THE I-95/I-295 NORTH INTERCHANGE

by Victor Ryzhikov, Antonio Ledesma, and Bob Szatynski, Parsons Brinckerhoff

The bridge nearing completion. This view was taken looking southbound and shows the bridge crossing over the exit to eastbound I-295. Photo: Ray Stanyard Photographer.

Cost, constructability, and aesthetics determine overpass design

The Florida Department of Transportation (FDOT) has completed construction of the initial stage of a three-phased approach for replacing the I-95 and I-295 interchange located 1.5 miles south of the Jacksonville International Airport. The purpose of this project is to improve capacity and operations by replacing the existing partial cloverleaf interchange with an all-directional four-level, system-to-system, high-speed interchange. This initial stage included a new segmental concrete box girder flyover bridge that provides for the southbound I-95 to eastbound I-295 movement along with the widening of an existing beam bridge that supports eastbound I-295 over U.S. 17 and the CSX rail line.

Three types of superstructures were considered during the initial Bridge Development Report (BDR). However, only steel box girders and segmental concrete box girders were ultimately considered feasible after the preliminary analysis was completed. This constraint was primarily based on estimated construction costs and issues related to constructability. Another deciding factor was aesthetics.

The interchange functions as a main access route to the City of Jacksonville. It is the first major feature experienced by most tourists and visitors traveling into Jacksonville from the north, FDOT agreed with city officials that emphasis should be placed on the aesthetic elements of the bridge as the city's northern gateway.

Each alternative was compared for aesthetics, constructability, maintenance costs, and construction cost, with consideration of the present value based on life-cycle analysis. The most influential parameter was construction cost. Construction professionals in Florida generally assume concrete superstructures to be the most economical choice. However, this does not hold true in the case of segmental concrete unless there are peripheral factors such as constructability issues or redundancy in the casting of the segments.

Geometric Requirements

The span arrangement was similar for both superstructure alternatives and was primarily dictated by the existing features of the interchange. The bridge has a maximum span length of 274 ft and the vertical profile was set to satisfy the required minimum vertical clearance of 16 ft 6 in. The new Ramp SE bridge rises above I-95, existing ramps, and I-295 to become the third-level structure in the interchange. The bridge has a horizontal curvature of more than 90 degrees with a radius of 1250 ft.

profile

I-95/I-295 (SR R/SR 9A) NORTH ENTRANCE INTERCHANGE–RAMP SE / JACKSONVILLE, FLORIDA

BRIDGE DESIGN ENGINEER: Parsons Brinckerhoff, Tampa, Fla.

CONSTRUCTION ENGINEER: Corven Engineering Inc., Tallahassee, Fla.

CONSTRUCTION ENGINEERING & INSPECTION: RS&H CS, Jacksonville, Fla.

PRIME CONTRACTOR: Superior Construction Co., Jacksonville, Fla.

POST-TENSIONING CONTRACTOR: Dywidag Systems International-USA Inc., Bolingbrook, Ill.

CONCRETE SUPPLIER: Preferred Materials, Jacksonville, Fla.

PRECASTER, SQUARE PILES: Standard Concrete Products, Tampa, Fla., a PCI-certified producer

The estimated construction cost for the precast segmental alternative was approximately 5% lower than the steel alternative.

While the precast concrete segmental alternative is sometimes considered to be more complicated than the steel alternative, it can offer some significant advantages in other arenas. For example, concrete segments are heavier and the balanced cantilever construction requires a strong back system along with post-tensioning for erection. However, the advantage is that single-column piers can be used that will reduce the cost for materials. In this project, the steel alternative was determined to be more complex, involving hammerhead piers, one integral pier, and one integral pier cap. Even though hammerhead piers are becoming simpler to construct, the two integral components included in the system present a higher degree of difficulty since post-tensioning is required in the caps.

The increased emphasis on aesthetics heavily favored the segmental concrete alternative. Given that this extremely long flyover was going to be a third-level structure, its underside would be highly visible to drivers traveling on I-95 and I-295. With its closed box shape, clean lines, and smooth bottom soffit, the precast segmental concrete box girder was clearly the most aesthetically pleasing choice.

To further enhance the aesthetics of the bridge, octagonal columns were used and the capitals were flared transversely at the top, matching the slope of the webs of the box girder. The tapered shape of the capital provides an elegant transition between the box girder and the supporting column. The columns measured 9 ft transversely and 7 ft longitudinally at their base.

The estimated construction cost for the precast concrete segmental alternative was approximately 5% lower than the steel alternative; consequently, the segmental concrete box girder bridge became the preferred alternative.

Superstructure Design

The bridge is a 10-span continuous structure with a total length of 2256 ft. It is 49 ft 3 in. wide. The span lengths range from 117 ft to 274 ft. The bridge is composed of 234 precast concrete segments with a top flange width of 49 ft 3 in. The typical segment has a depth of 9 ft 6 in. Variable depth segments are used at the piers with the depth increasing to 12 ft 0 in. to accommodate the longer spans. The top slab is transversely post-tensioned.

The design concrete compressive strength is 6500 psi for the segments and cast-in-place concrete closures. The bridge used the balanced cantilever method of construction and was erected using ground-based cranes. The bridge was designed according to the 2004 *AASHTO LRFD Bridge Design Specifications* (3rd Ed.) and the July 2005 FDOT *Structures Manual*. CEB-FIP Model Code 1990 was used for the time-dependent behavior analysis.

The superstructure rests on pot bearings with the superstructure fixed against longitudinal movement at four of the nine interior piers. Hexagonal shaped columns were used to support the bridge while maximizing the strength of the pier. Because the bridge curves over portions

Balanced cantilever construction over the I-95 southbound exit to I-295. Photo: RS&H CS.

PRECAST CONCRETE SEGMENTAL BOX GIRDER FLYOVER RAMP ERECTED IN BALANCED CANTILEVER / FLORIDA DEPARTMENT OF TRANSPORTATION, DISTRICT 2, OWNER

FORMWORK SUPPLIER: EFCO, Orlando, Fla.

POT BEARING AND EXPANSION JOINT SUPPLIER: DS Brown Co., North Baltimore, Ohio

POST-TENSIONING GROUT SUPPLIER: Sika, Lyndhurst, N.J.

BRIDGE DESCRIPTION: 2256-ft-long, precast concrete segmental box girder bridge consisting of 10 spans with a maximum span of 274 ft constructed using the balanced cantilever method

BRIDGE CONSTRUCTION COST: $45 million

AWARDS: *2010 PCI Bridge Design Award, Honorable Mention for Best Bridge with Main Span more than 150 ft*

Below: Cantilevers are supported using temporary support frames to stabilize the structure and reduce the loads on the pier during segment erection. Photo: RS&H CS.

Above: Construction of the Pier 3 cantilever begins with placement of the pier table. Pier tables were constructed using split segments to reduce the lifting weight. The tapered lines of the column cap create an elegant shape with the slope of the segment webs. Photo: RS&H CS.

of I-95, limited horizontal clearance prohibited the use of larger column sizes. To get the most cross-sectional area from the available space, the hexagonal columns offered an ideal shape as the bridge crossed this critical location at a skew.

For the substructure, the use of 24-in. and 30-in.-square precast, prestressed concrete piles and 36-in.- and 42-in.-diameter drilled shafts was evaluated. The relative ease and availability of 30,000-lb hammers made the use of 30-in.-square piles more appealing. As is common in Florida, square precast, prestressed concrete piles were used, since they are economical, offer proven performance, and are made by several precast concrete producers in the state. A resistance factor of 0.65 was applied to the factored design loads before estimating the pile tip elevations.

Designing a cost-competitive precast concrete segmental bridge project with only 234 segments can be a difficult undertaking. By using a variable-depth box to minimize concrete, splitting the pier segments to reduce the maximum lifting weight, and using clean yet simple shapes for the bridge elements, a design solution was devised that enabled the project to be built in a cost-effective manner, while also providing a preferred aesthetic solution.

The construction contract was awarded in April 2007. Construction began in October of 2007 and was completed in September 2010.

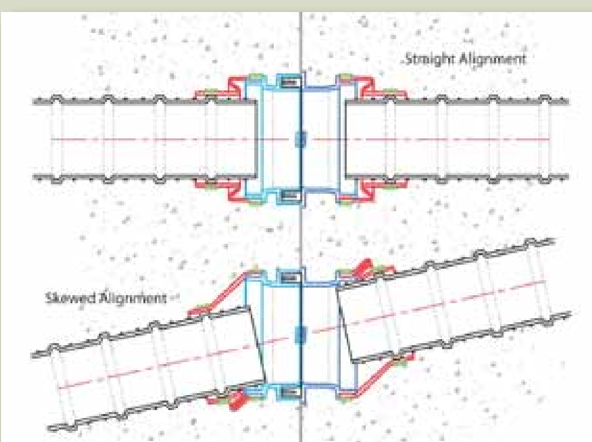
Victor Ryzhikov is senior supervising bridge engineer, Antonio Ledesma is lead bridge engineer, and Bob Szatynski is principal project manager, all with Parsons Brinckerhoff in Tampa, Fla.

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

Improved Tendon Protection Measures Lead to Increased Sustainability

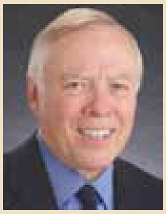
After finding corroded tendons in a few bridges in the state, the Florida Department of Transportation (FDOT) adopted stringent tendon protection requirements to increase the durability and sustainability of post-tensioned segmental concrete bridges.

The I-95/I-295 flyover bridge complies with FDOT's latest requirements for post-tensioning systems. One of the biggest changes to the industry was the introduction of the segment duct coupler used at the interface between precast segments for internal tendons. The segment duct coupler provides a fully protected connection between tendon ducts. This will increase the protection to the prestressing strands leading to an overall improvement in durability of the bridge and provide a longer-lasting structure for maximum sustainability. The GTI duct couplers are shown schematically and in use during segment match casting. Photo and drawing: Parsons Brinckerhoff.



The increased emphasis on aesthetics heavily favored the segmental concrete alternative.

The I-95/I-295 North Interchange flyover bridge in Jacksonville, Fla. Photo: Ray Stanyard Photographer.



AESTHETICS COMMENTARY

by Frederick Gottemoeller

This bridge seems simple, and it is. But the simplicity masks a series of sophisticated choices about proportions, shapes, and materials that make this bridge in fact extremely elegant. If one pays attention to the characteristics that we usually look right past, the elegance emerges.

Start with the geometry, the lines of the structure. All of the main lines of the structure—the edges of the parapet, the intersection of the overhang and the girder, the bottom edge of the girder—exactly follow the curve of the ramp itself. None are interrupted by a pier cap, expansion joint, or other competing line; none are broken into chords. The shadows cast by these elements divide the superstructure into parallel bands of strongly contrasting light and dark that reinforce the main lines of the structure and make it appear thinner. The overhangs are a large enough portion of the total width to make these bands significant. The end result is a bridge that itself reflects the curving, high-speed trajectories of the vehicles that use it.

The piers are thin at their bases so that landscape flows through the bridge without interruption. They widen at their tops just enough to provide room for the two bearings. The bearings hold the girder some distance above the top of the pier, so that you can see daylight between them from many angles. This demonstrates that the bridge is supported on just these two points, and makes it seem lighter than it is. It seems to float over the landscape. It is the like a waiter carrying a heavy tray. By balancing it on his fingertips, he makes the task seem effortless. Because the superstructure is lifted above the pier its lines run right past the pier, and are not interrupted by a pier cap or edge. As a final refinement, the girder depth increases just a bit over the piers, visually expressing the load concentration at that point.

Interchange bridges are mostly seen by people traveling at high speeds, who only have time to recognize the major lines and the largest shapes. This designer concentrated on getting these elements right. Time and money were not wasted on simulated finishes. Such finishes would be simply unrecognizable at highway speeds and the effort would therefore be wasted.

We don't all have the intensity of the Florida sun to play with, but in every area the sunlight has distinctive characteristics that can be used to enhance the appearance of a bridge. It is part of our job to figure how to take full advantage of that.