PROJECT

Southbound Interstate 95 to Eastbound State Road 202 (J. Turner Butler Boulevard) Flyover Bridge

by Andrew Mish, Summit Engineering Group (a Modjeski and Masters company)

The intersection of Interstate 95 (I-95) and State Road 202 (SR 202) is a major traffic interchange south of downtown Jacksonville, Fla. I-95 carries north/south traffic through the heart of Jacksonville, while SR 202, also known as J. Turner Butler Boulevard, carries east/west traffic to beaches on the Atlantic Coast. Commuter traffic on both roads through the greater Jacksonville area is significant, totaling more than 200,000 vehicles per day. A major congestion and safety concern of the old interchange was that the southbound I-95 to eastbound SR 202 traffic exited to a stoplight. During rush hour, vehicles on this exit would consistently back up onto the interstate for a mile or more.

In 2014, the Florida Department of Transportation (FDOT) awarded a design-build contract for the redesign and construction of the I-95 and SR 202 interchange. Four design-build teams were selected for the short-list group to present proposals to the department. The proposals were evaluated using a combination of technical score and total price. (For FDOT's process of selecting design-build teams, see "Refining the Adjusted-Score Design-Build Process" in the Summer 2018 issue of *ASPIRE®*.) The winning team presented a redesigned interchange that consists of four bridge structures, new ramp configurations, new highway alignments, and the widening of the I-95 and SR 202 roadways. The signature bridge of the project is a curved, post-tensioned, precast concrete U-girder flyover bridge that carries southbound I-95 to eastbound SR 202, eliminating the traffic

Aerial view of the J. Turner Butler Flyover Bridge prior to casting the bridge deck. Photo: Modjeski and Masters.

profile

SOUTHBOUND INTERSTATE 95 TO EASTBOUND STATE ROAD 202 (J. TURNER BUTLER BOULEVARD) FLYOVER BRIDGE / JACKSONVILLE, FLORIDA

BRIDGE DESIGN, CONSTRUCTION, AND ERECTION ENGINEER: Summit Engineering Group (a Modjeski & Masters Company), Littleton, Colo.

PRIME CONTRACTOR: SEMA Construction, Orlando, Fla.

PRECASTER: Dura-Stress Inc., Leesburg, Fla.—a PCI-certified producer

POST-TENSIONING CONTRACTOR: Freyssinet Inc., Sterling, Va.

backup problem. The bridge was opened to traffic on September 7, 2017.

The new southbound I-95 to eastbound J. Turner Butler Boulevard Flyover Bridge is a seven-span, 1342-ft-long structure. There are two superstructure units, with expansion joints at end bents and at pier 5. Unit 1 has four spans with a total length of 767 ft. Unit 2 has three spans with a total length of 575 ft. Span lengths vary from 140 ft to 232 ft. The overall width of the superstructure is 47 ft 6 in., which accommodates two 12-ft-wide travel lanes plus 8-ft and 12-ft shoulders. The structure is curved on a 1100-ft horizontal radius combined with a vertical curve that has an incoming vertical grade of +5.0% and an outgoing grade of -3.5%. The deck has a constant superelevation of 7.5%.

The superstructure is composed of curved, spliced precast concrete U-girders that are post-tensioned to form continuous spans. There are two 84-in.-deep constant-depth girder lines spaced at 23 ft 9 in. that support a 9-in.-thick deck, which includes a ½-in. sacrificial depth for grinding and wear. To minimize form changes, both the left and right girders are designed to be cast with the same 1100-ft radius. This casting method does not significantly affect the design, but it allows for vastly increased efficiency in girder production. The substructure consists of single-column piers supported on prestressed concrete pile foundations. Of the six interior piers, four use precast concrete pier caps that allow construction to take place with minimal falsework to accommodate the site conditions (see "Precast Concrete Pier Caps Aid Construction of Jacksonville Flyover Bridge with Tight Site Conditions." in this issue of *ASPIRE* on page 34). There was no room for formwork shoring that would be required for cast-in-place (CIP) concrete pier caps because any shoring would have interfered with traffic. A solution was needed that allowed casting and erection of the pier caps without any temporary shoring. The precast concrete caps were cast on site and erected onto temporary support brackets attached directly to the columns. They were designed to be cast flat for ease of construction, and erected to match the 7.5% cross slope of the bridge. Matching the cross slope with the cap provides a continuous and symmetrical aesthetic from the superstructure to the substructure.

Rationale for Integral Caps

There were three primary reasons for using integral caps on this project.

- They minimized the total structure depth from bottom of cap to top of deck by making the design more efficient with composite action between the CIP concrete diaphragm and the precast concrete cap. This was important to maintain traffic clearance both during construction and in the final alignment.
- They eliminate bearings, which require a large joint/gap between the bottom of the girder/diaphragm and the top of the cap. This eliminates the cost and long-term maintenance requirements for bearings.
- From an aesthetic perspective, they provide a seamless transition from the superstructure to the substructure, giving the appearance that everything was cast together.

Site and Construction Challenges

The flyover bridge is constructed over three major traffic crossings: southbound I-95, northbound I-95, and westbound SR 202. During construction, FDOT required that all lanes remain open to traffic. Only overnight lane closures were allowed, providing 6- to 8-hour windows for the construction and erection procedures that needed to occur in traffic areas. To facilitate construction, the maintenance-of-traffic plan was integral to the success of the project. Several traffic shifts were executed to open different areas of the project site for construction while maintaining all travel lanes, as required by FDOT.

Curved precast concrete U-girder span over Interstate 95 during U-girder construction. The girders are supported with integral cast-in-place concrete diaphragms made composite with precast concrete pier caps. Photo: Seidler Productions.

To accommodate the constant flow of traffic through the jobsite, several innovative features were incorporated into the bridge design. Precast concrete pier caps were used at the interior piers. Pier locations were adjacent to traffic during construction, so using temporary shoring to support formwork was not an option. The precast concrete pier caps also served to support pier girders during construction, eliminating falsework towers within the traffic zone. Pier girders were erected on a temporary falsework tower at one end and on the precast concrete pier cap at the other end, with a large cantilever beyond the pier cap.

The cantilevered pier girders supported drop-in girders on strongbacks, which eliminated the need for falsework towers at the splice locations. Strongbacks were connected to girders

FLORIDA DEPARTMENT OF TRANSPORTATION, OWNER

OTHER MATERIAL SUPPLIERS: Bearing supplier: R.J. Watson Inc., Alden, N.Y.; Expansion joint supplier: D.S. Brown Company, North Baltimore, Ohio; Lightweight aggregate supplier: Carolina Stalite Co., Gold Hill, N.C.; Stainless-steel reinforcement supplier: SteelCON Supply Company, Jacksonville, Fla.

BRIDGE DESCRIPTION: A 1342-ft-long curved, spliced precast concrete post-tensioned U-girder bridge on an 1110-ft horizontal radius

STRUCTURAL COMPONENTS: 2675 linear ft of 84-in.-deep curved spliced post-tensioned precast concrete U-girders; four precast post-tensioned concrete pier caps 36-ft-long by 7-ft 6-in.-wide by 4-ft 6-in.-deep; two cast-in-place post-tensioned concrete pier caps 35-ft 8-in.-long by 8-ft 0-in.-wide by 9-ft 4-in.-deep; six single-column piers 4 ft by 7 ft; 11,220 linear ft of 24-in.-square precast concrete piles

BRIDGE CONSTRUCTION COST: $66.7 million (for construction of entire interchange, including three additional pretensioned bulb-tee girder bridges)

Pier girder supported by precast concrete cap and falsework tower during construction. Photo: Modjeski and Masters.

through a partial-depth diaphragm, supporting them from the top. This approach provided the minimum vertical clearance over traffic because no hardware projected below the bottom surface of the girders.

Span 6 of the Flyover 1 bridge is one of the longest spans in the structure, measuring 228 ft 11 in. Girder shipping weights limited the maximum piece length to 100 ft for pier girders and 115 ft for drop-in girders. Because of the pier locations and site geometry, a single drop-in girder could not span between pier girders. The solution was a temporary straddle bent to support two drop-in girders at the central splice location in the span. The straddle bent spanned approximately 70 ft to provide clearance for three traffic lanes, the barrier rail, and a clear zone behind the barrier.

Structure Design

The foundations are composed of 24-in.-square prestressed concrete piles driven to an average depth of 100 ft below grade. Test piles were driven and monitored at each bent location to ensure that the required load-carrying capacities were achieved. A single CIP column supports each interior pier. The column geometry was controlled by the amount of space in the median between northbound and southbound I-95 at pier 3, leading to a 4 ft by 7 ft rectangular cross section with $1^{5}/_{8}$-in.-deep vertical reveals.

A temporary straddle bent supports girders at the splice location near midspan over J. Turner Butler Boulevard during construction. Bridge deck overhang falsework brackets are attached to the girders after the integral cast-in-place concrete diaphragms have been cast to support work platforms and wet deck concrete during construction. Photo: Modjeski and Masters.

Interior piers use both CIP and precast concrete pier caps. CIP pier caps are located at interior piers 4 and 5. These piers were designed with slide bearings to accommodate girder movement due to post-tensioning, creep, shrinkage, and temperature fluctuations. All other piers were designed with precast concrete caps and integral diaphragms, relying on column flexibility to accommodate longitudinal movement. All pier caps were designed using staged post-tensioning to provide sufficient strength and serviceability during the multiple phases of construction and in-service loadings.

The superstructure of the flyover bridge is composed of spliced, precast concrete post-tensioned U-girders. It is the second structure using these curved girders in Florida, and it is the first project using these girders for FDOT. The structure is designed using time-dependent load-history analysis. Each stage of construction is included in the analysis, and the structure is aged 30 years to account for long-term creep and shrinkage effects.

The girders were designed for the entire life cycle, from casting in the precast concrete plant to final service and ultimate conditions in the superstructure. When initially stripped from the formwork and stored at the precast concrete yard, the girders were mildly reinforced. Handling devices were located at approximately 0.2*L* locations, where *L* is the length of the span, to balance the positive and negative moments when the precast concrete section was handled. After stripping the girders from the formwork, post-tensioning tendons were installed and grouted at the precast concrete plant to control concrete stresses during shipping and erection. These tendons are also part of the final structure design.

Next, the girders were shipped to the jobsite and erected in sequence onto the temporary falsework towers and the concrete pier caps. To erect the drop-in girders, all other girders in the superstructure unit were erected with splices cast, lid slabs poured, and partial-length continuity tendons stressed. This process required a detailed erection sequence and coordination among the contractor, precaster, and post-tensioning subcontractor to minimize effects on the schedule.

CIP lid slabs were cast on the girders after erection and prior to post-tensioning. Casting the lid slab on site minimized girder weights for shipping, allowing for longer girders and less falsework. Before the lid slab was cast, the U-girder was an open cross section susceptible to torsional cracking. Girder sections were analyzed to ensure that torsional cracking due to placement of the lid slab would not occur. Once the lid slab cured, the torsional stiffness of the cross section increased significantly, up to 100 times that of the open section. The stiffer section is able to resist all continuity post-tensioning loading and torsion loading caused by the wet weight of the CIP deck.

After erecting drop-in girders, final closure pours were cast and continuity post-tensioning was applied in each superstructure unit. Tendons were grouted per project specifications to provide corrosion protection to the strands, to bond strands for strain compatibility behavior, and to enhance durability. Secondary diaphragms were cast at post-tensioned anchor blocks to provide protection and concrete cover for post-tensioning anchorages. The deck was cast on stay-in-place metal deck forms between girders. Finally, deck casting was sequenced to place positive moment regions first and negative moment regions last, to minimize the potential for deck cracking over piers.

Conclusion

The design and construction of the Southbound I-95 to Eastbound SR 202 Flyover Bridge is an excellent example of the versatility of precast concrete construction. Spliced, post-tensioned precast concrete designs can provide innovative and unique solutions to many bridge design challenges.

Tendon grouting is a critical component of the design and construction of this type of bridge. A strong commitment from each party to implement proper grouting specifications, grout plan submittals, quality control procedures, and quality assurance monitoring in accordance with industry specifications was an important aspect of this project. When procedures are properly implemented, spliced and grouted post-tensioned structures have proven to provide efficient designs and durable structures, and this project in Jacksonville builds on that history.

The project was a collaboration among all stakeholders to deliver a high-quality structure while addressing local traffic needs for years to come. Curved, spliced, precast concrete post-tensioned U-girders are an excellent solution for this flyover bridge structure, combining a beautiful aesthetic with a comprehensive engineered solution.

Photo: Modjeski and Masters.

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EDITOR'S NOTE

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AESTHETICS COMMENTARY

by Frederick Gottemoeller

Curved flyover ramps can be impressive and exciting structures. The ramps provide a three-dimensional representation of the curved, high-speed trajectories of the vehicles passing overhead. Whether or not there are vehicles present, the ramps illustrate the dynamic function of the interchange to sort traffic into various paths. The more the lines of the structure parallel the vehicle trajectories, the more powerful this effect is. Ramps constructed as cast-in-place or segmental box girders are particularly effective. Ramps made of conventional precast concrete girders are less so, because the girder lines are broken into individual chords.

So, it is great to see a new technology, precast concrete curved U-girders, spliced and post-tensioned, solve this visual problem. The lines of the girders, curved in both the horizontal and vertical planes, follow perfectly the geometry of the ramp and thus the trajectories of the vehicles on it. The sweep of the curved girder lines is well illustrated in the photos.

Locating the piers for curved flyover ramps can be a challenge. The horizontal and vertical clearance envelopes of the roadways below limit the available locations, and the additional vertical clearance required for a pier cap placed below the girders makes the challenge even greater. The dropped pier caps also visually interrupt the curved lines of the girder edges, diminishing the effect described in the previous paragraph. The designer of this flyover ramp addressed both problems by minimizing the distance the pier caps drop below the girder soffits. The visual integration of the pier caps and girders created by placing them in the same plane (more or less) makes for a seamless transition from superstructure to substructure, visually unifying the ramp. Finally, the thin pier stem attenuates the connection between the ramp and the ground, feeding a perception that the ramp itself is flying.

People know that bridges are inherently heavy structures. Designing our bridges to *appear* lighter than they really are is one way we can use our art to make bridges memorable.

Photo: Modjeski and Masters.