FOCUS

Lightweight high performance concrete was used in the spliced girders and concrete decks of the Route 33 Bridge over the Mattaponi River in Virginia. Photo: ©PB.

STAYING ON THE CUTTING EDGE

by Craig A. Shutt

Throughout its 120-year history, Parsons Brinckerhoff has pushed the boundaries of design for concrete bridges

Vijay Chandra, Senior Vice President

Since its founding in 1885, the company now known as PB has remained at the forefront of design by continually examining new technologies and incorporating new ideas into its concepts. That work has paid dividends in its bridge designs throughout its history, and it continues to pay off today and for tomorrow.

"PB's accomplishments in bridge designs represent a microcosm of innovative efforts and events that have occurred throughout the larger industry," says Vijay Chandra, Senior Vice President for the New York-based engineering firm. "PB has designed hundreds of concrete bridges, viaducts, and ramps during our history."

The company defines success for a project by delivering a sustainable value to its clients, communities, employees, and profession, he notes. "Since our founding, we've seen the world transition from discrete industrial societies to a technological culture on a global scale," he says. "As an integral part of this transition, the design of large-scale engineering works has proven to be an intensely human activity fueled by innovation and vision."

Concrete Designs

The company designs bridges using both concrete and steel based on a variety of factors including owner preference, location, design parameters, unique challenges, and aesthetics. PB has been using prestressed concrete from its earliest days in the 1950s, Chandra notes. Those projects include the first Sunshine Skyway Bridge, a 15-mile structure near St. Petersburg, Florida, on which it worked from 1947 to 1955. The design featured 16,000 ft of precast, prestressed concrete girders, one of the first uses of the technology.

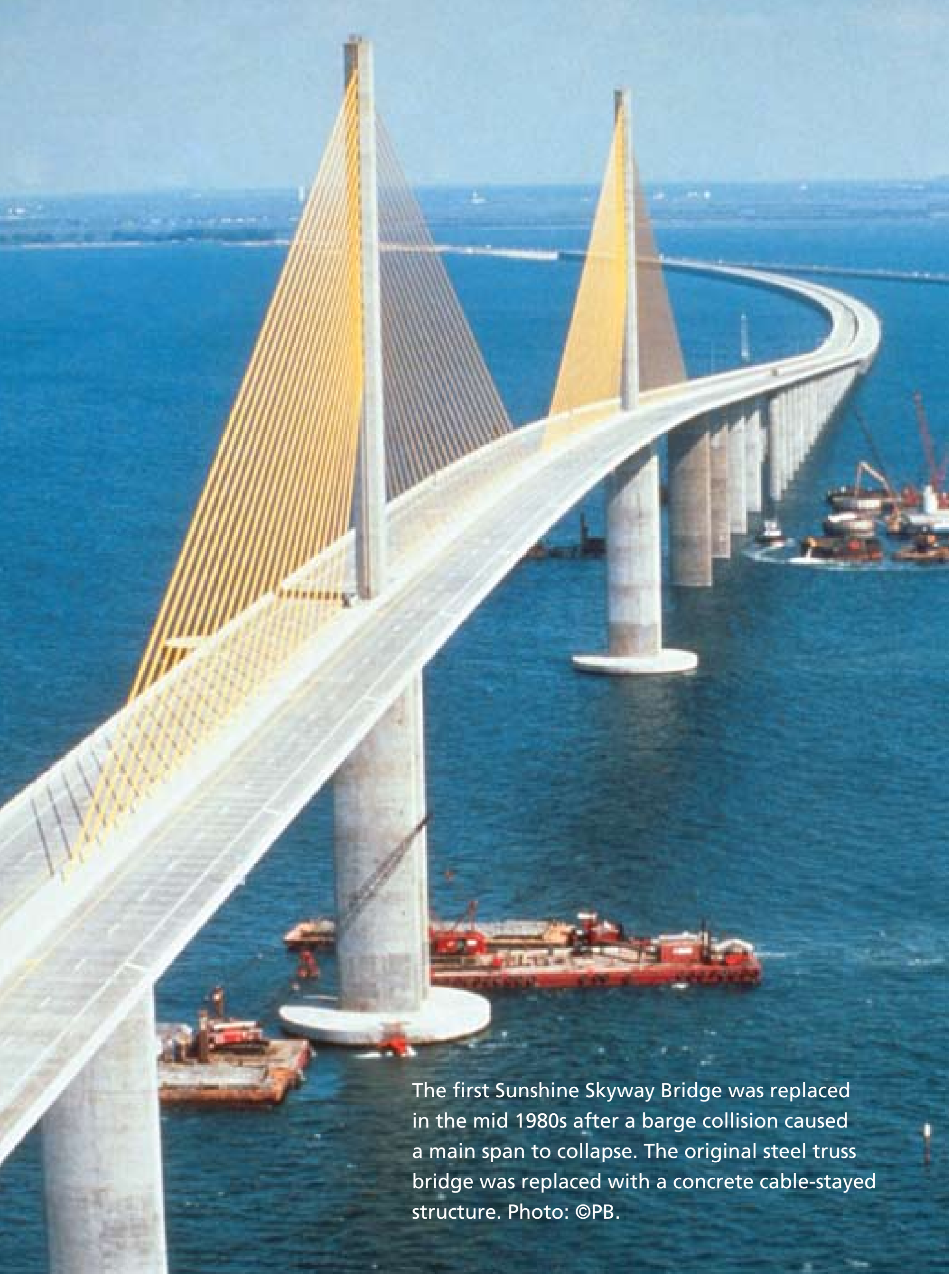
PB has continued to embrace the development of concrete designs ever since. "In the 1960s and early 1970s, whenever designers thought of creating spans greater than 75 to 80 ft, they thought of steel," he says. "In some measure, that was because of limitations in the plants and in transportation for concrete, so the spans were shorter. But even by the early 1970s, the market had changed so that concrete was being used to create longer spans.

One of the earliest such uses, in the late 1960s, was the Halawa Interchange in Honolulu, Hawaii, which comprised 16 major bridges, nearly all of which used precast, prestressed concrete girders. Two of those featured one of the first uses of what is now called "spliced-girder technology" to extend the span lengths of the girders.

"We have since designed many spliced-girder concrete bridges, and we have helped to increase the span lengths that can be achieved," he notes. To succeed with spliced girders, he adds, designers have to be certain they know what they're doing and are using experienced personnel. They also have to do detailed analyses to ensure they account for thermal effects and long-term creep and shrinkage. "That analysis has to be

Two of the bridges at the Halawa Interchange in Honolulu, Hawaii, featured one of the first uses of spliced-girder technology. Photo: ©PB.

The I-10 Bridge over Escambia Bay makes extensive use of precast components for the pier footings, bent caps, pier caps, prestressed concrete piling, and bulb-tee beams.
Photo: ©David Sailors.



The first Sunshine Skyway Bridge was replaced in the mid 1980s after a barge collision caused a main span to collapse. The original steel truss bridge was replaced with a concrete cable-stayed structure. Photo: ©PB.

'Repair and investigative analysis is becoming a larger part of the market.'

done precisely to be sure it is absolutely accurate," he says. "Constructability also is a key concern with spliced-girder bridges and has to be reviewed closely."

The firm designed the James River Bridge in Newport News, Virginia, during the mid 1970s. This bridge featured a monolithic design in which the deck girders and top slab were cast as a single unit 75 ft long and 36 ft wide. "The design was changed to the monolithic approach to create a smooth ride for the traveling public, greatly minimize future creep camber, and provide a durable structure," Chandra says. It was the second use of monolithic design in the country and provided a new approach that produced smoother riding surfaces.

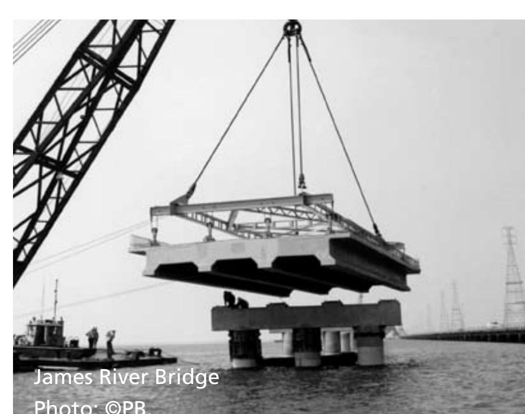
PB returned to one of its earlier successes in the mid-1980s with the redesigned new Sunshine Skyway Bridge. It built on the innovations of the first structure by designing piles, piers, and superstructure of the low-level approaches to resist ship impact forces. This was unprecedented at the time as ship impact design was only performed for the piers adjacent to the navigation channel.

The company was part of the design-build team for the Arthur Ravenol, Jr. Bridge across the Cooper River at Charleston, South Carolina. This bridge was the most complex project ever completed by the South Carolina Department of Transportation. The 3-mile-long crossing includes two interchanges, two high-level approaches, and a cable-stayed main span. A 100-year service life was an important design criteria for the cast-in-place and precast concrete.

New Markets and Technologies

"Repair and investigative analysis is becoming a larger part of the market, as more designers understand the need to strengthen what is already in place," Chandra says. The firm took such measures when it undertook one of its most recent high-profile projects—the Central Artery/Tunnel (CA/T) Project in Boston from 1996 to 2004. The massive project included a wide range of bridges, with innovations incorporated in small-, medium-, and long-span bridges.

The PB/Bechtel team design was the first to use the newly developed New England bulb-tee girder for some of the structures. Specialized techniques for integrating precast segmental box elements into the piers, as well as saw-



James River Bridge Photo: ©PB.

‘Durability is a key reason that we look at concrete designs.’

cutting precast segmental box elements to join them to straddle bents, were developed.

“We took on the challenge of doing extensive analysis and inspections for these bridges to avoid any problems with post-tensioning and took corrective and protective measures, when necessary. We have since used these evaluation techniques with other projects,” he says. The evaluation approach is being used on the recent Jamestown Bridge in Rhode Island.

Concrete bridges offer a lot of benefits in a variety of situations, he says. “Durability is a key reason that we look at concrete designs for specific bridges. In addition, concrete can be used for longer span bridges that we can design and erect very quickly.”

Aesthetics also are growing in importance, he notes, a goal that concrete designs can help meet. “There is more regard for aesthetics today in many communities, and we are paying more attention to it,” he says. Greater input is being seen by local citizens particularly for longer, high-profile bridges, he notes. “We are starting to see many more context-sensitive designs being used, and we have focused a lot of attention on creating harmony by balancing the design with its surroundings through a unique design or by fitting it to the surrounding environment.”

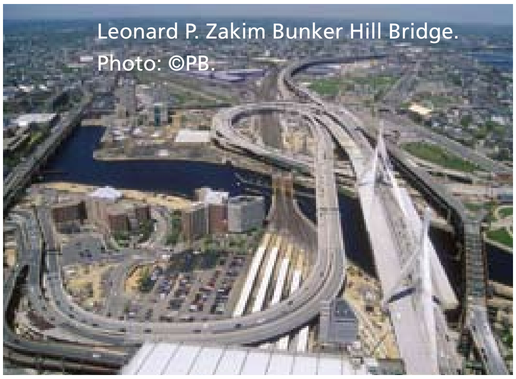
PB continues to expand its capabilities with concrete bridges and is keeping a close eye on new technologies. It was one of the first engineering firms in the mid-1970s to replace ½-in.-diameter prestressing strands in bridges with the 0.6-in. size. “We were looking to create spans as long as 110 to 115 ft,” he explains. “So we developed new beam types and used the larger strands to reduce the total number of strands while keeping the same spacing required for a ½-in. strand.” The approach saved about 15 percent in costs, he notes.

Today, research is proving that the design was a cost-effective method. “The research is showing that we were right in our analysis, and that’s great,” he says. “The use of 0.6-in.-diameter strands will add more opportunities for concrete designs.”

PB has extensive design experience with cast-in-place and precast concrete segmental box girder bridges and has supported the development of new post-tensioning techniques, especially related to grouting applications. “Prepacked grout, in particular, has great application potential and will speed up the construction process,” he says.

Many of the bridges on the Boston Central Artery/Tunnel project used segmental construction. Photo: ©PB.

The Ocean City-Longport Bridge, N.J., included three-span continuous units made from modified AASHTO Type VI 90-in.-deep spliced post-tensioned girders with a maximum span length of 222 ft. Photo: ©PB.



Leonard P. Zakim Bunker Hill Bridge. Photo: ©PB.

Throughout its history, PB has won many awards for its innovative bridge designs. Most recently, it won three awards in the 2007 PCI Bridge Design Awards competition. One award for Best Bridge with Spans less than 75 ft (Route 10 Bridge over Mink Creek, New Hampshire) and two awards for the Best Bridge with Spans over 150 ft (Arthur Ravenel, Jr. Bridge, Charleston, South Carolina and the I-10 Bridge over Escambia Bay, Florida). These bridges uniquely demonstrate the versatility of PB.

Self-Consolidating Concrete

Self-consolidating concrete also is becoming a key material that PB expects to see grow in usage. The concrete mix incorporates higher proportions of fine aggregate and a high-range water-reducing admixture, which significantly increase the material's workability and fluidity. As a result, it flows quickly into place, fills every corner of a form, and surrounds even densely packed reinforcement—all with little or no vibrating of the concrete.

"We expect to see self-consolidating concrete used more often in the next four to five years," Chandra says. His interest in the material was piqued during the CA/T project, when a precaster elected to use a rejected rebar cage for a segmental box girder to evaluate the use of self-consolidating concrete. "It was a complex cage that had mistakes, so the precaster used it to see how self-consolidating concrete would work in a highly congested reinforcement system," he explains.

The result was an excellent concrete component. "He didn't touch it up at all, and it looked great," he reports. "The best part is that, in using it, you don't have to sequence the placement or vibrate the forms to ensure they are completely filled. The concrete flows even into congested corners quickly with hardly any blemishes and no trapped air voids." That will save considerable time and cost as honeycombing and voids are eliminated—and the assurance that they are not present, saves even more time in inspection and improves reliability.

"The level of confidence I have is very high that it doesn't need to be re-worked and will save cost while adding durability. Currently, general specifications for the material that we can rely on are lacking. When that is settled and people have gained confidence in its use, I expect we'll see it being use more often. We'll certainly go for it."

'We expect to see self-consolidating concrete used more often.'

PB led the joint venture responsible for preliminary and final design of the Keehi Interchange near Honolulu International Airport. Photo: ©David Sailors.

The bridge industry is on the cusp of accepting the material for specific applications. Had it been available in the mid-1990s, I certainly would have been interested in its capabilities for helping with construction on the CA/T project. I know the FHWA is very enthusiastic about it, and I share their enthusiasm. I think it will be a good product."

Lightweight Concrete to Grow

Chandra also has his eye on the advances being made in lightweight concrete. It was used on the Leonard P. Zakim Bunker Hill Bridge, a cable-stayed structure over the Charles River in Boston. It also was used on the recently constructed Mattaponi River spliced-girder bridge in West Point for the Virginia Department of Transportation. Lightweight concrete was used in both the precast, prestressed concrete girders and the cast-in-place concrete deck.

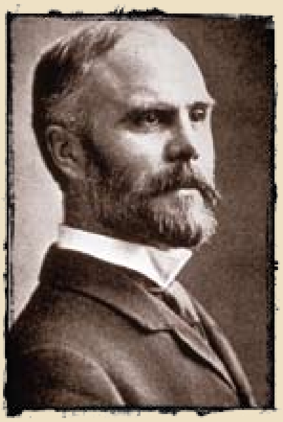
"Lightweight concrete has potential, but you have to look carefully at the conditions and the situation to ensure that the reduced weight will provide a strong benefit, as otherwise it can be an expensive approach," he says. "Spliced-girder bridges and cantilevered designs, such as at the Zakim Bridge, offer good opportunities, because we could offset the weight of the cantilever by using lightweight concrete."

As these concepts become more familiar and new ideas enter the market, PB undoubtedly will be evaluating their capabilities. "We have been at the forefront of technology, and we expect to continue to be there," he says. "We hope that the advancements that we've been a part of have helped to shape the concrete bridge industry and will be a catalyst for future innovations."

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

120+ Years of History

By the time William Barclay Parsons opened a New York office in 1885, he already was known as an ambitious and exceptional engineer. His first commission once open was to design New York City's first subway, the Interborough Rapid Transit (IRT). Completed in 1904, the line remains part of the world's most heavily used rapid-transit system.



His second major project was to chart the 1,000-mile railroad from Hankow to Canton, China, establishing the firm's global reach early in Parsons' career.

Pioneering highway engineer Henry M. Brinckerhoff became a partner in 1906, bringing his expertise in electric railways—and his invention of the third rail—to the firm. He designed the network of roads at the 1939 World's Fair in New York

After many iterations of its name due to partners being added and subtracted over the years, the firm became known as Parsons Brinckerhoff Quade & Douglas, Inc., in 1960. In 2006, the company and its worldwide subsidiaries became officially known as PB.

Today, PB provides comprehensive services for all types of infrastructure projects, including power, buildings, environment, and telecommunications. It works in 80 countries around the world through a staff of nearly 10,500 people in 150 offices from Boston to Beijing.

Photos: ©PB.