Tailor-made Work Approach Saved Texas Department of Transportation Money

and Ramped Up Construction Schedule on Marble Falls Bridge Replacement

By The Finley Engineering Group Inc.

With a little creativity, teamwork, and technical know-how, a contractor and its segmental bridge construction engineer were able to develop an alternate approach to the Marble Falls Bridge replacement project that won the contract and ultimately saved construction costs and time.

Started in December 2010, the $28.65 million demolition and new bridge replacement project is already ahead of its expected four-year construction schedule. The first of two new segmental bridges carrying US 281 over the Colorado River in Marble Falls, Texas, just outside of Austin, Texas, opened to traffic in December 2012. The twin Marble Falls bridges will carry two lanes each in opposite directions to replace a functionally obsolete steel truss bridge that was built in 1936. Designed by Texas Department of Transportation (TxDOT), the crossings will include six-foot-wide sidewalks for pedestrians and will be featured at nighttime with a fully lighted substructure and surface lighting, creating a beautiful backdrop to downtown Marble Falls residents and visitors.

US 281 is a major north-south highway from Wichita Falls to San Antonio and serves as an important evacuation route and emergency services access for the area. Designed by TxDOT's Bridge Division, the 958' long, straight bridge on a vertical grade of 1.286 percent consists of a three-span (274'-410'-274'), variable depth, cast-in-place segmental superstructure with a 47-foot-wide deck.

There were several factors leading to selecting a segmental design: 1) the nearest river crossing detour option being located more than 30 miles north, 2) a very limited site in terms of adjacent operating businesses and utilities restricting an alignment change, 3) active recreational lake traffic in the area that is reliant on tourists, and 4) high local regard for the look of the old truss bridge.

Project Information

There are 24 concrete segments per cantilever, with 48 segments total per bridge. Each segment measures 14' to 16' long and 47' wide. The variable segments sport a unique tapered boat hull design in the bottom slab, an aesthetic treatment that matches the community's focus on recreational boat racing. The segments have a box depth that ranges from 23' at the interior piers to 9'5" at the end spans, with a variable superelevation up to 5.5 percent. Each segment weighs a maximum of 150 tons.

It will be the second longest main span for a segmental bridge in Texas, and the only segmental bridge with no approach spans. Each crossing will carry two 12-foot travel lanes and a ten-foot shoulder.

The bridge crossing had to remain continuously open, requiring that construction be phased. Phase 1 involved building the northbound structure. Phase 2 shifts the two northbound traffic lanes to finish roadway work, and Phase 3 shifts the two southbound traffic lanes to construct the southbound structure. With the completion of Phase 3, southbound lanes are moved back to the southbound structure for the final lane configuration.

Creative Approach

Upon reviewing the bid from the contractor, TXDOT considered its proposed means and methods that aligned in a more efficient way for that particular contractor's crews and equipment to do the job. This solution offered TXDOT a nearly $2 million cost savings under the construction estimate.

"We knew we were very well equipped and capable for this project," said Eric Hiemke, project manager with Archer-Western Contractors, "but the means and methods outlined in the RFP made it time intensive and cost prohibitive for our team. We had ideas on other ways to get the job done, but needed a bridge design expert to confirm our thinking and prove that the ideas were safe, sound, and effective."

Working together, the engineer-contractor team reviewed the design, discussed various ideas, conducted additional research, and performed numerous calculations. The final alternative design and the means/methods not only built on the contractor's strengths, but it also shortened the construction schedule and reduced the amount of falsework and number of props required to get the job done. The initial concept of the alternate approach was presented to TxDOT in December 2010 and the final design approved just two months later.

"TxDOT includes in our segmental bridge specification three options for construction alternates that the contractor can propose for our consideration. The allowable alternates are post-tensioning layouts, segment lengths, and erection methods. So when Archer Western and FINLEY approached us with their proposed changes, we were happy to work with them to make it happen," said Amy Smith, P.E., Design Engineer with the TxDOT Bridge Division.

The major changes were to revise the pier table design, segment layout, and post-tensioning specifications. While the original design called for an even, balanced pier table (extending 30' to each side from centerline of column), the new design called for an unbalanced design (22' x 14' from centerline of column). The innovative approach required less length of pier tables, and, therefore, less falsework. The revised segment layout allowed for only two temporary supports (sta-


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bility props) during construction, as opposed to the four required with a balanced pier table. This shaved approximately 12 weeks off the construction schedule.

Temporary shoring for the prop involved two 30-inch diameter pipes founded on 20’ deep, 36-inch diameter drilled shafts designed to stop at the mud line. Tie backs to the column were set approximately six feet above the water line. An added benefit is that the prop was incorporated into the pier table falsework.

The transverse and longitudinal post tensioning was also modified. The RFP called for three strand transverse tendons at 2’-1” spacing. The alternate design utilized four strand tendons at 2’9-1/2” spacing. This modification saved on duct, heads, grout, caps and more. The original longitudinal post tensioning specified 15 strand tendons, while the alternate design outlined a combination of 19 strand and 12 strand per tendon. This modification allowed for smaller stressing anchors in some areas.

While reducing the length of each segment required more segments, the process of pouring each segment in the air using the form travelers was optimized and required less labor-intensive falsework to be built. The original design called for a 16’ typical segment, 16’ closure pours, 60’ pier table, and 77’4” end segment section. The alternate design specified a 14’ starter segment, 16’ typical segment, 10’ closure pours, 36’ pier table, and 55’ cast-in-place on falsework end-span segment. The concrete stressing strength/mix design was 4,000 f’c at 24 hours.

Another important piece to the alternate design was the knowledge that two form travelers that met the specifications of the Marble Falls Bridge project were becoming available from another job site just at the time the team would need it for their project. Typically, a form traveler of this type would have cost approximately $750,000 each and added several months to the schedule to design and fabricate.

The use of a precast footing box form system was an additional innovative method employed on this project. A large amount of rock at the bottom of the lake, close proximity to the existing bridge, and the need to maintain an open water channel for recreational/tourist boating traffic precluded the use of typical cofferdams to dewater the area in preparation to build forms and pour footings. Instead the alternate design called for drilling shafts into the rock riverbed and lowering an on-site precast concrete footing form to accommodate the forms and the work platform.

Aesthetics, Drawings and Controls

For this project, the TxDOT wanted a minimal column and footing footprint in the water to minimize boat collisions and to deter vandals from climbing on the piers for access. A flared column design with a seamless transition between the pier and pier table was chosen. The flared columns required a custom built form poured in two pieces, with six feet of column base three feet under the normal water level. The bathtub dewatering design allowed the entire column pour in dry conditions and included the ability for a two-pour column (column base and column). The vertical steel had a tendency to straighten during the pouring of the concrete because of the flared design, so the concrete mix had to be altered to allow for a slower pour rate to maintain stability of the steel. In addition, permission was given to the contractor to splice the column steel to minimize the cantilever length at the column base for easier installation.

Bridge Information Modeling (BrIM) made it possible to develop details quickly to meet the demanding schedule, including integrated segment drawings combining reinforcing bars, bolt inserts (for utilities), electrical conduits, etc., all into one drawing. A time-dependent, staged analysis of the structure was conducted to monitor stresses and anticipated deflections during construction so that adjustments could be made in the field if necessary.

The structures are being built using balanced cantilever construction to cross the river, with end segments constructed on falsework.

A detailed construction manual, which included the sequence of activities and detailed descriptions, was provided to the contractor. The geometry control manual gave an introduction to the construction method, guidance on typical methods based on experience with similar type bridges, and an overview about camber theory. The complementary geometry control software allowed the contractor to record actual camber measurements during construction so that modifications could be made immediately if needed. Stringent control of geometry and successive correction of minor casting deviations was required to ensure that the geometry of the bridge is maintained as each segment is added. The construction engineer and contractor's surveyor coordinated almost daily to ensure the geometry of the bridge was behaving as predicted in the analysis and to make minor adjustments when necessary.

Almost any construction project can benefit from looking at ways to improve the means and methods to match the strengths of the contractor and the materials and equipment that are readily available. Sometimes, as with the Marble Falls Bridge project, additional design, cost, and schedule efficiencies can be uncovered.

"In any new project, including this signature bridge for Marble Falls, TxDOT looks to balance design, function, operations, maintenance and most importantly, safety while still providing the same product or better," said Howard Lyons, TxDOT Area Bridge Engineer. "The public was very sensitive to the aesthetics of this bridge, since the lake is also used for recreation. Archer-Western Contractors put together a great team, and the alternative concepts developed by Archer-Western and FINLEY helped to meet the expectations of TxDOT and the public." ❖