

## PROJECT

# US 17-92 Interchange at SR 436

From congestion to concrete innovation

by T. J. Lallathin Jr., DRMP Inc.



The team's cooperative attitude allowed the project to meet and exceed the projected project schedule. The project is anticipated to finish 30 days ahead of schedule. Photo: Jim Uhing Photography.

Revamping one of the most congested intersections in the state of Florida was no small feat. With over 100,000 motorists traveling daily through the US 17-92/SR 436 intersection, located in Casselberry, Fla., designing and constructing a grade-crossing structure to alleviate traffic presented multiple challenges. These challenges included accommodating the Florida Department of Transportation (FDOT) District Five's budget, an accelerated schedule, and the unprecedented delivery and installation of the longest single-piece prestressed concrete beams in not just Florida, but the United States.

In the end, the design-build team will improve upon the bridge's construction schedule with minimal impacts on traffic—ultimately saving taxpayers millions of dollars and improving the mobility and safety of the intersection.

### Project Background

Just 13 miles north of Orlando, Fla., the US 17-92/SR 436 intersection

accommodates a heavy volume of commuter traffic and provides a major pipeline to motorists coming from Interstate 4 (I-4). Prior to construction, the junction of the two six-lane arterials was subject to heavy congestion and major delays, with motorists' wait time clocking in at 4 to 5 minutes. The solution was the construction of a bridge to carry US 17-92 over SR 436. The bridge is configured in three, simply supported spans with a main span of 209 ft and two approach spans of 124 ft, for a total bridge length of 457 ft. The US 17-92 flyover bridge has drastically decreased motorists' travel time since officially opening in April 2015, with drivers saving an average of 5 to 10 minutes in commute time. Motorists traveling on US 17-92 have realized the greatest improvement since they don't have to stop for the SR 436 cross traffic.

### Concrete vs. Steel Superstructure

Originally designed as two separate continuous steel plate girder bridges,

our team evaluated other options for the flyover bridge. Maintenance costs for concrete were also more economical compared to steel, which would require routine painting and more rigorous inspection. In addition, shoring towers would be needed to facilitate erection if steel girders were used, which would impede traffic on SR 436. The elimination of the shoring towers reduced traffic impacts and simplified the overall traffic control plan. Other advantages of using concrete beams over steel included improved aesthetics, reduced beam fabrication time, and reduced erection time. The benefits of concrete, coupled with lower upfront material costs, resulted in a total savings of approximately \$2 million, not including long-term maintenance costs.

The beams were designed with high-strength concrete (10 ksi) for increased structural capacity, which eliminated a beam line, reducing total beam costs as well as the dead load that must be carried by the

## profile

### US 17-92 INTERCHANGE AT SR 436 / CASSELBERRY, FLORIDA

**BRIDGE DESIGN ENGINEER:** DRMP Inc., Orlando, Fla.

**PRIME CONTRACTOR:** The Lane Construction Corporation, Maitland, Fla.

**CONSTRUCTION ENGINEERING & INSPECTION:** Metric Engineering, Lake Mary, Fla.

**PRECASTER/BEAM DELIVERY:** Dura-Stress Inc., Leesburg, Fla.—a PCI-certified producer

substructure. Although a shallower beam would have been adequate for the approach spans, the team used the same beam depth for all exterior girders to eliminate the discontinuity in the profile of the structure and to maximize the visual appeal. The approach spans consist of 78-in.-deep Florida I-beams (FIBs) and 96-in.-deep FIBs (exterior), and the main span consists of all 96-in.-deep FIBs. Using the 96-in.-deep FIB, the concrete beams were able to span greater lengths, which decreased cost and the construction schedule and increased maintainability.

## Substructure and Foundations

The beams are supported by concrete piers, oriented on a skew, comprised of a tapered cap and three rectangular columns supported by individual footings founded on 18-in. square prestressed concrete piles. While the piers are skewed, the end bents are radial to the centerline of construction resulting in variable beam lengths within the approach spans and constant beam lengths in the main span.

## Challenges

The size and weight of the beams posed challenges for every aspect of construction including precasting, delivering, and erecting the beam onto the substructure. Although more efficient and economical, the real test



At 209 ft, the main-span beams are the longest single-piece precast, pretensioned concrete beams in the United States. Photo: The Lane Construction Corporation.

in using concrete beams came in how the team would fabricate, deliver, and erect the 209-ft-long beams. The beams are the longest in Florida and recently confirmed to be the longest single-piece pretensioned beams in the United States.

The main span 96-in.-deep FIBs are conventional pretensioned concrete consisting of almost 70 yd<sup>3</sup> of concrete and weighing 267,000 lb. The prestressing consists of seventy-two 0.6-in.-diameter, low-relaxation strands. Additional strands would have caused problems with splitting forces and compression limits. The precaster added additional strands to the top flange of the beam to facilitate stability during transportation. These strands were not originally included in the beam design and were detensioned after erection.

The vertical curve was centered on the bridge. The length of the beams coupled with the steep 5% roadway grade on each end created large build-ups in the center of the span. Build-up values exceeding 8 in. were

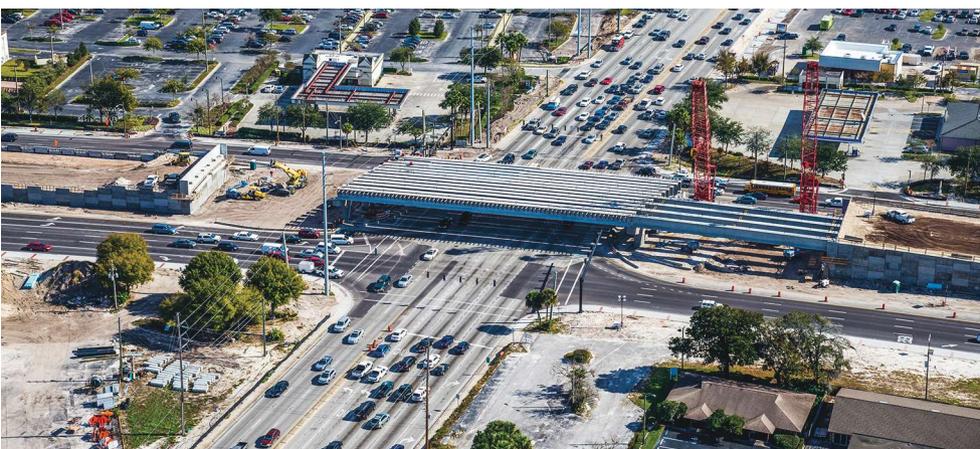
calculated and had to be accounted for during design. The additional load due to the build-up exceeded 260 lb/ft, which is equivalent to an additional one-third of the total deck load per beam.

The combination of the beam depth, the additional depth of geometric build-up, and the need to support the long span without additional post-tensioning required nonstandard concrete mixture proportions. The increased loads on the main span beam required the use of 10-ksi compressive strength concrete for the beams, which exceeded the current strength allowed by FDOT specifications. Special provisions and approved mixture proportions were required before the FDOT would approve casting the girders with a concrete compressive strength never used before on an FDOT project.

## Design and Fabrication

The most significant unforeseen construction challenge was the variation between the predicted camber of the beam and the actual camber. Several factors played into camber differences including how the beam was cast and additional strands added to the beam for handling. These strands were cut at the jobsite before concrete for the deck was placed. The effect of these strands was more significant than expected. Since the strands were fully stressed when the

The project's innovative approach has allowed a major construction effort to have a minimal impact to its dense commercial surrounding. Photo: Aerial Innovations Inc.



## FLORIDA DEPARTMENT OF TRANSPORTATION DISTRICT FIVE, OWNER

**BRIDGE DESCRIPTION:** Three-span simply supported bridge with a 96-in.-deep, 209-ft-long main span and two 124-ft-long approach spans for a total bridge length of 457 ft

**STRUCTURAL COMPONENTS:** Ten 78-in.-deep Florida I-beams (FIBs) and fifteen 96-in.-deep FIBs; 8½-in.-thick, cast-in-place concrete deck; cast-in-place, 6.5-ft-deep, concrete pier caps; 5 by 7 ft rectangular columns; and footings on precast concrete piles



A potentially complex beam setting was executed in an essentially seamless manner through application of modeling software prior to the actual beam placement. Photo: The Lane Construction Corporation.

concrete was at a lower compressive strength, and cut when the concrete was at a much higher strength, camber growth was reduced significantly.

The only casting bed at the precast facility that could accommodate the 209-ft-long beams was 500 ft in length. To meet the schedule, two beams were cast in the same bed. While this allowed for a faster production rate, one unintended result was varying camber between the two beams. After all tendons were stressed, the first beam was formed and the concrete placed. After the concrete cured, the forms were stripped and placed for the second beam and concrete was placed. Once the second beam's concrete reached the strength required for transfer, the strands were detensioned and both beams were removed from the bed and placed on dunnage. The difference in concrete strengths at the time of strand release caused variations in camber values when measured at the precast yard.

Compounding the issue of camber variation was the construction schedule. A bonus to reduce the project schedule was offered to the contractor after award. This forced the contractor to start erecting beams earlier than the design assumption. The beam age at erection varied from 16 to 58 days. Beams are typically erected at 120 days, which was assumed for design. While all beams had achieved the specified 28-day concrete compressive strength, the large variation in age at erection caused reduced beam cambers and increased variation in cambers.

To fully understand the camber and deflections that were taking place, the beams were surveyed at various stages during construction. At erection before the top transportation strands



Special delivery vehicles were used to transport the beams from the fabrication yard to the project site just over 40 miles away. Beams were delivered at the rate of two per night, resulting in a week-long delivery process. Photo: The Lane Construction Corporation.

were cut, the predicted design camber was 4.25 in. The minimum measured camber for all beams at this stage was 2.1 in. Once the top strands were cut the minimum camber value increased to 2.8 in. To better understand the field measured values, a three-dimensional (3-D) finite-element model was created to analyze the various stages of construction relative to the beams. The finite-element model was used to determine deflections for construction staging; the predicted deflections were very similar to field measured deflections.

### Delivery

Working closely with a PCI-certified precast concrete supplier, the design-build team addressed the delivery of the thirteen 267,000-lb beams that would need to be fabricated and delivered over 40 miles to the project site. The precaster performed a detailed evaluation of the delivery process, establishing a safe route between their plant and the project site. With two special delivery vehicles capable of supporting 340,000 lb, two beams per night were delivered, resulting in a week-long delivery process. The entire US 17-92/SR 436 intersection was closed and traffic was re-routed during off-peak hours to accommodate the delivery. Due to the length and load of the delivery vehicles, Florida Highway Patrol accompanied them to ensure a safe and uninterrupted delivery.

### Erection

The contractor used 3-D modeling software for the development of the beam erection plan. This was of particular importance because of the size of the beams, the relatively small work zone, adjacent traffic, and the proximity of overhead transmission

lines. What was fundamentally a difficult beam setting process was completed in a safe and expeditious manner as a result of analyzing the beam setting before it occurred.

### Schedule

The schedule for the design and construction of the project was 754 days. The project is ahead of schedule and is projected to beat the schedule by 30 days. This is significant because work is beginning on FDOT's massive, \$2 billion, I-4 ultimate project and the client's goal is to open the project to alleviate I-4 traffic. The project is on pace to finish early, aided by the innovative design.

### Summary

Through close and extensive coordination between the design-build team, FDOT, the city of Casselberry and other entities, before and after the project award, along with an innovated design approach, central Florida motorists are reaping the benefits. The new US 17-92/SR 436 grade-separation bridge supported by the longest single-piece precast, pretensioned concrete beams in the United States saved millions in taxpayer dollars, has resulted in reduced driving time, and was accomplished with minimal impact to traffic during the process. 

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