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Speed on base path

Accelerated construction used for Bahrain bridge

When the original design for an overseas bridge does not satisfy the concerns of the host nation, it is time for the engineering firm to develop an innovative solution.

That is what HNTB Corp. did in the case of a bridge that was built to link the U.S. Navy Support Activity Base to the U.S. Navy Port Facility in Manama, the capital and largest city of the kingdom of Bahrain. The engineers came up with a new design that resolved all outstanding concerns over traffic congestion, safety and aesthetics.

The P-954 Flyover Bridge, a single-span, tied-network-arch bridge, is the first bridge designed to be moved into place using self-propelled modular transporters (SPMTs) for the U.S. Army Corps of Engineers, Middle East District.

"The design is certainly innovative in this part of the world," said Mike Allen, senior structural engineer and technical coordinator for the U.S. Army Corps of Engineers, Middle East District. "Now it's a demonstrated solution."

A crucial link

Bahrain has been a base for U.S. naval activity in the Persian Gulf since 1947. In 1971, when Bahrain achieved independence from Britain, the U.S. Navy leased part of the former British base. Bahrain and the U.S. signed a Defense Cooperation Agreement in 1991 that granted U.S. forces access to Bahraini facilities, thereby ensuring the right to pre-position material for crises that might arise in the future.

The naval base in Manama is the home of the Fifth Fleet and serves as the nerve center for all naval operations in that vicinity. In early 2010, the U.S. Army Corps of Engineers, Middle East District, selected HNTB to design a bridge that would provide secure access from the U.S. Navy Support Activity Base to the U.S. Navy Port Facility over the Khalifah Bin Salman Causeway in Manama. The causeway is generally considered the most heavily traveled thoroughfare in Bahrain.

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"The base is divided by the causeway," said Christian Brown, HNTB's senior project manager. "There were a lot of security issues and safety concerns in getting from one side to the other. Depending on traffic, U.S. military and support personnel could expect a 30-minute to one-hour commute between the two base locations. There were logistical constraints that the Army wanted to alleviate, and the new bridge enhances security while reducing the travel time to only a few minutes."

HNTB had proposed a four-span and then a three-span prestressed concrete bridge. "The girder bridges were viewed as the most cost-effective approach," Brown said. "It was a structure that would be—from an appearance standpoint—rather utilitarian. And it would have required bridge piers to be placed adjacent to and in the median of the causeway. Placing the girders would have involved overnight lane closures, and once the bridge was completed, there would have been a little bit of encroachment on the median and shoulder area of the causeway."

But Bahraini officials were reluctant to approve that design. "Because it would be passing over such an important highway, the kingdom of Bahrain was very concerned about any possible disruptions to traffic on that roadway," Allen said.

Additionally, Bahrain had expressed concerns over the limited aesthetic appeal of a girder bridge that would cross one of the country's busiest highways.

"Weighing all those factors into consideration, we went back to the Corps and the Bahrain Ministry of Works and proposed an alternate structure type," Brown said.

Using special forces

Allen said that although the major challenges in winning the support of the host nation "were not entirely technical in nature, the solution ended up being mostly about engineering. Once we got more into the project, we were able to look at some technical options that hadn't been explored previously."

Working under a compressed schedule to meet the needs of the client, HNTB came up with a new design in six months, with completion reached in February 2011. After careful consideration of all the issues, engineers proposed a single-span, two-lane, tied-network-arch bridge, 122.5 meters long and 16 meters wide, with a steel arch rib and a concrete post-tensioned deck.

The new design reduced the impact on causeway traffic by using an accelerated bridge construction method to assemble the arch off-site and move it into place during a short roadway closure window.

The flyover bridge is one of the largest bridges HNTB ever designed to be moved over land and put in place with SPMTs. The move was accomplished with four 12-axle SPMTs using a series of translational and rotational maneuvers. The bridge traversed a distance of about 250 meters from the off-site facility where it was built to the final service location.

The total execution time for the move was about 25 hours from the time the SPMT wheels started to roll to the time the bridge was lowered and set in the final service location on the abutments. The total causeway closure time was 10 hours—from 11 p.m. to 9 a.m.

It could be built off-site and moved into place because it was a single-span structure. What was originally proposed was a multi-span bridge. Moving all those spans would have required a lot of causeway closures. The new design was for a longer bridge that could be picked up and put in place.

The new design also included retaining walls to reduce the sweep of the original bridge layout and stay within the footprint of the base.

Enhanced safety is another feature that is augmented by the new design. "Because the bridge was constructed away from the highway, it eliminated all of the potential safety hazards associated with working around all the heavy traffic on that highway," Allen said.

The minimum vertical clearance on and under the bridge meets and exceeds the 5.8 meters mandated by Bahrain, thus allowing for future expansion of the causeway. The vertical clearance also allows for maintenance

Fact Finder

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and repair or expansion of utilities that are located in the right-of-way.

The main support system of the bridge—the arch rib and post-tensioned concrete tie girder—are spaced at 10.6 meters center to center. Cantilever sidewalks are present on both sides of the bridge for an overall width of 16 meters. Pedestrians will be protected from traffic by a 0.815-meter-high concrete traffic barrier. A pedestrian railing on the fascia will provide a visual security screen from the causeway traffic below.

And the design for a graceful arch bridge was an improvement from an aesthetic standpoint.

Besides the importance of satisfiying the concerns of the host nation, designing an overseas bridge also posed other challenges for HNTB, whose bridge practice has primarily focused on work in the U.S. Indeed, P-954 is one of the first overseas bridges HNTB has designed in quite a number of years.

Designing a bridge in a country where HNTB was not familiar with the materials that were going to be used required the company to do more research upfront to determine what material strengths were available in the Gulf region.

Effective communication with Bahraini officials was crucial to the project's success. "The [U.S.] government was very interested in working with their host-nation partner in making sure that their concerns were addressed," Brown said. "We gave a separate presentation to the Ministry of Works on constructability of these arch-type structures and the benefits they would provide. We also created 3-D renderings of the proposed arch solution so they could visualize what that new structure would look like as well as fully understanding how it would be built."

Allen said HNTB's experience with complex signature bridges that are designed to be moved into place by SPMTs "was the real benefit that HNTB brought to the table. Having experience with both of those elements and combining them in this project solved our problem of minimizing disruption of traffic on the highway."

A new outlook

HNTB's work on the Bahrain bridge project represents the latest example of its involvement in accelerated bridge delivery methods and other innovative design solutions.

Clients are increasingly looking toward accelerated methods to deliver mobility-critical bridges. In the past five years, the industry has seen a proliferation of design-build, construction-manager/general-contractor, construction-manager-at-risk and public-private-partnerships projects.

Aligning business models with these new delivery methods requires the utilization of best practices. Among them are:

- Stressing value, not lowest price. A better design or construction solution may cost more initially, but it also may be the best value over the facility's service life. Therefore, owners are beginning to evaluate delivery teams on a holistic basis rather than on a lowest "bid day" price basis. Lowest price does not always equal best price. Because a low-cost project could take longer to build or become an expensive asset to maintain and operate, owners are factoring in user and life-cycle costs to ensure they are spending taxpayers' money wisely today and tomorrow; and
- Considering creative design and construction methods. In the past few years, clients have considered advances in bridge design and construction that are helping owners do more in less time and reduce overall project costs.

The industry also is pioneering new design methods that take advantage of refined analysis and production techniques and composite features incorporating materials where they are best suited, as well as elimination of superstructure joints and bearings to save construction time and reduce maintenance costs.

Meantime, with the P-954 Flyover Bridge scheduled to open late in August, Allen said the Army Corps is likely to consider a similar design solution in the future. "We've actually done it, and it's proven." R&B

McCombs is a senior project engineer/senior squad leader with HNTB Corp.

For more information about this topic, check out the Bridges Channel at www.roadsbridges.com.

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