Time-Saving Construction Techniques—I-59/I-20 Bridge Reconstruction

By Robert W. Sward, Structural Technologies LLC

Since the 1970s, precast concrete segmental bridge construction has been used throughout the United States and many other parts of the world. Precast concrete segmental bridges are highly durable structures and may have predicted service lives greater than 100 years. As with most other forms of precast concrete construction, precast concrete segmental bridges can be constructed relatively quickly and allow the contractor to take advantage of innovative construction techniques. The recently completed Interstate 59/ Interstate 20 (I-59/I-20) elevated bridge replacement project in Birmingham, Ala., showcases the benefits of precast concrete segmental construction (see the Project article on page 10 of this issue of *ASPIRE*®). This replacement project is one part of the $750 million Alabama Department of Transportation (ALDOT) reconstruction program for the I-59/I-20 corridor.

Precast concrete column in form with core form being extracted. Photo: Johnson Bros.

Strategies to Achieve an Aggressive Timeline

To minimize the impact of construction on the community, ALDOT opted to shut down the corridor to complete the replacement of the elevated structures in one phase. The maximum construction duration established in the contract was 14 months, but the contractor could maximize early-completion incentives by completing construction in 12 months. Constructing the replacement in multiple phases would have extended the project duration for several years. In May 2017, ALDOT awarded Johnson Bros. Corporation the $474.7 million contract for the I-59/I-20 bridge replacement project. This contract included a substantial bonus for early completion and unlimited liquidated damage penalties for late completion. To successfully complete this project and minimize schedule risk, Johnson Bros. implemented the following strategies.

Advance Work Beneath the Existing Bridge

The contractor decided to complete many of the new foundations and footings prior to shutting down the interstates for demolition. They used a combination of driven H-piles and drilled shafts and, where there was limited head room, implemented micropiles to install the new foundations around and beneath the existing elevated roadway.

Precasting the Concrete Substructures

By precasting 160 pier cap and column substructure elements, the contractor was able to benefit from the nearby casting yard and minimize critical path activities. Delivering and assembling precast concrete elements proved to be much faster than conventionally forming and pouring variable-height piers in place.

Use of Custom Shoring Towers in Precast Concrete Segment Erection

In the original design, the use of longitudinal erection trusses was assumed. This is a linear method of segmental construction in which the erection truss is launched to the next span only after one span is fully erected. To meet an incentive-maximizing 12-month construction schedule using this method, Johnson Bros. would have needed a minimum of six launching trusses working concurrently. This linear method of erection would have been risky because if the erection of a particular span could not progress in sequence, the contractor lacked the flexibility to quickly move the erection equipment to another work area.

Working with Structural Technologies/ VSL, Johnson Bros. elected to use custom shoring towers to support the precast concrete segments during segment erection in lieu of longitudinal erection trusses. This method reduced schedule risk

Precast concrete column segments in storage. Note the extended column reinforcement and grout sleeves that are visible on the ends of the segments. Photo: Johnson Bros.

Reinforcing bar cage with transverse tendons being installed into forms. Photo: Johnson Bros.

by providing the contractor the flexibility to deploy erection crews and equipment as needed to maintain the construction schedule, while allowing the use of more traditional construction equipment (cranes) for erection of the segments. If one particular span could not be erected in series, the crew and erection equipment could be redeployed to another area of the project. This method also allowed flexibility in sequencing the work.

The shoring towers supplied were custom designed and fabricated for this project. Shoring towers were preassembled at the fabricator's facility to ensure proper fit-up. The tower bases were fitted with screw jacks for vertical adjustments, and the tops were telescopic and fitted with jacking boxes. The main elements of the shoring towers were color-coded to be easily identified by field crews for their proper locations. Approximately 127 individual shoring towers were provided, which allowed the contractor to work on up to eight fronts at one time. To ensure that underground utilities near the towers would not be damaged by the construction loads imparted by the shoring towers, a foundation load analysis was performed.

Three-Dimensional Modeling

During the bid phase, a virtual three-dimensional model of the entire project was developed. Using this model, each bridge span was studied to confirm that it could be erected using the proposed shoring method. The study revealed that several spans would require special portal frames and/or sliding of the segments due to crane access limitations and ground conflicts, such as railroad tracks and streets that could not be closed.

Minimizing the Number of Segments

The length of typical and deviator segments was increased from 10 ft to 12 ft, which reduced the number of segments to cast, store, transport, and erect by about 400 segments. The team had to account for subsequent increases in segment weights and ensure that limits would not be exceeded for cranes, shoring, and hauling.

Dedicated Batch Plant

A project-dedicated batch plant was installed in the casting yard, including a quality-control lab. The dedicated batch plant ensured consistent delivery and quality of concrete as needed for both the jobsite (approximately 4 miles away) and the precast yard.

Maximizing Efficiency in the Casting Yard

The casting yard for the 2316 box-girder segments included 12 casting cells for the segments—eight for typical segments, two for pier segments, and two for expansion-joint segments. There were also 20 reinforcing bar jigs. In addition to the box-girder segments, 160 pier-cap and column elements were cast.

Casting cells and reinforcing bar jigs were organized to allow a single crawler crane to service four casting cells. The casting cells were fitted with movable shelters to protect both the segments and workers from the weather. To ensure reinforcement was ready when the forms were ready, each cell typically had two reinforcing bar jigs.

The segments included transverse post-tensioning (PT) tendons in the deck with four 0.6-in.-diameter, 270-ksi strands that were installed, tensioned, and

Casting cells for precast concrete box-girder segments with protective covers. Photo: Johnson Bros.

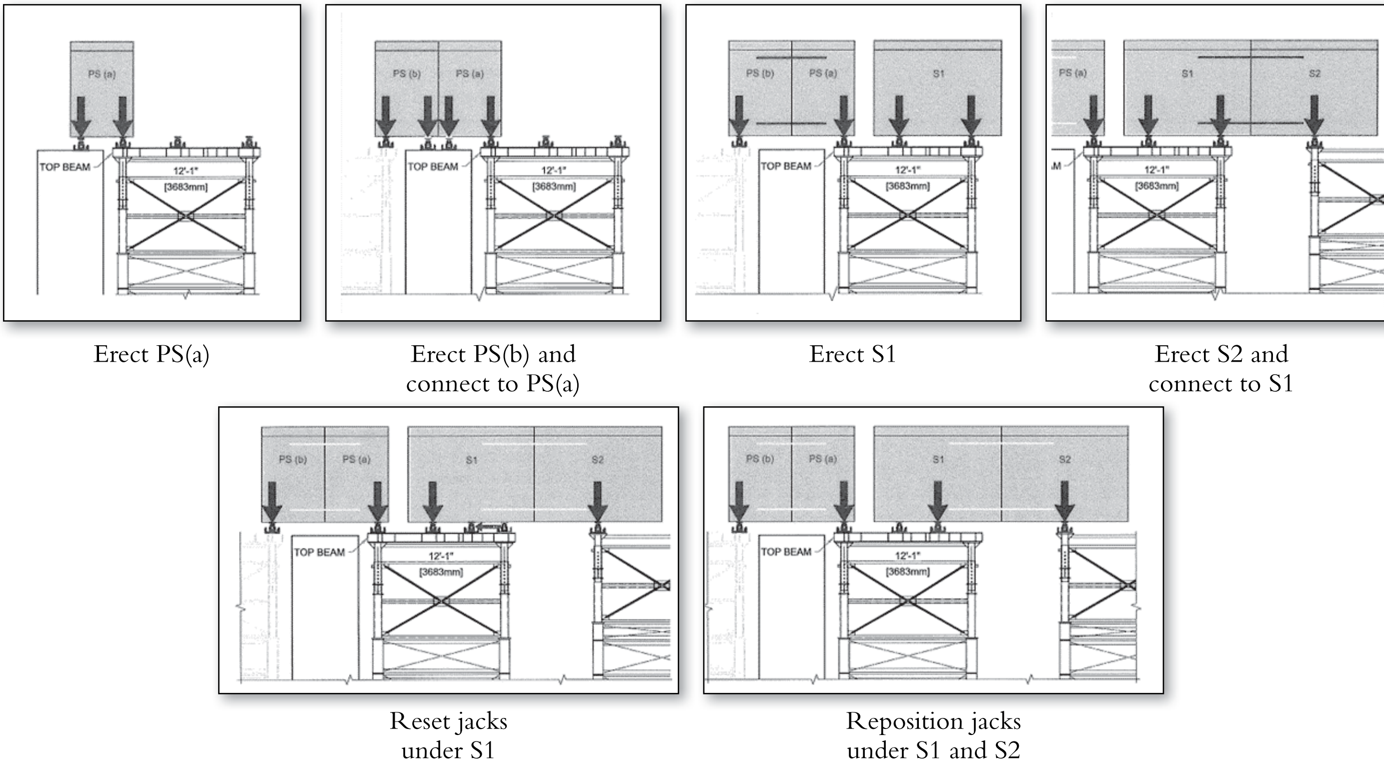


Figure 1. Typical segment erection sequence of a span. Note: PS indicates pier segment and S indicates span segment. Figure: Structural Technologies.

grouted in the casting yard. The 9386 four-strand PT transverse tendons were prefabricated and individually placed in the reinforcing bar cage. To minimize the number of transverse tendon pockets that would need patching, the dead-end anchorages of the four-strand transverse tendons were cast into the deck.

Once a segment was moved off the match-cast station, it was placed on a finishing stand where any blemishes were patched, and transverse tendons were tensioned. Segments were then moved and double-stacked in the storage area where transverse tendons were grouted. With eight different erection fronts, management of segment storage was critical to ensure that proper segments were delivered to the correct span and in the correct sequence.

Heavy segment haulers were used to transport the segments to the different erection fronts. During segment transit, the haulers were escorted by local police.

Multiple Work Fronts

During segment erection, the jobsite was organized into eight work fronts. Each had its own dedicated superintendent, crews, and erection equipment. Using multiple work fronts fostered a competitive environment that motivated crews to adhere to quality, schedule, and safety goals.

Typical Span Erection

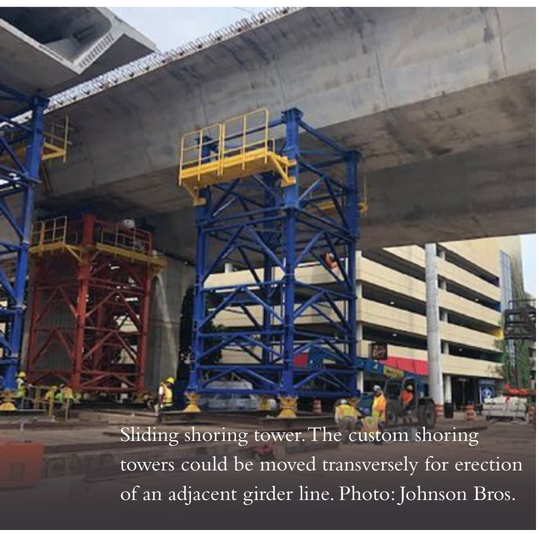
The shoring method for segment erection provided an additional benefit by reducing the time it took to erect segments. With a truss-supported method, the truss must be loaded with all segments before the segments can be joined together; this requires handling and moving the segments several times during the span erection cycle. In contrast, the shoring method does not require as much handling and moving of segments.

The span erection cycle began with the placement of shoring towers. Because the bridge typically had four parallel lines of box girders, towers could be moved transversely from one girder line to the next or set in position using a crane. Once the shoring towers were positioned, the typical span erection progressed by placing the leading edge pier segments, followed by the span segments (**Fig. 1**). The PT tendons were then installed and tensioned to an initial force. Closure joints were placed and the tendons tensioned to full force once the closure pour concrete achieved the minimum required strength. At this point, the shores were released and moved to the next span. An advantage of

Using a three-dimensional model, engineers determined that several spans would require portal frames. Here, two portal frames support segments over an existing bridge. Photo: Structural Technologies.

The erection of a split-pier segment. Photo: Structural Technologies.

The erection of the first span was completed on March 11, 2019. The main elements of the shoring towers were color coded to be easily identified by field crews for their proper locations. Approximately 127 individual shoring towers were provided, which allowed concurrent work on up to eight fronts. Photo: Structural Technologies.



Sliding shoring tower. The custom shoring towers could be moved transversely for erection of an adjacent girder line. Photo: Johnson Bros.

this shoring method was that the segments could be placed and aligned in the same operation, reducing the number of times the segments needed to be handled during span erection.

Conclusion

In the I-59/I-20 project, the project team leveraged precast concrete segmental bridge construction to deliver a durable structure efficiently and maximize an early completion incentive. The strategy of using custom-designed shoring towers to allow nonlinear construction, using longer but fewer segments, and the use of precast concrete substructure elements all served to enhance constructability and reduce the contractor's risks. The project team demolished 180 spans of existing structure in 41 days, precast 160 pier caps and columns as well as 2316 box-girder segments in 18 months, and erected the 172 spans of the new bridge in just over 7 months. This replacement structure opened in mid-January 2020 and will serve the people of Birmingham and the traveling public for years to come. A

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EDITOR'S NOTE

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