PROJECT

# LESS LEADS TO MORE

## Innovative design and construction methods result in full-project build-out

by Craig Finley Jr., Finley Engineering Group Inc.

For nearly 30 years, the Florida Department of Transportation (FDOT) has been working towards improving the 26-mile-long Palmetto Expressway in Miami-Dade County to safely accommodate significant, predicted traffic-volume increases. With combined-team ingenuity, engineering prowess, and alternative delivery methods, the largest and final portion of the massive undertaking, the Palmetto/Dolphin Expressway Interchange, is scheduled to be complete in the fall of 2015.

### Bridging the Gap

Section 5 of the 12-part, 20-year Palmetto Expressway reconstruction project, is a $558 million design-build-finance project that reconfigures a 16-mile stretch of expressway where SR 826 (Palmetto Expressway) and SR 836 (Dolphin Expressway) meet adjacent to the Miami International Airport. More than 430,000 motorists use the interchange daily, making maintenance of traffic one of FDOT's primary concerns.

### A Tall Order with Low Clearance

The project includes the full reconstruction and modification of two existing interchanges, adds one travel lane in each direction, widens and/or replaces bridges, increases shoulder widths, reconfigures entrance and exit ramps at all interchanges, and improves drainage, signalization, lighting, and signage. The design-build team introduced a redesign that included FDOT's desire to reintroduce three expressway access points, which would have been lost with the original design plan.

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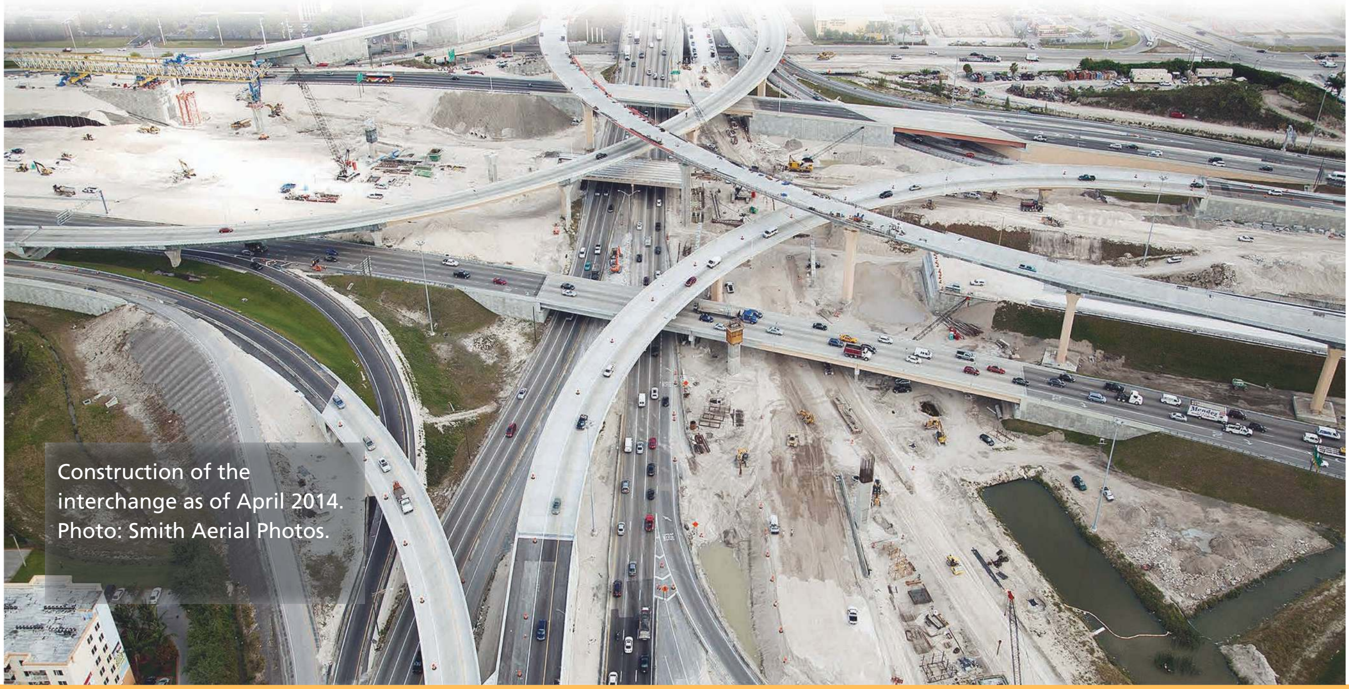
"Using non-traditional shaped piers, adjusting the footing size to accommodate conditions, and increasing span lengths all helped improve maintenance of traffic sequencing, which was critical to accelerating the project schedule," said



Construction of the interchange as of April 2014. Photo: Smith Aerial Photos.

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**PALMETTO/DOLPHIN EXPRESSWAY INTERCHANGE** / MIAMI-DADE COUNTY, FLORIDA

**PRIME DESIGN CONSULTANT:** BCC Engineering Inc., Miami, Fla.

**SEGMENTAL BRIDGE DESIGN AND CONSTRUCTION ENGINEER:** Finley Engineering Group Inc., Tallahassee, Fla.

**CONSTRUCTION ENGINEER AND INSPECTION SERVICES:** AIM Engineering and Survey Inc., Lehigh Acres, Fla.

**PRIME CONTRACTOR:** Community Asphalt Corporation, Condotte America Inc., and The de Moya Group Inc., joint-venture LLP, Miami, Fla.


This is a major route to Miami International Airport with more than 430,000 motorists using the interchange daily. Photo: Finley Engineering Group Inc.

Jose Munoz, president, BCC Engineering Inc. "Advance planning, which allowed the foundations for the last segmental bridge to be built much earlier in the schedule, was another critical aspect."

## Adding Up the Pieces

The project includes four precast concrete segmental bridge ramps. The last of these is currently under construction. All four bridges, with a total of 783 segments, traverse the core of the interchange and comprise 25% of the overall project effort. The bridge decks are 46 ft wide, box depths vary from 9 to 12 ft, and total bridge lengths range from 1100 to 2450 ft. The specified concrete compressive strength for the segmental box girder superstructure is 6.5 ksi, with the substructure at 5.5 ksi. The total deck area is 360,718 ft$^2$, with 7764 linear ft of bridge.

The top slab thickness varies from 9½ to 19 in. and is transversely post-tensioned. The longest span is 266 ft, with the tallest pier measuring 81 ft. The prestressing steel is 7-wire 0.6-in.-diameter, low-relaxation, grade 270 strand. The post-tensioning stressing force was 77 to 80% of the guaranteed ultimate tensile strength. All continuity tendons are external and use diabolos to deviate the tendons.

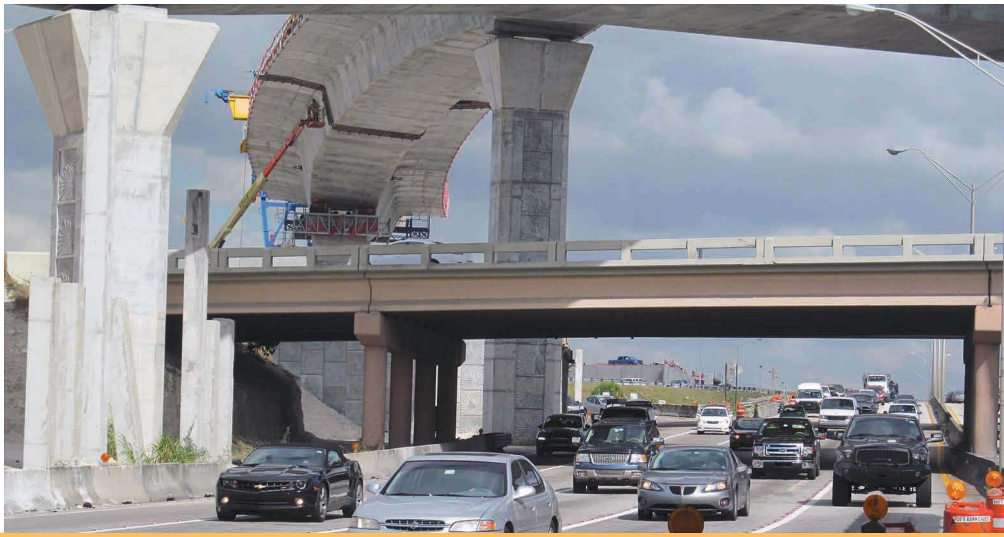
The segmental bridge ramps are the third level of the interchange with horizontal curve radii down to 590 ft and a maximum superstructure deck height of 95 ft above ground. All the bridges are supported on 24-in.-square prestressed concrete pile foundations—designed for 250 tons compression and 25 tons tension—and reinforced concrete piers and caps.

## Bi-directional Innovations

To meet the challenges, design and construction innovations were employed both from the bottom up and the top-down.

At the base, the geometric shapes of the footings for the segmental bridges vary to accommodate the limited space and the prestressed concrete piles. In addition to the challenging geometric shapes, the orientation of each footing is specified for that particular pier. All footings are designed to accommodate hurricane-level windforces, overturning movements from the launching gantry, and out-of-balance cantilever conditions. To minimize future traffic disruptions, foundations for bridges typically slated for construction later in the project were installed earlier in the schedule.

Most notable and significant among the design solutions, however, was the top-down construction approach to accommodate the incredibly tight site geometry. The project is adjacent to a major runway and a large residential building, a canal runs through the middle of the site, and the new elevated interchange, which is in the airport glide path, had to comply with strict Federal Aviation Administration height limits for both permanent and temporary structures.



Top-down construction was used to accommodate the small site and minimize traffic interruptions. Photo: Finley Engineering Group Inc.

FLORIDA DEPARTMENT OF TRANSPORTATION AND MIAMI-DADE EXPRESSWAY AUTHORITY, OWNERS

**POST-TENSIONING CONTRACTOR:** VSL, Hanover, Md.

**OTHER MATERIAL SUPPLIERS:** Overhead gantry and casting machines, DEAL, Bay Harbor, Fla.; Bearings and expansion joints supplier, The D.S. Brown Company, North Baltimore, Ohio; and Casting and erecting segments, Rizzani De Eccher, Bay Harbor, Fla.

**PROJECT DESCRIPTION:** Four horizontally curved, precast, segmental, post-tensioned concrete bridge ramps with a total length of 7764 ft

**STRUCTURAL COMPONENTS:** 783 precast concrete segments; cast-in-place reinforced concrete pier caps, piers, and pile caps; and 24-in.-square prestressed concrete pile foundations

The 460-ft-long, 475-ton gantry used on the Palmetto Interchange. Photo: Condotte.

The segment casting yard was located approximately 16 miles away and had two casting cells, which enabled the fabrication of an average of eight segments a week for a total of 783 segments. Photo: Rizzani De Eccher.

Balanced cantilever construction uses a 460-ft-long, 475-ton, self-launching overhead gantry. The self-launching overhead gantry was designed to build the bridges outward from the piers. As a result, temporary ground supports were eliminated and segments were stabilized off the pier caps. The use of variable-depth segments from 9 to 12 ft deep and weighing 62 to 86 tons helped to satisfy the vertical clearance limitations, improved maintenance of traffic sequencing, and made the project more economical by reducing the weight of the segments and the amount of material.

The pier caps, designed to support the balanced cantilever during construction, include loop tendons through the caps to tie down the launching gantry and curved balanced cantilever superstructure. Jacques Combault, technical director, at Finley Engineering Group, explained, "In addition to their vital functional role in the construction process, the pier caps contribute to the overall aesthetics, an important factor considering the prominent location of the interchange."

## Alternative Concepts

Three of four alternative technical concepts accepted for the segmental bridges were

- the use of external tendons and diabolos,
- haunched segments, and
- polystyrene core forms on piers.

FDOT allowed the use of diabolos for the first time for the segmental bridges based on the advanced design and demonstration of their successful application on segmental bridges in other states. This eliminated the use of traditional bent steel pipes, the segment weight was reduced, and it allowed for variable tendon geometry and continuous external tendon ducts. The external tendons provide the extra benefit of reduced maintenance costs through improved future access for tendon replacement, as well as upgrading and stressing of any single strand inside the box.

Haunching the segments allowed for an increase in span lengths, reduction in the amount of temporary supports adjacent to the highway, and an overall simplification of the interchange, which resulted in fewer segmental bridges and elimination of expansion joints. This also increased the efficiency of post-tensioning and provided the capacity to support the launching gantry.

Employing polystyrene in the hollow pier columns cores (except for solid bases and caps) eradicated the need for interior formwork, thereby reducing the amount of concrete material and overall mass of the structure.

## Less Can Be More

"This is a very complex project because of the sheer volume of work—45 bridges on five different levels all over very large traffic volumes," commented Vorce. "The project is 75% complete, and we're on budget and on schedule."

In the end, the key to this project's success was that everyone worked together as a team," said Raul Vega, CEI projector coordinator, AIM Engineering and Survey. "For example, designers and reviewers worked side-by-side during shop drawing reviews. Comments were addressed right away so we were able to complete this process in 21 days, 7 days ahead of schedule."

Budget constraints, maintenance of traffic, and site conditions were in the forefront throughout the project. To move this large transportation project forward, FDOT had the foresight to expand their options in terms of both delivery methods and technical concepts. Working as a team, the owner, designers, and contractors developed and employed creative "less is more" solutions that brought about greater results within a given amount of resources.

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