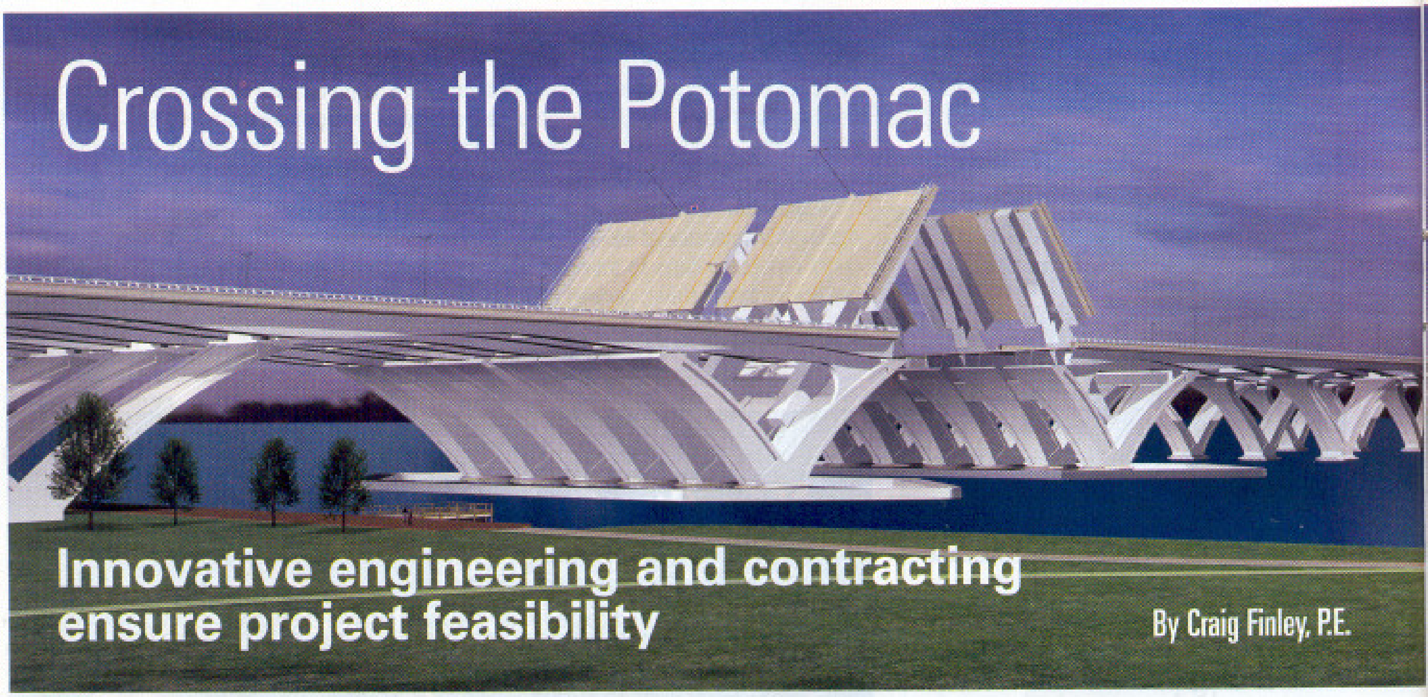

Crossing the Potomac

Innovative engineering and contracting ensure project feasibility

By Craig Finley, P.E.

The I-495 Capital Beltway is a 64-mile stretch of interstate highway that circles Washington, D.C. With about two-thirds of its length in Maryland and one-third in Virginia, the Beltway is one of the East Coast's busiest thoroughfares.

At its southernmost point, the highway spans the Potomac River via the 44-year-old Woodrow Wilson Bridge. A six-lane, bascule bridge, it crosses from Alexandria, Va., eastward into Maryland, touching the southernmost tip of Washington, D.C., along the way.

The bridge has held up well structurally, but its current capacity is woefully inadequate to accommodate the traffic demands it faces now and will face in the future. In 1988, the Federal Highway Administration, in cooperation with the Maryland State Highway Authority (MSHA), the Virginia Department of Transportation, and the District of Columbia Department of Public Works, conducted a study to consider options. This group, with tremendous input from experts and other area stakeholders, eventually formed a vision to replace the Woodrow Wilson Bridge.

For a structural engineer — or any other professional involved in the business of highway and bridge design and construction — the Woodrow Wilson Bridge replacement project is a goldmine of lessons learned. Time after time, project team members have applied innovative solutions to unique challenges. And it all started very early in the bridge design process.

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Design competition

When the project's owners announced a design competition for the bridge portion of the project, they sent a clear message that they wanted something unique — a design that stressed creativity and new ideas. "The typical way you design a bridge is to hire an engineer, they go to work and produce concepts, and you pick from those," says Deputy Director Robert J. Healy, P.E., who works in the Office of Bridge Development for the MSHA. "With a competition, you get the benefit of lot more people, different points of view, and different teams producing different concepts. There's more creativity, more ideas, and more options."

Why don't more projects use design competitions? For one, they are expensive — the four finalists were compensated $100,000 for each design submittal that met the criteria. And even that pales compared to the actual price tag of the designs — which easily can cost over half a million dollars to complete. Second, design competitions are a lot of work. In this case, the process required nearly three years to administer.

Finally, the selection process entails significantly more review; the Woodrow Wilson Bridge selection committee included 15 members from a variety of public and private backgrounds, as well as several technical advisory committees.

In the end, it was worth the effort, says Healy. Seven joint ventures submitted design proposals, and the committee selected four finalists who could each submit two designs. To ensure that the designs were judged on their own merits, each entry's submitting firm was kept confidential.

Rendering of the "arch-like" bridge design that won the design competition.

Design and Construction Team

Project name
Woodrow Wilson Bridge Replacement

Owners
Maryland State Highway Administration, Baltimore, Maryland
Virginia Department of Transportation, Richmond, Virginia
Federal Highway Administration, Washington, DC
District of Columbia Department of Public Works, Washington, DC

Design team
Parsons Transportation Group
- Parsons Corporation
- Finley McNary Engineers
- Dr. Christian Menn
- Rodderdam Bridge Consult
- Mueser Rutledge Consulting Engineers
- Gannett Fleming, Inc.
- GEOTECH Engineers, Inc.
- Rosales Gottemoeller & Associates
- Athavale, Lystad & Associates
- Sidhu Associates, Inc.
- Mahan Rykiel Associates, Inc.
- VanDermark & Lynch, Inc.

Bascule span subconsultant
Hardesty & Hanover

Owners representative
Potomac Crossing Consultants
- Parsons Brinckerhoff
- URS
- RK&K

Bascule bridge contractor
American Bridge/Edward Kraemer & Sons

Virginia approach contractor
Virginia Approach Constructors
- Granite Constructors
- Corman Constructors

Maryland approach contractor
Potomac Constructors
- American Bridge Company
- Edward Kraemer & Sons
- Trumbull Constructors

The committee settled on the "graceful, seamless concept" submitted by a team led by Parsons. The design called for parallel spans approximately 6,000 feet long, each six lanes wide, built on box girders and v-shaped piers. The project's original concept required the bridge to be "based on arches, in the tradition of notable Potomac River bridges." The Parsons team interpreted that to mean "arch-like" and opted for v-shaped piers — a decision that likely won the project.

Creative project contracting

Parsons' design was chosen unanimously on Nov. 18, 1998. Nearly three years later, team members gathered for the pre-bid conference in Greenbelt, Md., on Sept. 11, 2001.

More than just a bad omen, the terrorist attack hindered the construction effort by adding a large dose of uncertainty to the industry just as the project team began seeking a contractor to build the bridge. Price fluctuations, bonding questions, and security issues conspired to throw the bidding process into flux.

But Sept. 11 was only one of many complicating factors at that point in the project's lifecycle. Other major projects, including the Oakland Bay Bridge, commanded the attention of the few large contractors capable of doing the Woodrow Wilson work. The sheer size of the project, coupled with some cumbersome requirements in the contract documents, also limited the interest of capable contractors. The result has become industry lore — one bidder, $373 million over the original $487 million estimate. The bid was rejected and the team wisely took a step backward.

Following the first failed bid, members of the project team began contacting contractors to find out what went wrong. In the interim, the owners huddled with the design team and various other stakeholders to value engineer the design. This dual effort allowed the design team to institute changes that broadened the field of eligible contractors and offered them more incentive to bid.

The biggest change, which was incorporated during the value engineering process, was to replace the trapezoidal box girders that were originally proposed with plate girders. "Those box girders were so large, only a fabricator with water access could bid it," says Jim Ruddell, construction manager and owner's representative with Potomac Crossing Consultants. "It was a major value-added [decision] because it simplified the fabrication process. That translated into savings and more competition, and the appearance is not significantly different." A second critical change was to increase standardization of the V piers, making them easier and faster to build. Finally, the redesign allowed a cast-in-place option for the substructure, which

Completed foundations and pedestals from the Maryland approach.

opened the competition up to a broader group of prospects — though no winning bidder chose that option.

The team also made two key decisions related to the construction contract. First, it divided the single construction bid into three separate contracts, opening the door to smaller contractors and increasing competition. Instead of one massive contract of approximately $500 million, owners awarded separate contracts for the Virginia approach, the Maryland approach, and the bascule bridge. Secondly, the owners made the contract terms less restrictive, allowing contractors more leeway to add their own innovation and means and methods to save time and money.

A final stroke of innovation was the owners' decision to award the foundation contract separately, before the bridge design was finished. This fast-track approach to building the foundations required incredible foresight and coordination. However, because contractors got an early jump on building the massive foundations, the decision accelerated the project schedule by several months.

Innovative solutions

One hallmark of the Woodrow Wilson Bridge project is that the people involved did not let conventional wisdom stand in the way of getting the best project in the best possible way. In addition to the creative contracting, two other conspicuous examples stand out.

Steel plate girder superstructure placed on v-shaped piers.

An uncommon construction feature is the bridge's merging of concrete and steel construction: segmental concrete for the substructure and steel plate girders for the superstructure. "This type of arched construction has been done before, but I'm not sure that it's been done on quite this scale," says Greg Shafer, senior engineering manager for Parsons. "The combination of segmental construction with steel, particularly given the competitive nature between the two, is somewhat of a forced marriage. But it has been successful. The segmental method has turned out to be the fastest, most economical way to build these piers."

Also, the three-contract approach resulted in an unusual combination of long-line and short-line casting for the piers, which improved speed and efficiency of construction.

Bascule bridge

To accommodate shipping traffic on the Potomac River, the bridge is required to open. However, with its channel clearance increasing from 50 feet to 135 feet, the bascule should only open approximately 60 times per year compared with its current rate of more than 250 annual openings.

The bascule bridge may be the most impressive aspect of the Woodrow Wilson project. While not the longest or the widest bascule bridge ever built, according to Shafer the bridge has the largest movable mass among bascule bridges in the United States.

"The bascule spans themselves are massive and heavy," says Nick Altebrando of bascule span subconsultant Hardesty & Hanover. "While not record-setting in their length of 270 feet between trunnions, the bridge width as well as the concrete deck resulted in an enormous structure. Each leaf weighs close to 4 million pounds and the total load to move is over 32 million pounds."

The bascule came with other challenges, according to Altebrando. Because the owners did not want to use gratings, the team conducted significant analysis to reduce the cracking effects on the deck's durability and long-term performance. Another first was the use of stainless steel reinforcement for the bascule span deck. In addition, the pier sections above the plinths were structural elements with their own sets of cambers, deflections, and general behavior. Close coordination of the behavior of arch ribs and associated structural concrete was required and accounted for in the

Project update

The Woodrow Wilson Bridge Project is approximately 40 percent complete. Bob Douglass, deputy director of the MHSA's Office of Bridge Development, says the plans call for the outer loop (southern) bridge to open in spring 2006. They'll then shift traffic to the new structure and demolish the old bridge. The second span is slated to open in mid-2008. The project's final cost, including adjacent interchanges in Maryland and Virginia, is expected to be $2.4 billion.

design of the bascule span. Because live loads travel on the bascule span forward and behind the trunnion, the team developed a system of rear and forward live load bearings, anchorages, and lock machinery.

Another challenge was to accommodate the needs of the bridge operators. The control house needed appropriate view corridors because the bridge is almost 250 feet wide and the operator will have 8 lanes of vehicular traffic and marine traffic to monitor. In addition to enhanced Closed Circuit Television options and support from existing state traffic monitoring infrastructure, designers gave significant consideration to clearing traffic problems such as using movable barriers to provide flexibility between express and local lanes, as well as and the needs of first responders.

The design also needed to accommodate plans for future rail services. Because of the tolerances required, traditional shear transfer devices were insufficient. Instead, designers arranged a pair of "lock bars" on each bascule girder. They developed a moment couple at the span toes, which could carry the rail loads within the limitations for operational deflection of the rail carrier.

Conclusion

Collaboration and innovation prove, once again, to be the secret to success on large, complex projects. After the first bid attempt failed, the design team skillfully value engineered the project and incorporated innovative contracts — which enabled the Woodrow Wilson Bridge to be constructed. ■

Craig Finley, P.E., was closely involved in the design of the Woodrow Wilson Bridge replacement throughout the process. Initially, he was the president of design engineering subconsultant Finley McNary Engineers, Inc., and after Parsons Corporation acquired his firm during the project, Finley served as the principal in charge for Parsons. He is currently president of Finley Engineering Group of Tallahassee, Fla.