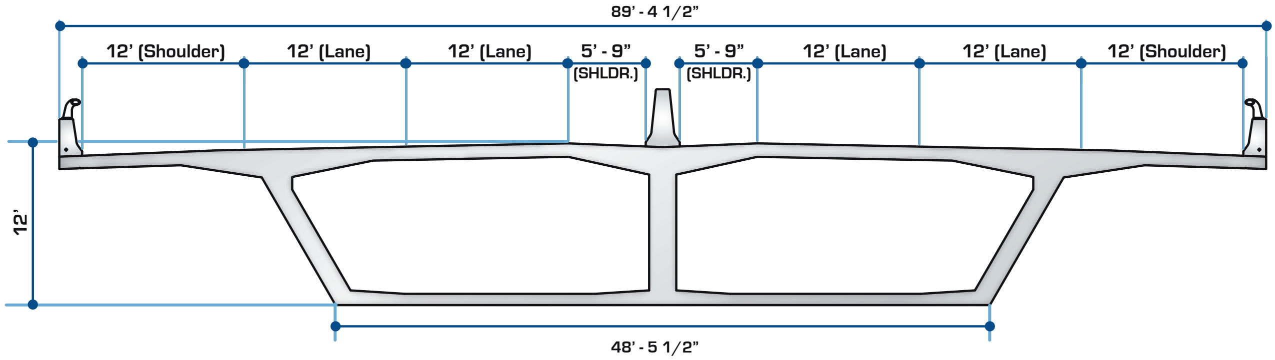
BRIDGE DESIGN ENGINEER: FIGG, Philadelphia, Pa.

CONSTRUCTION MANAGEMENT/CONSTRUCTION INSPECTION: SAI Consulting Engineers, California, Pa.; Finley Engineering Group, Tallahassee, Fla.

PRIME CONTRACTOR: Walsh Construction Co., Canonsburg, Pa.

CONCRETE SUPPLIER: Stone & Company, Charleroi and Uniontown, Pa.

POST-TENSIONING CONTRACTOR: Schwager Davis Inc., San Jose, Calif.



Monongahela River Bridge box girder cross section at mid-span.

eliminate two piers and provide a design more efficient for a concrete segmental bridge. The pier closest to the river bank on both sides was retained in its original position to speed the permitting process.

The design concept was bid by the contractor and approved by the Pennsylvania Turnpike Commission before final design drawings were completed. The project proceeded on a fast-track basis, with initial construction of foundations beginning as later drawings were being completed.

The fast-track process required a close relationship between Turnpike officials and the contractor, so they could work quickly through design-review meetings and facilitate reviews. This communication ensured that approvals were received in a timely manner so the contractor could proceed with foundations, piers, and the superstructure as the plans and project site were ready.

The 3022-ft-long bridge features seven spans, with a configuration of 259, 490, 490, 518, 504, 497, and 264 ft. The concrete segments consist of 89-ft 4½-in.-wide, dual-cell box girders with a center-web thickness of 2 ft and an outside-web thickness of 1.5 ft. The segment depth varies from 12 ft at midspan to 27 ft 2 in. at the river piers and 26 ft 7 in. at the land piers. The deck has an 11-in. minimum thickness. The bottom slab thickness varies from 3 ft 10 in. at the pier tables to 10 in. at midspan. The dual box design was chosen due to the wide structure, which carries four 12-ft-wide lanes, two 12-ft-wide shoulders, and a 14-ft-wide median.

200-Ft-Tall Piers

The key challenge came in designing the six piers, which range in height from 100 to 200 ft. That significant height required a sleek design that was in keeping with the thin profile of the superstructure, which was minimized further by the tall piers.

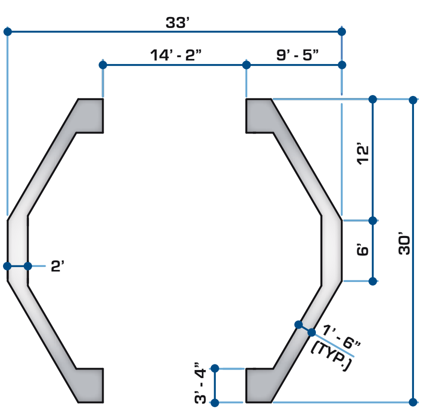
The piers were cast with 15-ft-tall jump forms that were advanced upward after each lift of concrete was placed and cured. The specified 28-day concrete compressive strength was 5500 psi. The two piers at the river banks were octagonal in shape with a 50-ft-tall solid concrete base to resist barge impacts, with the remaining 150 ft cast with a hollow center.

The approach piers further away from the river were designed as two, C-shaped, walled structures. They used the octagonal river pier shape split in two. This design aided flexibility and load-sharing via the twin walls and helped to balance the superstructure during construction while maintaining a consistent look to all of the piers.

The bridge is on a tangent alignment, and the deck is cast with cross-slopes to allow for drainage in both directions. Turnpike officials also had concerns with sulfate levels in the soils due to a local mining quarry. To alleviate those concerns, the footing and first lift of Pier 6 and Abutment 2 concrete elements were cast with moderate sulfate-resistant concrete using Type II cement.

The pier design was created to enhance the efficient and sleek appearance of the segmental superstructure. The goal was to eliminate wasted concrete and

Monongahela River Bridge pier cross section for C-shaped piers on land.



CAST-IN-PLACE CONCRETE SEGMENTAL BOX-GIRDER BRIDGE BUILT IN BALANCED CANTILEVER ON CAST-IN-PLACE CONCRETE PIERS / PENNSYLVANIA TURNPIKE COMMISSION, HARRISBURG, PENNSYLVANIA, OWNER

BRIDGE DESCRIPTION: Seven-span, 3200-ft-long, two-cell concrete segmental box-girder bridge with spans of 259, 490, 490, 518, 504, 497, and 264 ft, and with concrete piers 100 to 200 ft tall

STRUCTURAL COMPONENTS: Variable-depth, two-cell cast-in-place concrete segments that vary from 12 ft to 27 ft 2 in. deep with an 89-ft 4-in.-wide deck, two octagonal concrete piers at the river, and other piers shaped like the river piers split apart into twin walls

BRIDGE CONSTRUCTION COST: $95 million minimize the structure in the piers, pier caps, or superstructure to ensure no disruptions to the smooth lines. The piers provide a look that respects the context of the site, creating a different appearance from every perspective owing to their geometric shapes.

Limited Site Access

The balanced cantilever method was used on the project due to the limited access at the site. Using cast-in-place concrete with form travelers minimized equipment on the ground and equipment to lift components 200 ft in the air. However, the remote project area and tall piers created challenges for concrete placement for the superstructure. Concrete was pumped from the ground to the forms.

The box girders feature low-permeability concrete with a specified compressive strength of 6000 psi. Close communication with the contractor and the ready-mix concrete supplier ensured there was a steady flow of concrete for segment casting requiring as much as 180 yd^3. This portion of the work was fairly typical except for the exceptional heights involved. The bridge is located in a fairly remote portion of the state, with few concrete plants in the area, so logistics were a key part of the planning for the project.

The concrete superstructure was cast year round, including the harsh winters of western Pennsylvania. This required more attention to curing methods, which consisted of using enclosures, heating elements and wet burlap on the deck. Epoxy-coated reinforcement was used in the deck as well as any bars extending into the deck, including diaphragm and web reinforcement.

Four Form Travelers Used

Construction of the superstructure, which is nearing completion, is being accomplished with four form travelers, two per cantilever, allowing two cantilevers to be constructed simultaneously. Cantilevers 2 and 5 were cast first, followed by 3 and 6. Cantilevers 1 and 4 are being completed this fall, with finishes and other detail work expected to be completed by spring 2012.

The bridge is constructed using balanced cantilever construction, with seven spans including a main span of 518 ft and piers up to 200 ft tall. Construction of the final cantilevers at Piers 1 and 4 are underway as bridge construction enters the final stages.

In all, 51,000 yd^3 of concrete, 7 million lb of reinforcing steel and 3 million lb of post-tensioning tendons are being used in the project. After each pair of segments is completed, they are post-tensioned both transversely and longitudinally with cantilever tendons within the deck. Once the spans are closed between the cantilevers, the continuity tendons along the bottom slab and draped tendons that extend from pier to pier are stressed to complete the span.

When the bridge is completed in the spring, users will benefit by having a distinctive concrete structure set against a lush environment and constructed at low cost. The bridge will ease access in the area well into the future. Even better, it provides a best-value solution for the Pennsylvania Turnpike and a durable bridge that will benefit users for 100 years or more.

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For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

Pier tables begin the balanced cantilever superstructure construction.

Twin-wall, C-shaped piers provided a structurally efficient and aesthetically pleasing design.

June 22, 2011—Using balanced cantilever construction, the superstructure varies in depth from 26 ft 7 in. at the land piers to 12 ft at the center of all spans.