The twin structures have span lengths of 150 ft and will replace the existing bridge across the Susquehanna River.

Speed, economy, and minimal disruptions are key ingredients for first vehicular concrete segmental bridge built in Keystone State

Segment Setter Blazes New Trail on Turnpike

by Craig A. Shutt

Officials at the Pennsylvania Turnpike are finishing the state's first vehicular segmental concrete bridge, to be opened in May. The mile-long structure provided a variety of benefits, including speed of erection and a construction approach that provided little disruption to the tight site. The design has worked so well that more such projects are planned along the turnpike.

The bridge, spanning the Susquehanna River in York and Dauphin Counties, is part of the Turnpike's massive $1-billion total reconstruction project, which will cost approximately $5 million per mile. The program is the first complete restoration of the toll road since it was built in 1940 and involves widening bridges and overpasses along the route in advance of adding a third lane in each direction. The construction project requires tight scheduling and rapid construction to ensure traffic can move smoothly during the multi-year project.

profile

SUSQUEHANNA RIVER BRIDGE / YORK AND DAUPHIN COUNTIES, PENNSYLVANIA

ENGINEER: FIGG Engineering Group, Tallahassee, Fla.

PRIME CONTRACTOR/PRECASTER: Edward Kraemer & Sons, Inc., Plain, Wis., and G. A. and G. F. Wagman, Inc., York, Pa., a joint venture

CONCRETE SUPPLIER: Hempt Brothers, Camp Hill, Pa.

"Because we charge drivers for the use of our road, we have to ensure we can maintain traffic while construction is underway, so speed is critical for all our projects," explains Gary Graham, Bridge Engineering Manager with the Harrisburg, Pennsylvania-based Turnpike Commission. Even so, costs also are a key factor in design decisions. "We approached this design as we would any other project, by looking at what was the most economical format," he says. "Cost is always one of the highest criteria in our evaluations, and this approach won hands down."

The design features twin structures, each 5910 ft long and 57 ft wide, with precast concrete, segmental spans, typically 150 ft long, erected span-by-span on cast-in-place piers founded on drilled shafts. In addition to carrying three lanes of traffic in each direction across the Susquehanna River, the new bridge spans the Norfolk Southern Railroad, Amtrak railway lines, the Steelton-Highspire Railroad, State Route 230, and Culver Island.

The concrete bridge replaces a combination steel truss and plate-girder bridge built in the 1950s. A feasibility study in 2000 indicated that, because of the deterioration to the webs and flanges, replacement would be cheaper—but just barely.

"We decided it wasn't economical to renovate the existing bridge due to the time involved in the rehabilitation and the constructability issues," says Graham. "And we'd still have a 50-year-old bridge at its core." By constructing a new bridge alongside the existing one, traffic would be disrupted only during the final tie-in of approaches.

Turnpike officials initially planned to use 120-ft-long precast concrete I-beams as the most economical and rapid design, he says. But after seeing several segmental concrete bridge designs by FIGG Engineering Group in Tallahassee, Florida, Graham contacted the company to evaluate if that approach would work in this case. "We had worked with FIGG on other alternative designs, which ultimately hadn't been chosen, so we were familiar with their work," he says.

'A key attraction was the rapid construction that we saw was possible with this format.'

A formliner was used to create the appearance of quarried limestone on the columns to complement the commission's headquarters.

In particular, the Garcon Point Bridge in Florida had been notable for its construction at $50 per ft^2. "That was unheard of," he says, as typical turnpike costs have run $150 to $170 per ft^2. A key obstacle was that Pennsylvania

PRECAST SEGMENTAL BRIDGE / PENNSYLVANIA TURNPIKE COMMISSION, OWNER

BRIDGE DESCRIPTION: Twin 5910-ft-long precast concrete segmental bridges consisting of a total of 80 spans with a typical length of 150 ft

STRUCTURAL COMPONENTS: Drilled shafts, 39 cast-in-place concrete piers, and 1040 precast concrete segments

BRIDGE CONSTRUCTION COST: $82.42 million

An underslung erection truss was used with the span-by-span method of construction.

Department of Transportation design manuals do not encompass segmental bridges. "Some criteria ultimately take them out of the mix," he says, such as needing to allow for deck replacements.

Without examples to view in Pennsylvania, turnpike officials went with FIGG engineers to view examples in Maine and Boston. They then had to convince turnpike commissioners, as well as the local contracting community, of the benefits. "There was a real concern that we were excluding local contractors by creating a design with which they had no experience," he says. Ultimately, the winning bid was secured by a joint venture between Edward Kraemer & Sons Inc. of Plain, Wisconsin, and G. A. and G. F. Wagman, Inc. of York, Pennsylvania.

The segmental design offered key advantages, explains Jay Rohleder, Senior Vice President with FIGG. "Segmental bridges offer an economical approach because they are constructed quickly without falsework," he explains. The Susquehanna River is non-navigable, which also ruled out the option of transporting components to the site via barge, he adds. "Economy was paramount to the selection, as well as the ability to advance quickly through the permitting process.

Graham agrees. "A key attraction was the rapid construction that we saw was possible with this format," he says. "Our goal is to build as fast as possible, get in, and get out. With the precast concrete components, we could work through the winter. It offered the shortest duration of all bridge types, and that was a major advantage." FIGG created an erection scheme to lead turnpike officials through the process and schedule prior to commencing construction, he notes.

The new bridge was constructed parallel to the existing structure—so closely, in fact that between less than 1 ft and no more than 30 ft separate the two structures. Temporary shoring was provided at abutments on the east side, where the bridges are separated by inches, to maintain fill between the structures, Rohleder says.

The contractor gained access to a slag pile located just above the east abutment site, where components could be cast. After casting and curing, the precast concrete segments were loaded onto a low-boy trailer and driven to the bridge site via an access road. The segments were driven onto the bridge to the segment setter, placed at the edge of the previously constructed span.

The segment setter lifted each segment off the low-boy trailer and set it onto the erection truss. A trolley then transported the segment along the truss. The segments were aligned one by one, the joints coated with epoxy, and the segments pulled together with temporary post-tensioning. This process continued until the complete span was assembled. A 6-in.-wide cast-in-place closure placement was then placed at both pier segments. The closure placements were allowed to set overnight prior to post-tensioning the segments. Then the truss was advanced to the next span. The final post-tensioning consisted of eight 27-strand tendons.

Construction progress was done in three phases due to specific site logistics, Graham explains. The process began with the bridge's east lanes, which were built out to a central island in the river. Then construction returned to the east side and the westbound lanes were built completely across the river, after which the final half of the

A custom-made segment setter was used to move the segments from the low-boy trailer onto the twin erection trusses.

We wanted to create something of a signature bridge for the turnkpike.

eastbound lanes were completed from the island to the west side of the river.

This approach was needed because a causeway was constructed to aid in installing the drilled shafts and piers. "We couldn't shut off the river completely with the causeway in the east channel, so we used the causeway out to the island to advance the shoring towers," explains Rohleder. The causeway then was removed from that half of the river and built into the other half to extend the shoring towers completely across the river, during which the entire westbound lanes were constructed.

Work at the island was complicated by the discovery of archeological artifacts, including arrowheads. "Evaluating those and ensuring they were secured slowed us down," Graham says. Ultimately, the Turnpike Commission purchased the island to provide complete access for both the archeological exploration and the construction needs.

The segmental design produced further savings due to its handling of utility lines, Rohleder notes. The bridge spans railroad lines with electrical transmission lines overhead. The initial proposal by Amtrak called for extra tall temporary towers to be installed to lift the lines out of the way of construction. Once the bridge was finished, the lines would be returned to lower, permanent towers included in the construction plan.

But the segment setter eliminated the need for a tall crane to be located on the bridge to handle the segments. It had low enough clearance to ride beneath the existing transmission towers, so they didn't need to be replaced temporarily. That saved both time and money, as the lines could simply be shifted from the existing towers to the new ones when the bridge was completed.

The designers added a particular aesthetic touch to the project—which, like the segmental design itself, opened new doors for the system's structures. The bridge is the longest on the turnpike, and it sits adjacent to the commission's headquarters building, which was renovated in 2001. "We wanted to do something to make it stand out and create something of a signature bridge for the turnpike," Graham explains.

Precast segments were produced and stored adjacent to the bridge site.

To achieve that, the contractor used a formliner to mimic quarried limestone, which matches the design of true stone used on the headquarters building. "We originally considered taking a cast of the building's façade to use as a mold, but they were able to develop it simply from a picture of the building," says Rohleder. The formliner was used to create a ribbon of texture up the center the piers. At the top, the texture splays out across the pier cap in the shape of a keystone, to reflect Pennsylvania's status as the Keystone State.

Highlighting this design more is accent lighting placed along the girders, he notes. A slight curvature was put on the soffit at the girders' bottom web, where lights could be installed on the lip. The lights catch the edge of the curvature and create dimension and shadow lines to show off the textured piers.

"This was our first project for really jumping into creating a more aesthetically pleasing design, but now we're planning to do it for all of our bridges," says Graham. "This one really led the way."

That's also the case with the segmental concrete construction approach, he says. The westbound lanes are completed, with the final half of the eastbound lanes planned to be completed in May. That won't be the last bridge to be constructed this way, he says. "We saw a lot of benefits from this construction, including the ability to work from above to create less impact from the ground. Any time you can stay off the ground and out of the way of railroad tracks and utility lines, you're better off. Segmental construction will help us in many ways to avoid those issues."

The economy, speed, and flexibility make the segmental design a strong choice for other situations, he says. A cast-in-place design planned to span the Allegheny River near Pittsburgh is considering a segmental approach, he says, and it also will be evaluated for use on other projects over the course of the massive reconstruction.

Officials also are designing the Mon-Fayette Expressway in western Pennsylvania, a north-south highway that will connect West Virginia with Pittsburgh, he notes. "There will be a lot of opportunities for us to use segmental construction there." Rohleder agrees. "There are 13 bridges now being designed, and segmental construction will be reviewed for several of those. We believe there will be many more opportunities for segmental bridges in this program."

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