Life span

Bridge design enters era of innovation as old structures need replacing and resources remain scarce.

By Christina M. Zweig

The new Lake Champlain Bridge, connecting Crown Point, N.Y., and Chimney Point, Vt., replaces the 80-year-old bridge that was found to be deficient.

Modern bridge design often brings to mind engineering feats like the Magdeburg Water Bridge, a 3,012-foot navigable aqueduct in Germany, or exciting visuals like the lit-up cables of the Octávio Brias de Oliveira Bridge, a bridge in São Paulo, Brazil over the Pinheiros River – the only bridge in the world that has two curved tracks supported by a single concrete mast shaped like an "X." Bridge design is evolving at a rapid pace, and while some of these modern marvels have a striking appearance, most modern bridges have an equal amount of innovation but a much more subdued look.

HNTB Corporation, an industry leader in planning, design and construction of complex long-span and movable bridges, argues that "Innovation and creativity play an increasingly essential role in modern bridge design and engineering today. With one in every four bridges in America structurally deficient or functionally

Dr. Jeffery Volz, assistant professor of civil, architectural and environmental engineering at Missouri University of Science and Technology, tosses a block of foam inside the three-story high-bay structures lab. Volz is joined by (from left) Matthew Hopkins of Burfordville, Mo., a graduate student in civil engineering, Amanda Steele of St. Joseph, Mo., a senior in civil engineering, and Hesham Tuwair of Tripoli, Libya, a doctoral student in civil engineering.

obsolete, our nation is facing an investment of billions of dollars to rebuild or replace its aging bridge infrastructure."

Despite their cost, bridges are absolutely vital to the economic and social health of any community.

"Bridges are first and foremost socio-economic lifelines, vital to our economic health at the local, regional and national scale," said Ted Zoli, HNTB national technical director for bridges, in a press release.

Modern methods

Funding woes are pushing innovation in bridge design, with delivery methods such as design-build, public-private partnerships and construction manager/general contractor becoming increasingly popular – and making for faster and cheaper bridges, and shorter service interruptions.

Sometimes innovation is coming from unexpected quadrants.

The Federal Highway Administration announced in March the acceptance of proposals by California and Vermont to explore innovative ways of using federal funds to cover certain indirect costs of managing highway projects. The FHWA said the announcement is in keeping with its "Every Day Counts" initiative, designed to shorten the time for highway project delivery, enhance roadway safety and protect the environment.

FHWA's approvals are the latest in an ongoing testing and evaluation program designed to encourage states to find alternatives, or improvements, to conventional highway grant funding strategies.

"Motivated by the lack of current funding, the uncertainty of future funding and the 'impact to user' cost of protracted construction schedules, departments of transportation increasingly are using accelerated methods to deliver mobility-critical bridges," says Robert Turton, National Bridge Practice Leader, HNTB Corporation. "In the past few years, we have seen DOTs consider advances in bridge design and construction that are helping owners do more in less time and reduce overall project costs."

The fast-paced world of accelerated bridge design and construction is pushing creative design and construction methods, Turton says.

"A center span is built off-site, allowing it to be constructed

A rendering of HNTB's Cleveland Innerbelt Bridge.

simultaneously with approach spans. The center span is then floated in and lifted into place," and "entire sections of bridges are constructed and then maneuvered over highways using self-propelled modular transport machines," Turton offers as examples.

A good example of innovation can be seen in FINLEY Engineering Group, Inc.'s contribution to a Texas project. The firm is providing services to Lane Construction Corporation for two new I-35 bridges over the Brazos River in Waco. The new bridges will be the first use of an "extradosed" design for the Texas Department of Transportation that will not only meet aesthetic requirements but create sidewalks and overlooks for pedestrians, ramps, u-turns, and access to the future Baylor University Sports Complex. The three bridges are 620 feet long, with a 250-foot main span that will include steel beams working in conjunction with pylons anchored by shallow-angled cables that will carry between 20- and 30 percent of the bridge load. Drilled 10-foot diameter shafts about 50 feet deep will provide a foundation for the bridge. The shafts will transition into aesthetic columns and pylons and the beams will rest on a continuously poured concrete cap that helps support the deck.

"In the last 10 years, this bridge typology has become very popular and is more common internationally. It's a cross between a cable stayed bridge and cantilever constructed prestressed box-girder bridges. This type of design is very efficient and aesthetically pleasing," said Craig Finley, managing principal, FINLEY, in a press release.

Modern materials

The Missouri University of Science and Technology says that the majority of the nation's 600,000 bridges were built nearly 50 years ago using traditional materials including steel, concrete and rebar. The structural integrity of these bridges, which are nearing the end of their lifespan, has been greatly reduced due to weathering, wear from vehicle traffic, de-icing chemicals and reduced maintenance.

The university says 17 percent of Missouri's bridges are deficient and not enough resources are available to repair and rebuild them, with researchers there working to develop innovative and inexpensive

materials that can replace these relic structures.

"A common saying for civil engineers is that we could build bridges that last forever, but we can't afford it," said Jeffery Volz, assistant professor of civil, architectural and environmental engineering at Missouri S&T, in a press release.

Newer designs have called for replacing the concrete and rebar with fiber reinforced polymers (FRP). Built with intricate honeycomb structures, glass carbon fiber bridge decks are strong, lightweight and corrosion resistant. Despite offering a longer life and lower maintenance costs, fiber reinforced bridges come with a higher price tag up front – nearly twice the cost of traditional structures – because the honeycomb structure is extremely expensive to construct.

Volz sees the development of new materials as a great opportunity. Using a $120,000 grant from the Missouri Department of Transportation matched with a $60,000 grant from the U.S. Department of Transportation, S&T researchers are exploring how high-density polyurethane foam could eliminate the need for the honeycomb structures. Sandwiched between FRP facings, polyurethane foam is often used in cars, planes and prefabricated buildings.

"We're using a formulation of polyurethane foam that can withstand compression beneath a truck wheel," Volz said. "By adding glass fibers to the polyurethane foam, we can get up to 1,000 psi."

The sandwich deck panels can be built in a factory and then shipped to site on trailers. The panels are so light that each one can be carried by only two people.

"The foam and FRP panels offer the same cost as concrete but could live forever," Volz says. "It should last until we have flying cars and don't need bridges anymore."

Modern values

Truly modern bridges also are designed to work in harmony with the environment.

HNTB designed the Happy Hollow Park and Zoo Pedestrian Bridge in San Jose, Calif., to be an example of efficient design that conserves limited resources. The bridge uses standard materials, the minimum number of material sizes and an eight-fold symmetry. There are only two rolled sections on the bridge (one for the arch ribs and one for the tie girders and cross bracing) and only one cable size is used for both bridges. Unpainted weathering steel eliminated the need for painting and paint maintenance for the bridge's lifetime.

HNTB Corporation worked closely with New York State Department of Transportation to incorporate environmental sustainability in a landmark project: The Lake Champlain Bridge in Crown Point, N.Y. The bridge, designed by Theodore P. Zoli, is a replacement for an old bridge that closed unexpectedly in 2009 due to the discovery of severe deterioration. The replacement bridge was constructed at the same location and opened to traffic in November, 2011.

As a main passage between New York and Vermont, the span traverses French and Indian War historic sites in both states, is within the Adirondack Park and crosses pristine Lake Champlain – all areas of high environmental and cultural sensitivity. Temporary ferry slips and landings were built so a ferry could be used during bridge construction to eliminate what would have been a nearly 100-mile traffic detour. The work was done without collateral intrusion into the environment, while protecting and preserving the historic sites.

"We applaud NYSDOT for its commitment to rebuilding and maintaining our transportation system in a sustainable manner, recognizing the need to reduce transportation's carbon footprint and preserve our natural surroundings," said Peter Melewski, vice president and Albany office leader for HNTB, in a release.

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