Design firm's experience in all types of materials leads it to consider more hybrids and to examine the potential that concrete provides

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Ted Zoli, Director of Long-Span Bridge Design

Ray McCabe, National Director of Bridges and Tunnels

HNTB Looks To Concrete's FUTURE

By Craig A. Shutt

The 10-lane Leonard P. Zakim Bunker Hill Bridge in Boston is a concrete cable-stayed bridge featuring 270-ft Y-shaped towers. The 1432-ft-long project has won a number of design awards for HNTB. Photo: ©Andy Ryan

HNTB's long history with bridge structures has given its engineers the culture and experience to design for a wide variety of applications and challenges. That work has only begun, its executives say, with more exciting designs and new materials on the horizon.

"We're one of the few practices that routinely designs bridges using a variety of materials and with both short and long spans," says Ted Zoli, Director of Long-Span Bridge Design. "There are circumstances where several material options are viable, but in many cases, there is a clear preference." Ray McCabe, National Director of Bridges and Tunnels, adds that such flexibility ensures clients can achieve whatever specific criteria they require.

"Right from the start, HNTB has had a culture of delivering technical excellence regardless of how that takes shape," McCabe says. "Our culture has always been to avoid forcing a bridge design to create an award-winning structure even when the challenges or demands call for it. We tailor our designs to fit the customer's needs. If one of those needs is a signature bridge, then we will deliver that while also meeting other program needs."

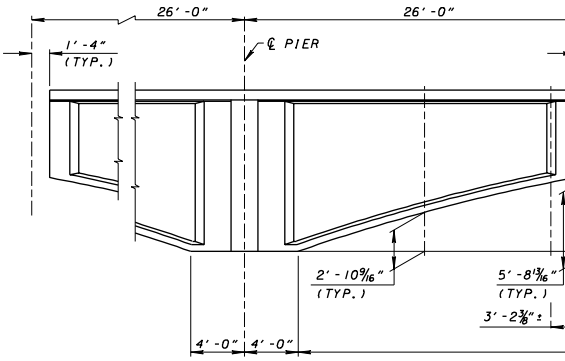
The company has delivered a number of signature bridges, perhaps more than any other firm in the United States, since it opened its doors in 1914. Many of them have featured concrete components. (For more on the company's history and past projects, see the sidebar and accompanying project overviews.)

"We have some unique design elements for which we are known," says Zoli. One of those is a concrete bow-tie strut that the firm often uses with cable-stayed bridges, in which the form very much aligns with the function. "It is, in a formal sense, an optimized structure, with the depth of strut varying to match the moment demands." This design has been used on a variety of HNTB projects over the past 20 years, providing an element that is as functional as it is distinctive.

Formability Adds Advantages

The concrete bow-tie strut is an indication of how the company takes advantage of the material's inherent formability, Zoli adds. "Concrete structures may readily be shaped to resist design forces, giving us the ability to express the way that loads are carried by the structure and to meet the design goals as efficiently as possible."

Concrete bow-tie strut used with cable-stayed bridges aligns form and function.



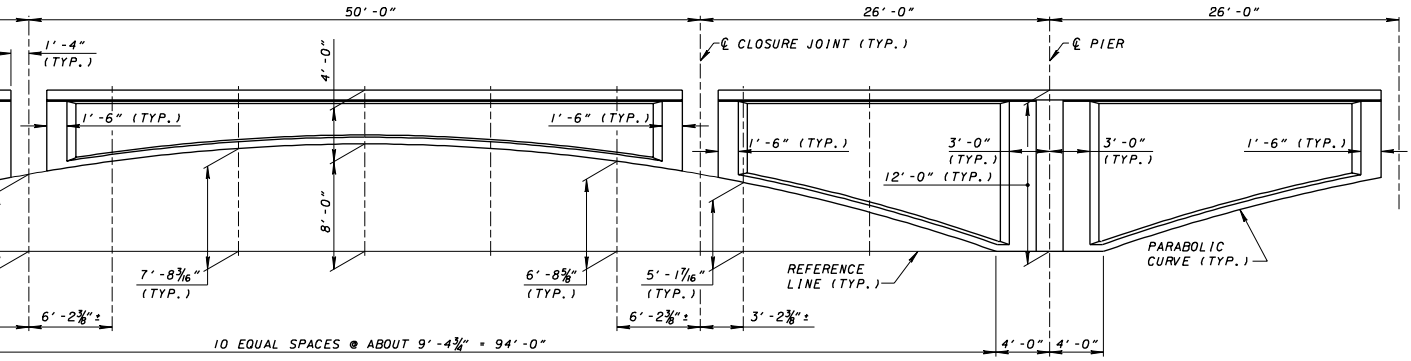
'Concrete bridges are often ideal replacements for our nation's aging steel bridges.'

That flexibility provides a significant advantage at a time when infrastructure needs are becoming a growing concern across the country, he notes. "Concrete bridges are often ideal replacements for our nation's aging steel bridges, particularly with the advent of segmental construction." That's becoming more important in the Northeast in particular, he points out, as many bridges built during the Works Progress Administration era (1936–1943) are nearing the end of their service lives.

A key reason for concrete's popularity with owners and others around the country is the growing concerns with maintenance, both designers say. "Steel-truss bridges have been so problematic from a maintenance perspective that there's a general trend to replace steel trusses with lower-maintenance concrete superstructures, resulting in less inspection and maintenance costs," Zoli says.

Durability A Key Attribute

Durability can be enhanced by high performance concrete mixes, which are becoming more of the norm today, Zoli says. "High performance concrete has



GIRDER GEOMETRY - PIER MODULE AND MID SPAN MODULE

Photo: ©grandlubell.com

The Perry Street Bridge in Napoleon, Ohio, completed in only nine months, used 7000 psi compressive strength concrete to create variable-depth precast concrete modules that simulate concrete arch construction. The project recently won awards from PCI, PCA, and PTI.

changed our profession in the last five to ten years. We see more and more states adopting high performance concrete throughout the United States, primarily to enhance superstructure service life. Many owners are moving to high performance concrete designs as a way to reduce maintenance costs."

High performance concrete also is being used for its strength properties, McCabe notes, but even in those instances, its low permeability and durability are key ingredients. "Durability is critical in all of our designs," he says. "That has to go hand-in-hand with other properties of the mix for it to be effective."

Construction speed is a key reason that lightweight concrete is being used more often, McCabe says. "With precast concrete bridges, weight can be an issue in delivering components to the site. Today, it's much easier to deliver lower-weight, highly efficient, and durable structures. That is the wave of the future." Lightweight concrete also provides advantages in high-seismic regions, he notes. "It can create very effective foundations and provide considerable economy." It also is being used for longer bridges, particularly those with movable portions, where weight is an issue, and for locations where foundation conditions are poor.

The Sixth Street Viaduct in Milwaukee is the first cable-stayed bridge for vehicular traffic built in Wisconsin. Featuring high performance concrete to achieve a 75-year life expectancy, it features a post-tensioned concrete design with a cast-in-place deck. The transverse, concave-like bottom profile has a 5 ft thickness in some haunches.

The formability of concrete is one of its key attributes.

HNTB Through The Years

HNTB Corporation opened its doors in 1914 with a focus on moveable bridge designs. Originally known as Harrington, Howard & Ash, it changed its name to Howard, Needles, Tammen & Bergendoff in 1941 and shortened that to HNTB Corp. in 1993.

In 1975, a merger with Kivett & Myers launched the company's architecture practice, which became HNTB Architecture Inc. in 1994. It also draws on the experience of its 2,900-plus employees in both its transportation-infrastructure and architecture companies to serve clients through HNTB Federal Services Corporation, which was formed in 2004. The company provides government-sector clients with services that include architecture, planning, civil and transportation engineering, security planning, and military facility design.

One of the firm's first bridge projects was the Arroyo-Seco Viaduct in Pasadena, Calif., a high-rise, ribbed-spandrel arch bridge that is still in use. The company's work has resulted in a variety of innovations in design and construction through the years. Those innovations include the design of the Jesse H. Jones Memorial Bridge over the Houston Ship Channel, which opened in 1982 with the longest prestressed concrete segmental box-girder main span in America (750 ft).

More recently, the company's notable concrete bridge work has included the Sixth Street Bridge in Milwaukee; the Perry Street Bridge in Napoleon, Ohio; the Leonard P. Zakim Bunker Hill Bridge in Boston, and Florida's Hathaway Bridge, all of which are shown on these pages.

The company has won a multitude of national and regional awards for its bridge designs. Those include several for the Leonard P. Zakim Bunker Hill Bridge, including the Outstanding Civil Engineering Achievement Award from the American Society of Civil Engineers and the Grand Award from the American Council of Engineering Companies. The Perry Street Bridge was named Best Bridge with Spans between 65 and 135 Feet in the 2006 Design Awards Competition sponsored by the Precast/Prestressed Concrete Institute, one of 10 winners in the Portland Cement Association's Tenth Biennial Bridge Awards Competition, and recipient of the Post-Tensioning Institute's 2006 Award of Excellence.

Engineering News-Record magazine ranks the company as the third largest firm designing bridges, the seventh largest involved with highways, and the sixth largest involved with transportation projects of all types. It also ranks No. 25 among the Top Design Firms in the magazine's rankings.

Spliced Girders and Segmental Bridges Grow

Longer–span bridges also are using more concrete spliced girders and segmental construction, both designers agree. "There continues to be the opportunity to use either method," McCabe says. "Both have advantages depending on the application. In design-build or alternative design approaches, the decision is being left to the contractor, who typically bases the decision on past experience and risk assessment."

"Post-tensioned construction offers unique opportunities to increase the span range we can achieve while remaining competitive with long-span steel girders," says Zoli. "But the manner in which the bridge is built becomes a fundamental aspect of the design, requiring the designer to be more involved in the construction process. It creates an added responsibility and gets the engineer thinking about the exact way in which the bridge is to be built. That can create a more efficient design."

A number of these trends can be seen in the Perry Street Bridge in Napoleon, Ohio. Officials at the Ohio Department of Transportation wanted to replace the existing 700-ft-long bridge in less than one year to minimize disruptions across the Maumee River between north and south Napoleon. They also wanted to retain the original appearance and not disturb the river bottom. To achieve these goals, HNTB's designers decided the bridge "had to be constructed with as much precast concrete as possible," says James M. Barker, HNTB project manager.

To satisfy the project requirements, the designers used precast, prestressed concrete modules consisting of variable-depth, decked, bulb-tee girders. The modules contained pretensioned strands to control stresses during shipping and handling, and were spliced at the quarter points of each span using post-tensioned tendons to establish continuity. The completed structure simulates a concrete arch. The river crossing was disrupted for only nine months.

Composite structures, in which steel and concrete components combine, are becoming more common. HNTB used such an approach recently in its design for the Leonard P. Zakim Bunker Hill Bridge, a cable-stayed structure over the Charles River in Boston. The project features heavier precast concrete box girders in the back spans, which work as counterweights to balance the lighter weight steel floor system used in the main span.

"It was an interesting choice, necessitated by the large number of subsurface utilities and tunnels, foundation locations and limited back-span length," Zoli says. Adds McCabe, "We expect we'll be doing more designs that marry the benefits of steel and concrete in composite designs, as we see improvements in high performance concrete and lightweight concrete."

Such intricate and complex designs are creating closer partnerships among the construction-team members, McCabe adds, and that's particularly apparent as more owners use design-build formats. "The design-build process is still evolving in the industry, but it's becoming more typical, because the design-bid-build process is leading to costs that go over budget too often," he explains. "Owners are being pressed to keep projects on budget and on time, and they are looking for solutions that will see the bridge they've designed be completed as planned. Design-build keeps the designer and contractor focused on ensuring the project remains on budget."

Cable-Stayed Designs Offer Efficiencies

The designers also see cable-stayed bridges becoming a more popular option for concrete bridges in the future. "Short-span cable-stayed bridges offer great efficiencies," says McCabe. "We expect to see an evolution to more efficient and quickly built concrete solutions, and flat slab cable-stayed bridges offer one approach that works."

Zoli agrees that this approach will grow. "Flat slab cable-stayed bridges provide remarkably efficient structures that are quite easy to build in either precast

'Post-tensioned construction offers unique opportunities to increase the span range we can achieve.'

Sixth Street Viaduct, Milwaukee

The Hathaway Bridge in Panama City, Fla., is a design-build replacement bridge that features two parallel structures constructed with precast concrete segmental box girders. Each structure features seven 330 ft spans, 265-ft-transition spans, and 200-ft-end spans.

'We expect to see an evolution to more efficient and quickly built concrete solutions, and flat slab cable-stayed bridges offer one approach that works.'

concrete or cast-in-place." Relatively narrow superstructures with span lengths exceeding 800 ft offer great potential for this application, he says. "They're really a missed opportunity in America, but they represent a great way to create efficient designs, particularly for small-scale bridges with spans between 500 and 700 ft—and there are many such opportunities. The flat slab cable-stayed bridge provides a cost-efficient and easily maintained design that creates a beautiful structure."

The need will grow as more steel truss bridges become functionally obsolete and need replacement, he says. "We believe the future points to more cable-stayed bridges. We're continuing to extend the span range where cable-stayed bridges are effective." The company's design of the Sixth Street Viaduct in Milwaukee shows the potential. The replacement project, representing the first cable-stayed design for vehicular traffic in Wisconsin, features a pair of post-tensioned cable-stayed bridges of 574 and 665 ft. It was designed to provide a 75-year service life.

What Lies Ahead?

Other concrete applications and innovations loom on the horizon, both designers agree. Zoli is anticipating an evolution in the use of conventional materials in new combinations, as designers consider new concepts. One such is the use of small-diameter, high strength steel cord, such as are used on radial tires, as reinforcement in concrete. "The combination of high strength steel cord with high strength concrete has the opportunity to create an interesting new material that may result in new design and construction strategies."

McCabe also expects to see concrete production methods evolve, and he expects one area of change will focus on curing methods. "We need to achieve more foolproof curing methods," he says. He anticipates improved concrete mixes and a reduction in the heat of hydration in the mixes, as well as creating faster-setting mixes that don't crack, will encourage that evolution. "I expect in the next 10 years, we'll see more work being done to improve these mixes."

The engineers are excited about the potential designs that can be achieved as concrete expands its strength and durability while maintaining its flexibility. "Concrete is particularly suited for innovative designs, because it's not limited by the fabrication process," says Zoli. "We can form it into any shape we want. That's the freedom you get from using concrete."

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