AECOM

THE STRUCTURE *BEHIND* THE STRUCTURE

by Arthur Schurr

How the AECOM bridge practice gets things built

President Franklin Roosevelt said, "There can be little doubt that in many ways the story of bridge building is the story of civilization." And the people who create those bridges are a big part of that story.

Designing and constructing bridges is like no other profession. Though firmly anchored in the earth, bridges can soar skyward like cathedrals. Majestic, grand, inspiring, and iconic, bridges can define a location and transform a region. Yet in addition to their considerable visual, aesthetic, and cultural contributions, bridges also must fulfill a very practical function. At their core, they are a means of getting people and things from Point A to Point B, using the most efficient route possible.

Given that fusion of art and function, anyone who would aspire to design these structures must be part Renaissance thinker, part tinkerer, part linear analyst, and part romantic—but always a full-time team player. It takes a unique blend of individual creativity and selfless teamwork to design and build a successful bridge. Formed to meet that need, the AECOM bridge practice unites a brigade of experts into a global unit that is ready to ply its trade wherever it is most needed.

Illustration: Shutterstock

'We have more than 850 bridge engineers located in 51 offices around the globe.'

"In examining the Brooklyn Bridge right after it was completed, someone described it as a 'durable monument' that would 'convey some knowledge of us to the most remote posterity.' But they also said the Brooklyn Bridge was a 'work of bare utility; not a shrine, not a fortress, not a palace, but a bridge.' And that is exactly how I see what we do," explains Ken Butler, AECOM's national director of bridge services. "Though bridges are a testament to our present sense of aesthetics, culture, and technological achievement, we only build bridges because they are needed to provide passage."

As a 12-year veteran with the firm and almost a quarter century of bridge design expertise, Butler knows how AECOM's bridge practice works. For him, the firm's philosophy and principles are reflected both in the bridges they've built, and in the underlying structure of the bridge practice itself.

"We have more than 850 bridge engineers located in 51 offices around the globe, half of which are located in the United States. As a result, we can offer the full range of bridge services—supporting everything from small overpass structures to major, complex, signature bridges. To deliver on that offer, we rely on a huge reservoir of talent and a three-part technical structure.

"Bridge engineers in each of our local offices represent our first component. They provide a broad array of technical services to a diverse client base that includes departments of transportation, toll authorities, and other public agencies.

"Next, we have a dedicated practice staffed with engineers who have highly specialized technical backgrounds, experience, and expertise in designing and constructing major, complex bridges. Members of this group go anywhere their expertise is needed. They're kind of like a SWAT team of bridge designers. Whether it's the Indian River Inlet cable-stayed bridge in Delaware, the Richmond–San Rafael Bridge in California, the Florida Avenue Bridge in New Orleans, or the East 153rd Street cable-stayed bridge in New York City, they go and get the job done.

"Finally, the third part of our structure is our international component, largely operated by a company unit known as Maunsell. Our international component has lent its expertise to projects throughout the world. They, too, have completed everything from small overpasses to signature bridges that are very dramatic and instantly recognizable. They are currently providing bridge engineering services for the two longest span cable-stayed bridges in the world: Sutong Bridge in China and the Stonecutters Bridge in Hong Kong; and the longest span, cast-in-place concrete box girder bridge, Second Gateway in Australia.

"What gives our structure its real power, though, is that we can transfer expertise fluidly around the world—wherever and whenever it is needed. We can deploy world-class expertise to any locale that requires it. By flexibly integrating our global technical resources, we can meet virtually any client's needs, no matter how small or large, simple or complex."

Boasting more than 43,000 employees globally, and revenues of $5.2 billion in 2008, AECOM serves clients in more than 100 countries. Ranked first in overall transportation design by *Engineering News-Record*, and third in bridge design, the firm prides itself on providing a "blend of global reach, local knowledge, innovation, and technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments." Lofty as that may sound, Butler believes it's a very practical, functional blueprint.

"Local expertise is more than sufficient for most projects. But when a project is considerably more complex or unusual, we bring in the requisite expertise from around the country or anywhere in the world. That specialized expertise ensures that our clients get the best technical knowledge, experience, and methods available. That isn't just marketing rhetoric; it's what we do."

This reliance on resource transfers and staff allocations isn't confined to the bridge practice; it is reflected throughout the firm. Many AECOM projects seem like makeshift meetings of the United Nations. According to Butler, though, creating an international mix is never the end goal—but it often is the end result. Rather, it's about deploying the appropriate resources for the task at hand. For example, consider the Delaware Department of Transportation's (DelDOT) Indian River Inlet Bridge.

Indian River Inlet Bridge

Located in Rehoboth Beach, Del., the Indian River Inlet has posed a considerable engineering challenge for nearly a century. The most recently built bridge—dating back to 1965—has a problem: the forceful inlet tides are severely scouring its piers. When the bridge was initially built, inlet depth was measured at 28 ft. Recently the inlet depth was measured at more than 100 ft. A new bridge was needed, one that could overcome the harsh environmental effects that had damaged previous bridges, Butler explains.

"The existing bridge had piers in the water within the inlet. As a result of the shape

The upper and lower trestles with total lengths of 2843 ft and 3643 ft, respectively, were replaced with double tees measuring nearly 44 ft wide and 100 ft long. They were match cast in three segments and post-tensioned together in the precaster's plant. The units were also post-tensioned transversely. Each weighs 425 tons.

Precast concrete jackets for the pier shafts used in the retrofit of the Richmond-San Rafael Bridge across San Francisco Bay, are shown in the precaster's yard and installed in place.

of the inlet and the way the tides ebb and flow, scour was a destructive and perennial issue. The inlet had scour holes up to 120 ft deep. Obviously, either the existing bridge piers would be eventually scoured out or major counter-scour measures would be required. The key for the new bridge was to take all the piers and substructure out of the inlet water.

"Given the geometric constraints, we approached it with a form-follows-function mentality; we were really looking for the most economical structure in terms of durability and maintenance for the 100-plus-year service life the client required. So, we created a cable-stayed bridge with a very shallow profile, a 6-ft-deep superstructure. With a combination of precast and cast-in-place concrete, the bridge has single-mast, 240-ft-tall towers that evoke the graceful lines of sailboats. We wanted to make the bridge as slender and unobtrusive as possible, given its pristine coastal environment. We wanted it to blend into the beautiful coastal region and not overpower it."

To be constructed under a design-build partnership with Skanska, the $150 million Indian River Inlet Bridge will stretch 2600 ft, with a 950-ft-long clear span over the inlet. The scour issue is eliminated by placing all supports out of the water; the new foundation consists of 36-in.-square piles. The bridge is scheduled to be open to traffic by the summer of 2011. Heavy construction will begin in early 2009.

The design solution developed for the Indian River Inlet Bridge project demonstrates the flexible effectiveness of AECOM's bridge practice. In addition to partnering with long-time collaborator Skanska and regular subconsultants, AECOM tapped its local Philadelphia office for necessary expertise to get the job done. And AECOM Maunsell is providing erection engineering on the project. AECOM's three-part technical structure once again proved effective for this project.

Richmond-San Rafael Bridge

The Richmond-San Rafael Bridge provides another illustration of how the firm's bridge practice works. Operated by the California Department of Transportation (Caltrans), the Richmond-San Rafael Bridge carries more than 60,000 vehicles a day. Part of I-580, the bridge is one of four spans crossing San Francisco Bay; it connects the cities of San Rafael in Marin County and Richmond in Contra Costa County. Consisting of two single-deck, reinforced concrete approach trestles with 50-ft-long spans and a combined length of approximately 6500 ft, the bridge also boasts built-up steel-girder spans at both ends, including single-deck and double-deck structures with a combined length of 3600 ft. In addition, two variable-depth, double-deck, cantilever-truss-type structures span the navigational channels with 537.5-ft-long anchor spans and 1070-ft-long center spans that reach a combined length of 10,600 ft. Not a typical bridge by any measure, there were additional significant complications.

Just 4 miles from the Hayward Fault and 10 miles from the infamous San Andreas Fault, the bridge sits between two of the most dangerous and sensitive zones surrounding any elevated structure in the world. Also, because it is one of only four structures crossing San Francisco Bay, closing the bridge to traffic was not an option. Tasked with the role of designing 6500 ft of replacement trestle at the west approach of the bridge in the $735 million project, the AECOM design team had to create a solution that was both effective and efficient.

"We were assigned to perform seismic analysis and retrofit design of the bridge," explains Androush Danielians, associate vice president and manager of the firm's Los Angeles structural engineering department. "Seismic analysis of such a long structure required special techniques. To account for variations in the seismic forces experienced by the structure, multi-support excitation time-history analysis was used to evaluate the structural behavior in a seismic event. Simply put, multi-support excitation exerts different magnitudes of seismic force at each support. Although the other portions of the bridge were retrofitted, we determined that replacement of the trestle portion of the bridge would be more cost-effective than seismically retrofitting it. But the replacement work faced unique conditions; we could not close the bridge completely for any extended period."

"Our solution was to bring in precast, prestressed complete deck sections; these double-tee sections were 100 ft long per span. At night, we would close down the bridge, replace one span, and then open it up for the morning rush. That avoided a lot of construction issues. And aside from wanting traffic to flow to serve the traveling public, we had another serious incentive to make the plan work.

"Any construction delay that caused the bridge to open late incurred a potential penalty of $28,000 for each minute the bridge opened late. That's a pretty serious motivation to make sure that everything goes smoothly and on time. And it did. The penalty was never invoked, not even once. Key to the plan, though, was the precast option. Using precast, prestressed concrete sections for the superstructure made the replacement of the trestle portion possible under these conditions."

Use of the precast, prestressed concrete elements and the design did not go unnoticed. At its 2007 annual national bridge conference in Phoenix, Ariz., the Precast/Prestressed Concrete Institute (PCI) bestowed on AECOM the "Best Bridge Project with Spans Between 75 and 150 Feet" award for its work on the Richmond-San Rafael Bridge. According to the PCI jury, "The project demonstrates the advantages that can be achieved by standardizing sections, even with 64 spans of more than 100 ft. The bridge offered an excellent example of the applications of precast concrete elements in a fairly complex bridge design."

AECOM's internal structure played a vital role in the project's success. Though primarily handled from the Los Angeles office, the project drew in AECOM engineers from around the country—from Oakland and Sacramento to Richmond, Va., and Tallahassee, Fla.

"Our Florida office provided decisive expertise on this project. Precast bridges are very common in Florida, less so in California. Designers from our Florida office helped us create a unique solution, one that impressed Caltrans enough for them to sign off on several 'firsts' in terms of design and execution. Being able to draw on such varied expertise equipped us to create the optimal solution for our client."

Additional U.S. Projects

The firm's technical structure has enhanced AECOM's ability to serve its clients on other projects as well. In New Orleans, La., AECOM is performing detailed design and construction support for the Florida Avenue Bridge project. Part of the $4 billion Transportation Infrastructure for Economic Development (TIMED) program for the Louisiana Department of Transportation and Development, the $220 million Florida Avenue Bridge project is one of three major bridge components of the TIMED program.

Designed to provide reliable access between St. Bernard and Orleans parishes over the Inner Harbor Navigational Canal (IHNC), the project includes a four-lane, 78-ft-wide, high-level bridge over the IHNC. The five-span main unit over the IHNC is 1516 ft long and includes a 470-ft-long center span, which provides 300-ft-horizontal and 156-ft-vertical navigational clearances.

For the Pennsylvania Turnpike Commission, AECOM is providing preliminary and final design engineering for a new 5-mile section of highway that includes more than 19,000 linear ft of elevated, multi-level, curved structure. Located in North Versailles Township near Pittsburgh, Pa., the $240 million Mon-Fayette Expressway (Section 53E) includes a complex, multi-level, system-to-system closed interchange and a system-to-service interchange for this strategic expressway segment. This segment is critical to industrial redevelopment along the Monongahela River.

In Boston, AECOM provided detailed design and construction support for significant elements of the Central Artery/Tunnel project in an $850 million engagement with the Massachusetts Highway Department. Responsible for final design of major structural components and coordination of various design elements and subconsultants for several portions of the Big Dig, AECOM completed considerable bridge work on the project—including approximately 9000 linear ft of auxiliary steel and concrete viaducts and bridges over boat sections, new bridges on Broadway and Dorchester Avenues, and approximately 2000 linear ft of mainline steel and concrete viaducts.

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International Component

The core bridge practice has proven to be quite effective for projects both local and national. But the third part of the three-part technical structure described by Butler—the international component—has made significant contributions as well. In New South Wales, Australia, AECOM performed concept and preliminary design, as well as detailed design and documentation for the "Sea Cliff Bridge" (as the Lawrence Harvey

The selection of structure type and erection method for viaducts on the Taiwan High Speed Rail was influenced by the variable terrain and wide river plains; the choice of structural layout played an important part in achieving an economical design. Seismic load effects, although only a part of the entire design process, determined the dimensioning of key elements such as substructure and foundation.

The superstructure of the Taiwan High Speed Rail comprises precast, post-tensioned concrete box girders, 3.25 m (10.7 ft) deep and up to 35 m (115 ft) long, weighing up to 780 tons.

Drive Bridge has come to be known). This dramatic bridge south of Sydney actually consists of two adjoining bridges. The southern bridge section, featuring two 62-m (203-ft)-long end spans and three 108-m (354-ft)-long main spans, was constructed using the cast-in-place balanced cantilever method. The northern section of the bridge is an incrementally launched structure with six 30-m (98-ft)-long main spans and an 18-m (59-ft)-long end span. The two bridges join to form a viaduct that bypasses the southern amphitheater, which is vulnerable to rock falls.

Also in Australia are the Westlink M7 bridges. Located in western Sydney, the $1.1 billion Westlink M7 project is a 40-km (25-mile) motorway that required the construction of 142 bridges including 31 segmental bridges. Timely construction of the bridges was critical to the early opening of the motorway, and bridge standardization was essential. While conventional pretensioned, precast concrete beam designs were used for span lengths up to 35 m (115 ft), precast segmental box girder bridges were chosen for the longer span bridges and motorway overbridges. AECOM provided detailed design and construction support for the Roads and Traffic Authority of New South Wales.

Travel from Taipei to Kaoshiung in Taiwan will soon become much faster with the implementation of the Taiwan High-Speed Rail Link. The $17.5 billion rail project will enable 300,000 people a day to travel at speeds of up to 300 km/hr (186 mph) on a newly constructed 345-km (214-mile)-long high-speed line. Since the line traverses extremely active seismic regions, 38 km (24 miles) of the alignment will consist of high-level viaducts. In providing construction design, the AECOM team faced a number of challenges on the fast-track design/build project—severe seismic concerns, difficult ground conditions, and demanding program and construction constraints.

But wherever they may be located, AECOM bridge projects can benefit from the unique expertise that is available through a network of local, national, and international sources. For Butler and AECOM, the system works. But he cautions that just like designing bridges, designing a practice to create bridge solutions is never a static endeavor. The practice must adapt and reinvent itself continually to meet evolving requirements.

"Clients are very sophisticated; they know their needs better than anyone else. Our job is to provide the best options for satisfying those needs. In the United States, we're facing a particularly difficult time, especially in light of the I-35W collapse in Minnesota. The traveling public is concerned; we must address those concerns, and restore confidence in our infrastructure. Ultimately, though, it comes down to funding. Whether it's through user fees or public-private partnerships or some new funding approach, we must get more creative to help our clients develop new solutions.

"The answers can come from anywhere. That's why we instituted the structure we have. When it comes to expertise, geography should be unimportant. Firms should be able to marshal resources wherever they are needed to achieve the best result for a client. We've learned that the integration of expertise across borders—local, national, or international—facilitates knowledge transfer and exchange. We make ourselves better and learn more by interacting with our fellow designers throughout the company, throughout the world. And in turn, that provides greater value for our clients."

Designing and constructing bridges is like no other profession. As Franklin Roosevelt said, "There can be little doubt that in many ways the story of bridge building is the story of civilization." The women and men of the AECOM bridge practice are part of that story. Their profession helps advance society's progress, creating iconic structures that serve people's needs.

Arthur Schurr is a freelance writer who reports on transportation infrastructure for national and international publications.

Sustainability

"Twenty or 30 years ago, sustainability was hardly even an issue. Now, it's a standard. And it will continue to evolve in ways we can't imagine today. As budgets become tighter and funding becomes more limited, owners are incorporating sustainable elements to make their infrastructure last longer and perform better. They need to lower maintenance costs and minimize future replacement costs. So as bridge professionals, we must constantly seek out innovative materials and methods. But it's equally important to listen" explains Ken Butler, AECOM's national director of bridge services.

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