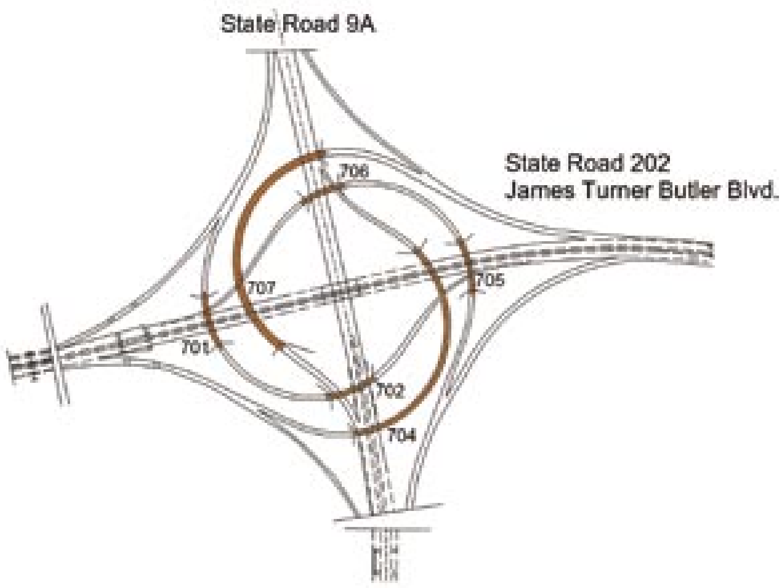
Steel Design Saves Big

BY JESUS MUSTAFA, P.E. AND JIM TALBOT



A steel design saved the Florida Department of Transportation 10 percent—nearly $8 million—in the final bids for a six-bridge interchange now under construction in Jacksonville, Fla.

PRIOR TO BIDDING, THE FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT) DEVELOPED DUAL DESIGNS FOR A HIGHLY CONGESTED INTERCHANGE IN JACKSONVILLE, FLA. TO INCREASE COMPETITION. (FDOT now has an official policy to create dual designs for projects costing more than $25 million.) Designs for the superstructure evolved through different schemes before the final steel design was selected for its economic advantage.

Bidding

FDOT performed concept studies for the interchange in 1999. The designers originally assumed that the six bridges would have a steel or concrete segmental box superstructure. FDOT asked the concept designers to look into a double composite steel box with concrete segmental box design after the first bridge development report. The inside deck would exist only for strength, and not for vehicles, in the double composite option. This steel concept proved to be an innovative, inexpensive design. However, FDOT thought it was too developmental for curved structures of this nature and chose the more conservative alternate—the concrete segmental design.

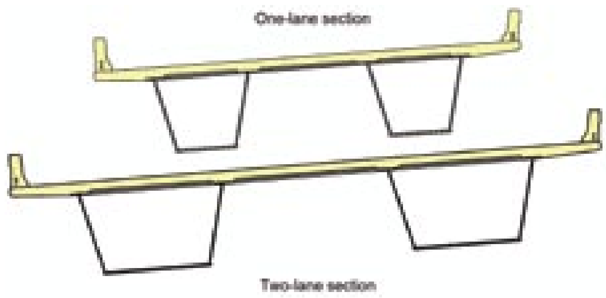
By the time the concrete segmental alternate plans were ready to bid in 2003, the engineers' estimate had grown considerably. Changes in means and methods of construction and Florida inspection requirements resulted in cost increases. FDOT was also concerned with the prospect of severe traffic disruption.

FDOT requested a conventional steel box alternate design to improve bidding competition. The alternate steel design was completed in 10 months. When FDOT bid the project in May 2004, the segmental concrete alternate came in at $74 million, beating the steel alternate by a few million. However, the traffic plan maintenance had to be redesigned. FDOT had to re-bid the project in May 2005.

This time around, the engineers' estimate for the segmental concrete alternate was $88 million. As a result, each contractor submitted a bid for only the conventional steel box alternate. Increasing costs ruled out the concrete segmental alternate primarily because of the complexities of the interchange's tight radius. Each of the interchange's six bridges was designed to follow a 775'-radius curve. The tight curvature, using 10' concrete segments, would have required more and heavier support piers.

The low bid for the steel alternate was approximately $80 million—only 4% higher than the previous steel bid—despite steel prices that had escalated since the previous two years.

Compared to the concrete segmental design, the new steel box design generally reduced the number of support columns, often by a third. Steel, being lighter, also significantly reduced the size of the



Bridge superstructures consist of double trapezoidal box girders. Following NSBA recommendations, all top and bottom flanges of a box girder will have a common width. Increased flange thickness, rather than width, will accommodate the need for greater support.

pier footings, and designers could position piers in more desirable locations. Finally, commercial development had occurred around the interchange site since the original bidding took place and would have made establishment of a large casting yard for concrete segmental construction extremely difficult.

Bridge Design and Construction

Construction began July 2005 for the three-level, semi-directional interchange, located at the intersection of St. Johns Bluff Road (State Road (SR) 9A) and James Turner Butler Boulevard (SR 202). The first steel is scheduled for delivery in November 2006.

The superstructures of the interchange's six circular bridges consist of double trapezoidal boxes. Grade 50 steel will be protected by a three-coat paint system, and each bridge will have a closed drainage system. The bridges over SR 9A will be able to accommodate future widening by one lane.

The superstructures will rest on single concrete columns that flare at the cap. A single pot bearing will sit under each steel box (sometimes called tub girders). Conventionally, steel boxes have one bearing under each web, doubling the number required. In this case, the designers centered the bearing in the box bottom flange to simplify construction. One point of contact per box will ease the work of dealing with geometric rotation caused by both superelevation and curvature. A single bearing per box also facilitates future jacking for maintenance. Contractors can put jacks on either side of the bearing and lift the whole box.

Following recommendations by the National Steel Bridge Alliance (NSBA), all top and bottom flanges of a box girder will have a common width. Increased flange thickness, rather than width, will accommodate the need for greater support. This concept somewhat complicated the designers' work but will greatly simplify steel box fabrication.

Five of the six bridges will have one lane while a sixth will have two lanes. Flanges of a single width can be sliced from large steel plates welded together lengthwise. The five one-lane bridges have 21" top flange widths, and the two-lane bridge has top flange widths of 23", both at the field sections and at the pier. Positive moment areas have 16" flanges.

Two smaller bridges over SR 202—bridges 701 and 705—will have piers centered in the roadway. The designers specified a temporary wall to facilitate construction for these bridges while minimizing disruption to traffic. The technique is similar to a cofferdam. With the wall in place, the contractor will be able to come in with a crane, build the foundation, and get out.

Middle piers for the two smaller bridges over SR 9A—bridges 702 and 706—will be between the roadway and the ramps, so the temporary walls will not be necessary.

The larger one-lane bridge, 704, will have eight-spans and an overall length of 1,714'- 8". This bridge will be divided into three continuous units, with strip steel expansion joints between the units.

The typical section for all five of the one-lane bridges will have web thicknesses of ¾". The widths across the top and bottom flanges of the trapezoidal boxes are 8' and 5', respectively. The web will have a vertical depth of 6'.

About 10' will separate the two steel boxes. The deck will overhang the steel boxes by about 5' on each side. These dimensions bring the total width across the deck to about 36'. The bottom flanges of the steel boxes range in thickness from ¾" to 1-7/8" and will be field-spliced with bolts at the seams.

Bridge 707 will be longer and wider than the others. Having two lanes, its deck width will be about 49'. The typical two-lane superstructure will also consist of double trapezoidal steel boxes but with larger dimensions than the other bridges. In this case, the trapezoidal boxes measure 12' across the top. The bottom flange width will be 9'. The webs will have a vertical depth of 6.5', and about 13.8' will separate the steel boxes.

The steel boxes will have both internal and external cross frames (diaphragms). The V-shaped intermediate cross frames within the boxes will simplify the passage of inspectors. The curvature of the structure will require temporary external cross frames between the steel boxes during construction. Before casting the slab, the girder's two top flanges may experience large differential deflections, making fit-up extremely difficult. The temporary external cross frames will control differential flange displacement and rotation of individual tub girders prior to slab placement. Designers positioned these temporary K-shaped intermediate cross frames at the same points as the internal ones.

When completed, the new six-bridge interchange will allow SR 202 to connect Jacksonville's developing downtown to its beaches. SR 9A will eventually become part of Interstate 295, looping around the city as a beltway.

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