PROJECT

U.S. 281 BRIDGE over the Colorado River

Tailor-made work approach saves time, money at Marble Falls crossing

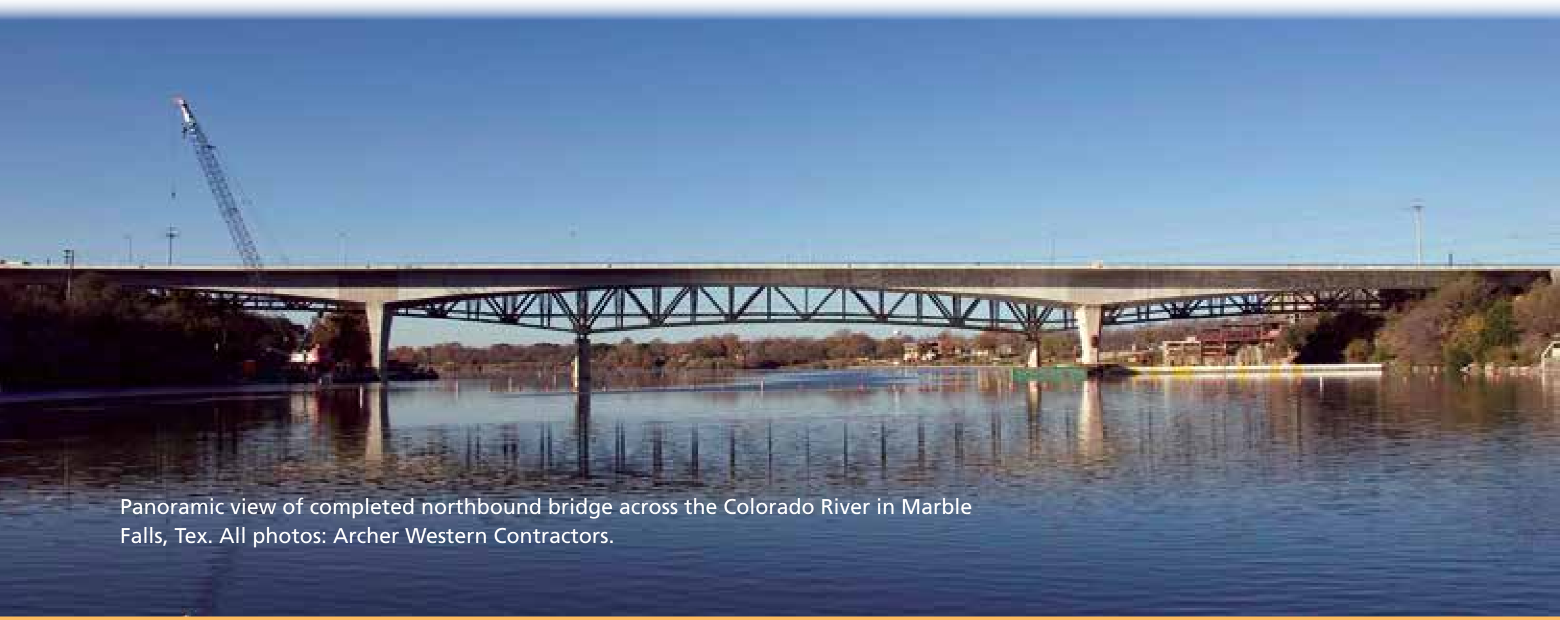
by Robert Alonso, FINLEY Engineering Group

With a little creativity, teamwork, and technical know-how, a contractor and their construction engineer were able to develop an alternative 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 bridge replacement project is already ahead of its expected four-year construction schedule. The first of two new segmental bridges carrying U.S. 281 over the Colorado River in Marble Falls, Tex., opened to traffic in December 2012. The twin bridges will carry two lanes each to replace a functionally obsolete steel truss bridge that was built in 1936. Designed by the Texas Department of Transportation's (TxDOT's) bridge division, the crossings include 6-ft-wide sidewalks and a fully lighted substructure and surface lighting, creating a beautiful backdrop to downtown Marble Falls.

U.S. 281 is a major north-south highway from the Canadian border to the Mexico border, and serves as an important evacuation route for the area. The 958-ft-long, straight bridge, on a vertical grade of 1.3%, consists of two parallel, three-span, variable-depth, single cell, cast-in-place, concrete segmental box girder superstructures with span lengths of 274, 410, and 274 ft.

There were several factors leading to the selection of a segmental design:



Panoramic view of completed northbound bridge across the Colorado River in Marble Falls, Tex. All photos: Archer Western Contractors.

profile

U.S. 281 BRIDGE OVER THE COLORADO RIVER / MARBLE FALLS, TEX.

BRIDGE DESIGN ENGINEER: Texas Department of Transportation, Austin, Tex.

ALTERNATE SUPERSTRUCTURE DESIGN AND CONSTRUCTION ENGINEER: FINLEY Engineering Group Inc., Tallahassee, Fla.

CONSTRUCTION ENGINEERING INSPECTION: Texas Department of Transportation, Austin, Tex.

PRIME CONTRACTOR: Archer Western Contractors, Atlanta, Ga.

CONCRETE SUPPLIER: Ingram Readimix Inc., New Braunfels, Tex.

POST-TENSIONING CONTRACTOR, FORM TRAVELER, AND POST-TENSIONING MATERIALS SUPPLIER: VSL, Fort Worth, Tex.

- The nearest river crossing detour is located more than 30 miles north.
- Limited right-of-way restricted an alignment change.
- Active recreational lake traffic in the area relies on tourists.
- Local residents have high regard for the look of the old truss bridge.

Bridge Information

There are 24 concrete segments cantilevering from each pier making a total of 48 segments per structure. The variable-depth segments have a unique tapered boat hull design in the bottom slab, which is an aesthetic treatment that matches the community's focus on recreational boat racing.

The segmental boxes have a depth that ranges from 23 ft at the interior piers to 9 ft 5 in. at the end spans, with a variable superelevation up to 5.5%. The bridge deck has a width of 47 ft, the thickness of the webs is 1 ft 6 in., and the bottom slab varies in thickness from 1 ft 10 in. to 4 ft 10 in.

Creative Approach

The contractor offered TxDOT a nearly $2 million cost savings under the construction estimate by proposing means and methods that aligned more efficiently with the contractor's crews and equipment.

"We knew we were very well-equipped and capable for this project," says Eric Hiemke, project manager with Archer Western Contractors, "but the means and methods outlined in the request for proposal (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 construction expert to confirm our thinking and prove that the ideas were safe, sound, and effective."

Working together, the engineer-contractor team developed an alternative design and the means and methods that not only built on the contractor's strengths, but also shortened the construction schedule and reduced the amount of falsework and number of temporary supports. The initial concept of the alternative approach was presented to TxDOT in December 2010 and the final design approved just two months later.

Working together, the engineer-contractor team developed an alternative design and the means and methods that not only built on the contractor's strengths, but also shortened the construction schedule and reduced the amount of falsework and number of temporary supports.

"TxDOT includes three options in our segmental bridge specification 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 the contractor and their consultant approached us with their proposed changes, we were happy to work with them to make it happen," said Amy Smith, design engineer with the TxDOT bridge division.

Pier table constructed on falsework.

Partial cantilever with temporary stability support to the left of the pier.

The major changes were to revise the pier table design, segment layout, and post-tensioning specifications. While the original design called for a balanced pier table, the new design called for an unbalanced design. The innovative approach required shorter pier tables, and, therefore, less falsework. The revised segment layout allowed for only two temporary supports during construction, as opposed to the four required with balanced pier tables. This reduced the construction schedule by approximately 12 weeks.

The transverse and longitudinal post-tensioning were also modified. The

TEXAS DEPARTMENT OF TRANSPORTATION, OWNER

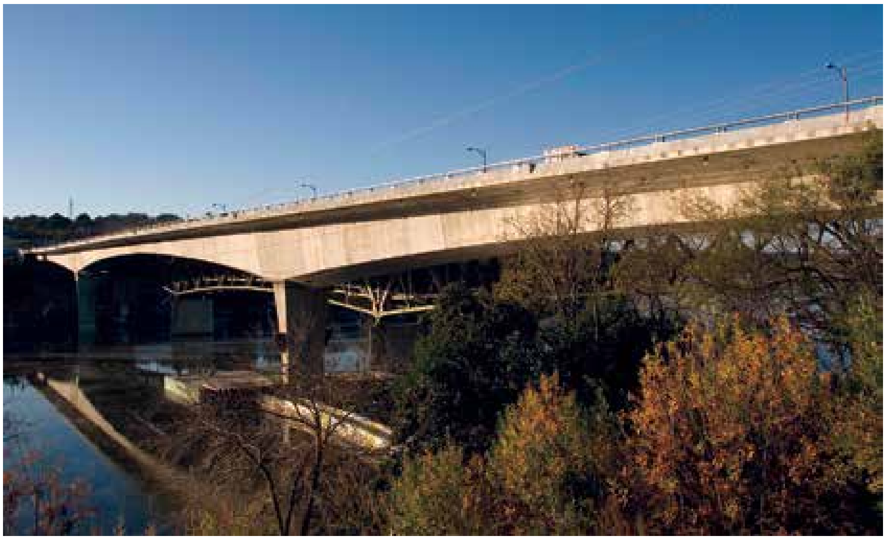
ROADWAY AND HYDRAULIC DESIGN: Jacobs Engineering Group Inc., Pasadena, Calif.

OTHER MATERIAL SUPPLIERS: Formwork–DOKA USA, Little Ferry, N.J.; Bearings–Dynamic Rubber, Athens, Tex.; Expansion Joints–CMC Capital City Steel, Buda, Tex.; Drilling–W.W. Foundation Drilling, Houston, Tex.; and Prepackaged grout–BASF, Houston, Tex.

BRIDGE DESCRIPTION: A 958-ft-long, straight bridge on a vertical grade of 1.3%, consisting of a three-span (274, 410, and 274 ft), single-cell, variable-depth, cast-in-place, concrete segmental box girder superstructure with a 47-ft-wide deck

STRUCTURAL COMPONENTS: 48 variable-depth, cast-in-place concrete segments; two concrete piers with flared columns and footings; and precast concrete footing box-forms

BRIDGE CONSTRUCTION COST: $28.65 million



Completed northbound bridge.

RFP called for three-strand transverse tendons at 2 ft 1 in. spacing. The alternative design utilized four-strand tendons at 2 ft 9½ in. spacing. This modification reduced the number of ducts, heads, grouting operations, and caps. The original longitudinal post-tensioning specified fifteen 0.6-in.-diameter strand tendons, while the alternative design outlined a combination of nineteen and twelve 0.6-in.-diameter strand tendons.

Although reducing the length of each segment required more segments, the use of the form travelers required less labor-intensive falsework. The original design called for 16-ft-long typical segments, 16-ft-long closures, 60-ft-long pier tables, and 77-ft 4-in.-long end segments. The alternative design used 14-ft-long starter segments, 16-ft-long typical segments, 10-ft-long closures, 36-ft-long pier tables, and 55-ft-long cast-in-place concrete on falsework end-span segments. The specified concrete compressive strength was 4 ksi at 24 hours. The design strength for the superstructure was 6 ksi.

Knowing that two form travelers were becoming available from another job-site just at the time the team would need them for the project saved on costs and schedule. Fabricating form travelers would have cost approximately $750,000 each and added several months to the schedule.

Aesthetics, Drawings, and Controls

For this project, the TxDOT wanted a minimal footprint in the water to alleviate boat collisions and to deter vandals from climbing on the piers. A flared column design with a seamless transition between the pier and pier table was chosen. A traditional footing was not used. The column base, which provided the connection between the drilled shafts and column, was 6-ft-deep, with the initial 3 ft below the normal water level. A precast concrete lost-form design allowed concrete for the entire column to be placed in dry conditions.

A time-dependent, staged analysis of the structure was conducted to calculate stresses and anticipated deflections during construction so that adjustments could be made in the field if necessary.

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.

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 have been required to ensure that the geometry of the bridge was maintained as each segment was added. The construction engineer and contractor's surveyor coordinated almost daily to ensure the geometry of the bridge was matching that predicted in the analysis and to make minor adjustments as 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, additional design, cost, and schedule efficiencies can be uncovered.

'TxDOT looks to balance design, function, operations, maintenance, and most importantly, safety, while still providing the same product or better.'

"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 engineer. "The public was very sensitive to the aesthetics of this bridge, since the lake is also used for recreation. The contractor put together a great team and the alternative concepts developed by the contractor and their engineering consultant helped to meet the expectations of TxDOT and the public."

Robert Alonso is senior bridge engineer and Orlando office manager for FINLEY Engineering Group, and project manager for the alternative segment design and construction engineering.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.