JOURNAL

FOUNDED 1916
Florida Engineering Society
October 2014

TRANSPORTATION

Governor Scott Announces $806.7 Million for Six Transportation Projects

Autonomous Vehicles Drive the Future of Transportation Infrastructure

Big Data Analytics, Big Transportation Opportunity

SUNRAIL TOD:
Reshaping Central Florida—
Build it and they will come...

The Transportation Crisis: Where Do We Go From Here?

Creating Injectable Barriers Utilizing Geotechnical Polymers for Hydrogeologic Control

Connector Will Take Hikers, Bikers from Coast to Coast

Less **Leads to More**
Innovative Design and Construction Methods Result in Full-Project Buildout

Also featured are highlights and images about the FES/FICE 98th Annual Summer Conference and Exposition.
To view all the photographs taken at the annual conference, please go to FES' Facebook.

Bridge 9 is under construction as of April, 2014. Photo courtesy of Smith Aerial Photos.

Less Leads to More

Innovative Design and Construction Methods Result in Full-Project Buildout

By Craig Finley Jr., PE, Finley Engineering Group Inc.

For nearly 30 years, the Florida Department of Transportation (FDOT) has been working towards improving the 26-mile 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

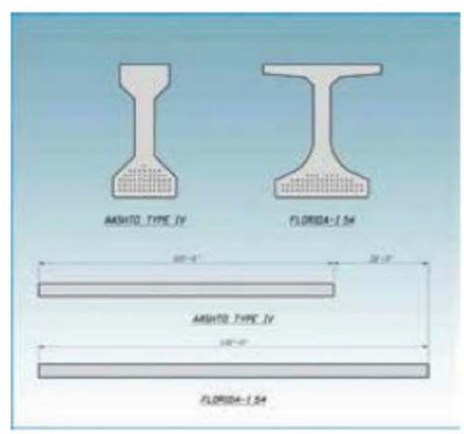
Section 5 of the 12-part, 20-year Palmetto Expressway reconstruction project is a $558 million design-build-finance project that reconfigures a 16-mile stretch of expressway where SR 826 (Palmetto Expressway) and SR 836 (Dolphin Expressway) meet adjacent to the Miami International Airport. More than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

"The project was bid as a design-build-finance contract with bid alternates. This enabled us to let the job earlier than if we had to wait and have all money funded in the year of the letting like regular construction projects," explained Gus Pego, PE, District Six Secretary, FDOT. "Using bid alternates with a maximum bid amount allowed us to capture the available funding and include additional scopes of work in the contract that we were uncertain could be afforded due to the volatility of construction pricing during the recession in 2009. This format caused the design-build team to tighten their belts and include as much scope in their bids as possible for fear that someone else would include more scope. The successful firm indicated to us that they trimmed an additional $20 million from their bid in order to reach the highest bid alternative. This required creativity with respect to roadway and bridge design as well as MOT phasing."

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 which allowed for FDOT's desire to reintroduce three expressway access points (which would have been lost with the original design plan). The redesign also lowered outside directional movements from the third level to the second level, and optimized use of the new Florida I-beam shape precast concrete girder.



Florida I-beam. Courtesy of BCC Engineering.

- Introduced to the FDOT Standards in 2009.
- Replaces the FDOT AASHTO Type Beams.
- Various types of FIB sizes used: FIB-36", 45", 54", 63", 72" and 78".
- Allows for longer spans, lower profiles and/or elimination of beam lines compared to their AASHTO counterparts.
- Takes advantage of higher strength concrete (Typ. f'c= 8.5 ksi).
- More stable during fabrication, shipping and construction.

The redesign removed two loops in the middle of the new interchange, replacing them with a turnaround slightly west, and lengthened the four complex segmental bridges. "Removing the loops created a more open layout at the central point of the interchange," said Enrique I. Espino, PE, President, Condotte America Inc. "By concurrently lengthening four segmental bridges, we were able to eliminate four other segmental bridges at the interchange and several more conventional bridges along a canal that runs through the site."

Bridge lengths: Bridge 9 (N-W) – 2,310'; Bridge 11 (E-N) – 1,785'; Bridge 15 (W-S) – 1,100'; Bridge 19 (S-E) – 2,540'. The Community/Condotte/de Moya Joint Venture earned the top score for its preferred alternative, but also finished first in terms of technical approach and shortest construction schedule (five years). Rendering courtesy of Touchstone Architecture.

"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 Jose Munoz, PE, President, BCC Engineering Inc. "Advance planning for building the foundation for what would be the last segmental bridge much earlier in the schedule was another critical aspect."

Adding Up the Bits and Pieces

The last of the four precast segmental bridge ramps is currently under construction. All four bridges, with a total of 783 segments, traverse the core of the interchange and comprise 25 percent of the overall project effort. The bridge deck is 46 feet wide, box depths varies from 9-12 feet and total bridge lengths range from 1,100-2,450 feet. The concrete grade for the segmental box girder superstructure is 6500 psi, with the substructure at 5500 psi. The total deck area is 360,718 square feet, with 7,764 linear feet of bridge. The top slab thickness varies from 9 ½-19 inches and is transversely post-tensioned. The longest span is 266 feet, with the tallest pier measuring 81 feet. The prestressing steel is a 7-wire strand, low relaxation steel, with a grade of 270 of 0.6" diameter. The post-tensioning stressing stressing force was 77%-80% GUTS. All continuity tendons are external and use diabolos to deviate the tendons.

The segmental bridge ramps are the third level of the interchange, with radii down to 590 feet and a maximum superstructure deck height of 95 feet above ground. All of the bridges are supported on 24-inch prestressed concrete pile foundations (250 tons [C] and 25 tons [T]) 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 footings for the segmental bridges vary in geometric shapes to accommodate the limited space and the prestressed concrete piles. In addition to the challenging geometric shapes, the orientation of each footing is specified to that particular pier, and all are designed to accommodate hurricane-level wind angles overturning movements from the launching gantry and out-of-balance cantilever conditions. To minimize future traffic disruptions, foundations for bridges typically slated for later in the process 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, in the glide path of the airport, must comply with strict Federal

Continued on Page 22

Design-Build Team

Owner: Florida Department of Transportation (FDOT) is overseeing the project and providing funding in conjunction with the Miami-Dade Expressway Authority (MDX) and the American Recovery and Reinvestment Act (ARRA)

Contractor: Community Asphalt Corp Condotte America Inc., The De Moya Group Inc., JV, LLP, Miami, FL

Prime Design Consultant: BCC Engineering Inc., Miami, FL

Segmental Bridge Design and Construction Engineer: Finley Engineering Group Inc. (FINLEY), Tallahassee, FL

Overhead Gantry and Casting Machines: DEAL, Bay Harbor, FL

Bearings and Expansion Joints: The D.S. Brown Company, North Baltimore, OH

Casting and Erecting Segments: Rizzani De Eccher, Bay Harbor, FL

Post-Tensioning Contractor: VSL, Hanover, MD

Construction Engineering & Inspection – Segmental Bridges: AIM Engineering & Survey Inc., Lehigh Acres, FL

Pier cap/temporary erection jacks

Temporary vertical tie down system.

The use of external tendons also reduced maintenance costs by allowing improved access for future tendon replacement, upgrades and stressing of any single strand inside the box.

Aviation Administration height limits for both permanent or temporary structures.

Balanced cantilever construction continuing on the last segmental bridge features a 460 feet long, 475-ton, self-launching overhead gantry supplied by DEAL. Rather than assembling and raising the precast sections from below, 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 (9' to 12' high 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, 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."

"This project is supported by two casting yards," said Dari Vorce, Florida Department of Transportation District Six Construction Project Manager. "One near the project for the segments, and the other on-site for all the pilings, beams and mechanically stabilized earth (MSE) walls. The 17 acre on-site casting yard saves trucking time and costs. The Rizzani De Eccher casting yard was located approximately 16 miles away and had two casting cells which enabled the fabrication of an average of 8 segments a week. The transportation time of the segments ranged from 30 to 90 minutes, depending on the route and time of day."

17-acre casting yard for Florida-I Beams, Prestressed Concrete Piles and MSE Wall Panels, located within the project limits. Photo courtesy of Smith Aerial Photos.

Alternative Technical Concepts (ATCs)
Three of four Alternative Technical Concepts (ATCs) submitted in the proposal for the segmental bridges were accepted—the use of external tendons and diabolos, haunched segments and polystyrene core forms on piers.

This ATC proposed the first use of diabolos in the state, which the DOT has specifically precluded in the RFP. FDOT allowed their use for the first time, 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 allowed for variable tendon geometry and continuous external tension 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 column cores (except for solid bases and caps) eliminated 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 5 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, PA, CEI Projector Coordinator, AIM Engineering and Surveying. "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, seven 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,

This is a major route to Miami International Airport (MIA), with more than 430,000 motorists using the interchange daily.

Polystyrene was used in the hollow pier columns, except at the base and caps, which are solid. This eliminated the need for interior formwork and reduced the overall mass of the structure and the amount of concrete required.

The diabolos eliminated the need for schedule 40 pipe, reduced the segment weight, allowed for variable tendon geometry and continuous external tension ducts.

and contractors developed and employed creative "less is more" solutions that brought about greater results within a given amount of resources. ■

The Rizzani De Eccher 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 courtesy of Rizzani De Eccher.

The transportation time of the segments ranged from 30 to 90 minutes, depending on the route and time of day.
Photo courtesy of Rizzani De Eccher.

About the Author:

Craig Finley Jr., PE is Managing Principal at Finley Engineering Group Inc. (FINLEY). He has over 32 years as a consulting engineer, involved in the design, management, construction engineering and inspection of a wide range of complex bridge types with spans from 40 feet to over 5,000 feet. He has had extensive experience in directing the preparation of the design, construction engineering and management of over ninety segmental bridges designed and/or constructed in the United States and around the world. This experience has come predominately as part of a contractor's team in design-build, value engineering and P3 projects.
He can be reached at craig.finley@finleyengineeringgroup.com or 850-894-1600.