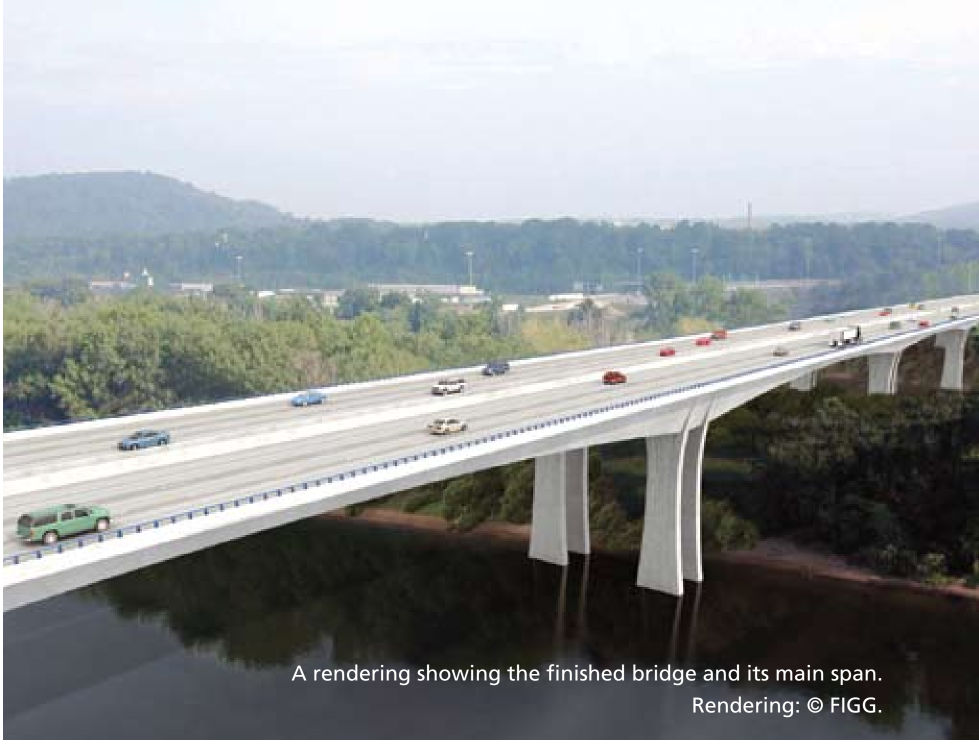
PROJECT

ALLEGHENY RIVER BRIDGE

Sustainable Design and Construction

by Brian Ranck, Pennsylvania Turnpike Commission and Ken Heil, FIGG



A rendering showing the finished bridge and its main span. Rendering: © FIGG.

New Pennsylvania Turnpike Bridge balances aesthetics, economy, and environmental sensitivity

The Pennsylvania Turnpike Commission's new Allegheny River Bridge, near Pittsburgh, is Pennsylvania's first cast-in-place balanced cantilever bridge. The bridge construction began shortly after the U.S. Open Championship at Oakmont Country Club's golf course in the summer of 2007, and the bridge construction will be completed in early 2010, ahead of the U.S. Women's Open Championship at Oakmont. The Pennsylvania Turnpike bisects Oakmont Country Club within the limits of the Allegheny River Bridge project.

The existing Turnpike Bridge over the Allegheny River was opened in December 1951 and carried two lanes of I-76 traffic in each direction. Options to both replace and repair the aging structure were evaluated prior to design of the new bridge. The narrow width of the existing bridge, projected traffic demands, and the Turnpike Commission's long-term goal of widening to three lanes in each direction led to the decision to replace the existing bridge.

The new bridge carries I-76 over the Allegheny River and consists of twin 2350-ft-long parallel structures for eastbound and westbound traffic with an 8-ft-wide gap between bridges to facilitate future access. The alignment of the new bridge is downstream and roughly parallel to the existing bridge, allowing two lanes of traffic in each direction to be maintained during construction and minimizing traffic impacts to Pennsylvania Turnpike customers. The contract was awarded for the project in May 2007 with a low bid of $189 million. In addition to the main river bridge, the overall Allegheny River Bridge Replacement Project also includes three overpass bridge replacements, reconstruction of the Allegheny Valley Interchange ramps and interchange bridge, construction of three major walls, approximately 2 miles of approach roadway reconstruction, and demolition of the existing bridge.

The New Bridge

Variable depth concrete segmental box girders which are 26 ft deep at the

profile

I-76 ALLEGHENY RIVER BRIDGE / NEAR PITTSBURGH, PENNSYLVANIA

ENGINEER: Figg Bridge Engineers Inc., Tallahassee, Fla.

CONTRACTOR AND POST-TENSIONING CONTRACTOR: Walsh Construction Company, Chicago, Ill.

CONCRETE SUPPLIER: Stone and Company, Tarentum, Pa.

FORM TRAVELERS FOR CAST-IN-PLACE SEGMENTS: NRS-ASIA, Norway

The Pennsylvania Turnpike Commission's new Allegheny River Bridge will result in a sustainable bridge that will serve the Pittsburgh area for many years.

main span piers, 19 ft deep at the side span piers, and 11 ft deep at midspan cross the Allegheny River Valley. Using traveling forms, the bridge is being cast in place using the balanced cantilever method, working from the tops of the piers. Incrementally working out from the piers, five cantilevers result in six spans of 285, 380, 380, 444, 532, and 329 ft. The two end spans include 105-ft- and 69-ft-long portions beyond the balanced cantilever that are cast in place on falsework.

The cross section of the segmental box girder was designed as a single-cell box girder with a constant core form without ribs or transverse drop beams in order to simplify formwork and casting operations. Variable wing lengths accommodate deck widths from 61 ft (typical) to 84 ft at the westbound end span adjacent to the interchange.

Each segment is cast with 2 in. of additional monolithic top slab concrete thickness to form an integral wearing surface. The top flange of the box and the integral wearing surface were post-tensioned in both the longitudinal and transverse directions to provide compression in the deck for long-term durability of the final riding surface. Milling ½ in. at the end of construction ensures the best final riding surface. The design allows for complete removal of the integral wearing surface and replacement with an overlay in the future.

Construction

Balanced cantilever construction began from pier tables cast in place atop twin-wall piers to provide a platform for launching the traveling forms. One side of the pier table was 16 ft long while the other side was 24 ft long; the asymmetry kept the cantilever balanced

A 4-ft closure is all that remains to complete a 380 ft span at a height of 100 ft over the Allegheny River. All photos: © FIGG.

The balanced cantilever construction method allowed traffic flow through the Allegheny River Valley on the roads below while construction took place 54 ft overhead.

CAST-IN-PLACE, POST-TENSIONED BOX GIRDER / PENNSYLVANIA TURNPIKE COMMISSION, OWNER

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

PREPACKAGED GROUT: Sika, Lyndhurst, N.J.

BRIDGE DESCRIPTION: Twin, 2350-ft-long, segmental box girder bridges built using cast-in-place balanced cantilevers with a 532-ft-long main span over the Allegheny River

BRIDGE CONSTRUCTION COST: $189 million (total project)

The concrete pier shape was selected by the Pennsylvania Turnpike Commission Team.

to within a half segment to minimize out-of-balance loads on the piers while utilizing constant 16-ft segment lengths for ease of construction.

Year-round cantilever construction utilizes four traveling forms for the superstructure to meet the project schedule. Daily low winter temperatures in nearby Pittsburgh are 20 °F on average, making a cold weather concreting plan vital for maintaining production. Construction began at Pier 1 where access was the most straightforward, with the eastbound (EB) bridge being built first to allow for traffic phasing. Cantilevers 1EB and 2EB were cast in tandem, and then the four traveling forms were alternately advanced to cast the remaining cantilevers. Four-ft-long closure segments connect each of the cantilevers at the center of the span. The superstructure is supported with internal high-strength steel post-tensioning tendons containing nineteen 0.6-in.-diameter strands, and external post-tensioning tendons containing twenty-seven 0.6-in.-diameter strands.

Piers and Foundations

Twin wall piers were selected for an optimum design that eliminated the need for temporary towers during construction. Strength and slenderness of the twin walls are balanced with their height to provide the required flexibility for creep and temperature effects. The piers are 100 ft tall for river Piers 2 through 5 and 60 ft tall at Pier 1. All piers in the river were designed for barge impact loading (3000 kip maximum), ice loading, and scour provisions.

Studies during the design phase of the new Allegheny River Bridge project indicated that several foundation options provided viable solutions. To stimulate a competitive bidding arena and maximize economy in the foundations while taking advantage of contractors' expertise, fully detailed foundation bid options were included in the bid documents for both pipe piles and drilled shafts at all piers. Pier 5, which has relatively shallow bedrock, also had a spread footing option. The contractor chose pipe piles for Pier 1 and drilled shafts for Piers 2 through 5.

As of January 2009, foundation construction is complete, and the twin-wall pier construction is nearly complete, with only Piers 2WB and 5WB remaining. Completion of the eastbound bridge is scheduled for November 2009 to accommodate a key shift of eastbound traffic off of the existing bridge and roadway. Completion of the westbound bridge is scheduled for early 2010.

Brian Ranck is bridge/tunnel maintenance coordinator, Pennsylvania Turnpike Commission, Harrisburg, Pa., and Ken Heil is senior bridge engineer, FIGG, Exton, Pa.

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Environmental Challenge


Photo: © FIGG.

A Context–Sensitive Solution

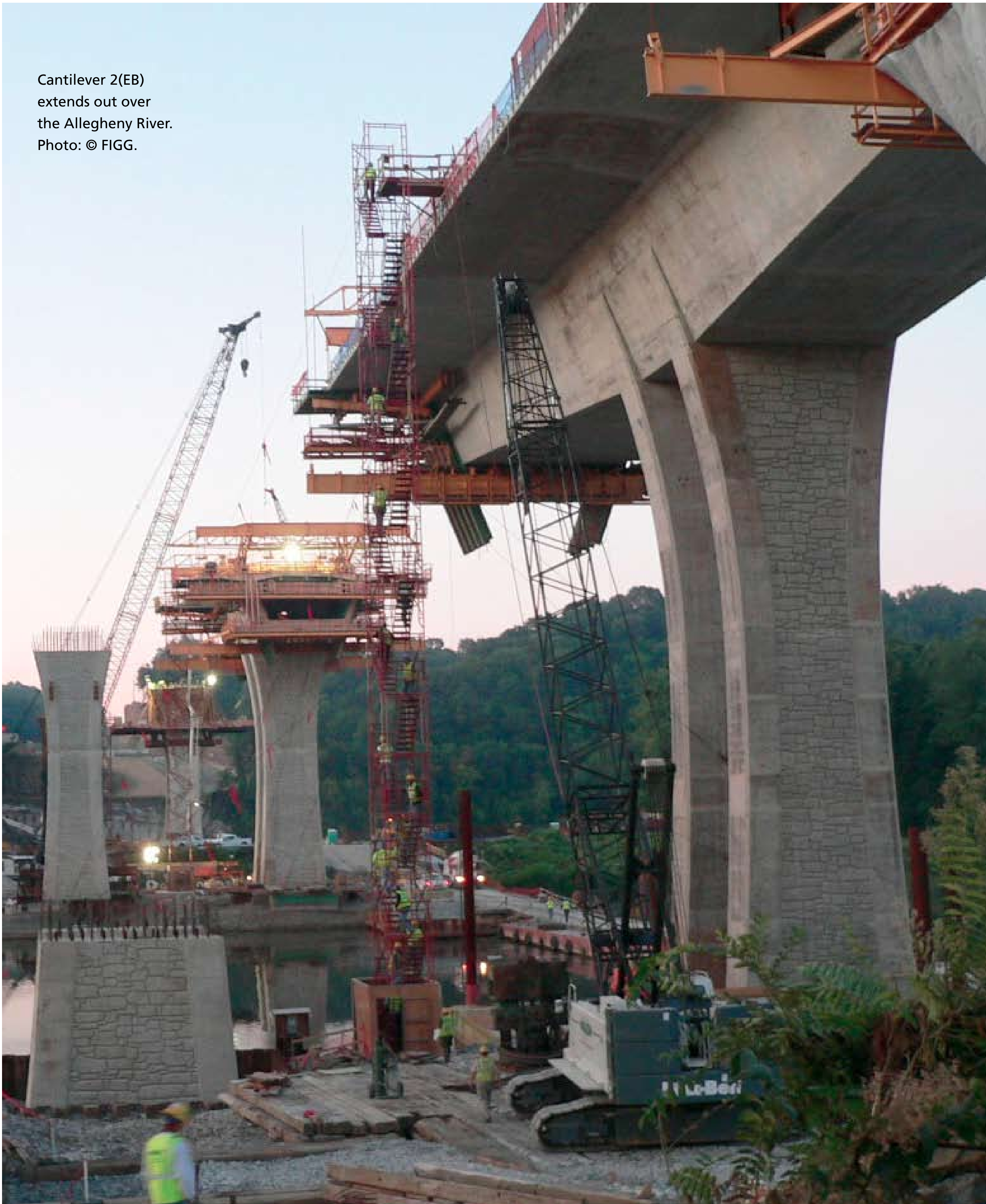
FIGG designed the new Allegheny River Bridge to be a sustainable, environment-friendly structure that would fit in harmony with the landscape around the Allegheny River and Fourteen Mile Island (part of Allegheny Island State Park) while preserving the river and other historically significant areas nearby. Span arrangements were planned to accommodate a busy multi-modal transportation network that runs through the Allegheny River Valley. The new bridge crosses a local road, Norfolk Southern Railroad, the two channels of the Allegheny River, Fourteen Mile Island, and Allegheny Valley Railroad. Balanced cantilever construction allows for continual flow of highway, rail, and barge traffic throughout the duration of construction. The 532-ft-long main span preserves the existing horizontal clearance needed for the navigation channel of the Allegheny River, which supports commercial barge traffic. The new river piers are close to the river banks and island to entirely avoid the archaeologically sensitive zone on Fourteen Mile Island, while being sensitive to the aquatic habitat. The Allegheny River's history of fluctuating water levels also contributed to the decision for locating piers adjacent to the river banks.

The concrete pier shape was selected by the Pennsylvania Turnpike Commission (PTC) Team during the design process using a FIGG Bridge Design Charette™. The PTC was presented with several pier shape options and selected a curved pier that complements the graceful sweep of the variable depth superstructure. FIGG considered constructability, repetition, and reuse of formwork at all piers during design to maintain an economical pier shape. To simplify construction, a parabolic curve was approximated by combining two circular radii. A variable height rectangular base compensates for the different heights at each pier. Concrete formliners and earth-toned stain are used to create a stone texture on the pier faces. The stone texture was selected by the PTC to complement existing stonework at Oakmont Country Club and the surrounding landscape.

The Pennsylvania Turnpike Commission's new Allegheny River Bridge will result in a sustainable bridge that will serve the Pittsburgh area for many years. Built from the top down to keep traffic flowing, the long, sweeping spans deliver an aesthetically pleasing design that also functions to protect the sensitive river environment.

Piers from the bridge are textured and stained to complement the landscape from the golf course at Oakmont Country Club. Photo: © FIGG.

The variable depth superstructure creates an arching form over the Allegheny River. Photo: © FIGG.



Cantilever 2(EB) extends out over the Allegheny River. Photo: © FIGG.

Once the superstructure cantilevers were 184 ft and 192 ft long, forms were lowered onto a barge in one piece, dismantled into smaller sections, and then relocated to a new pier for the next cantilever construction. Photo: © FIGG.