Interstate 49 Inner City Connector Interchange—Simplifying Complexity

by Jerry Pfuntner, FINLEY Engineering Group

The 36-mile Interstate 49 (I-49) Corridor is a four-lane highway, with a 4-ft-wide inside shoulder and a 10-ft-wide outside shoulder, that stretches from Interstate 220 (I-220) in Shreveport, La., to the Arkansas state line. Located in Caddo Parrish, La., Segment K of the project is a new interchange with four ramps connecting I-220 and I-49.The I-49/I-220 interchange ramps are the first post-tensioned, precast concrete segmental box-girder bridges constructed in Louisiana. The three segmental bridge ramps consist of 700 precast concrete segments and have 271,000 ft^2 of deck area. The three ramps present complex geometry for rural interchange, with the ramps having precast box-girder widths between 31.5 and 50.83 ft, straddle piers, cantilever piers, and horizontal curves with a minimum 550 ft radius. This article describes the measures taken to simplify the precast segmental concrete design to maximize construction efficiency, ensuring that the proposed project could compete against an alternative steel box-girder design.

First Steps

Before the first calculation was performed, the design team defined the precast concrete project in terms of constructability. Variables such as access, maintenance of traffic, and the number of segments were assessed to determine the most cost-effective solution to construct the three segmental bridge ramps.

It soon became apparent that balanced-cantilever erection with ground-based cranes would be the most economical solution for this project. With the construction method set, a conceptual design was generated to maximize design efficiency and streamline the project details. The designers decided on the concept of external continuity post-tensioning (PT) with diabolos and a combination of linearly haunched and constant-depth segments, which met the project's aesthetic goals.

Varying Ramp Geometry

The project design used a total of 700 precast concrete segments. To make this design economical, a cross section was developed that would require only one box-girder core form. If the project had required multiple segment cores, casting would have been less efficient and the costs of precast concrete segment fabrication would have been higher.

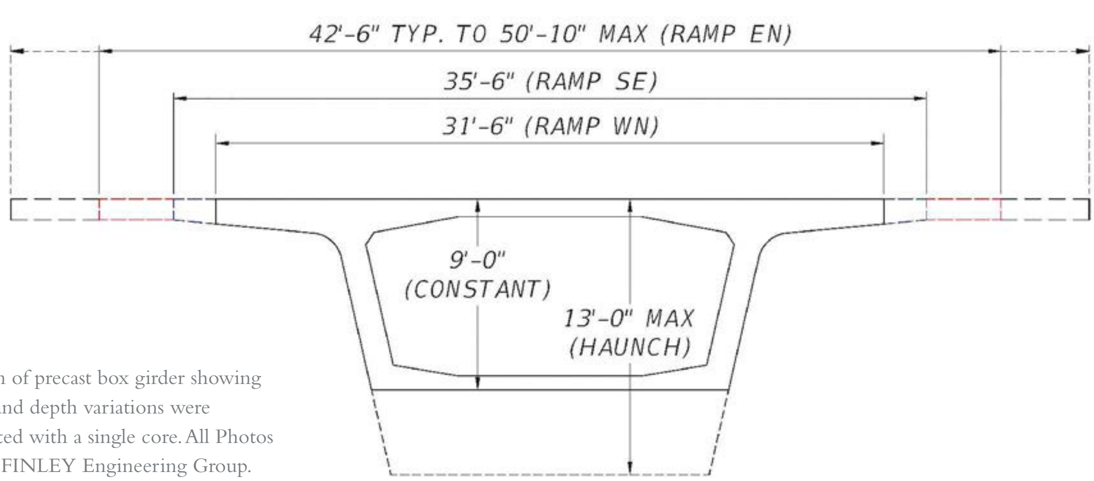
The geometric requirements for each ramp were distinctive. Ramp EN is 3070 ft long with a horizontal radius of 3500 ft. The box-girder width varies between the typical width of 42.5 ft and a maximum of 50.83 ft within a gore transition span. Ramp SE is 3300 ft long, with a box-girder width of 35.5 ft and a horizontal curve radius of 840 ft. Ramp WN is 700 ft long, with a box-girder width of 31.5 ft and a minimum horizontal curve radius of 550 ft.

To develop a box-girder cross section that would envelop such a wide range of widths and span lengths, a key part of the conceptual design involved balancing the PT details, transverse reinforcement bar sets, torsional requirements, and cantilever wing design to create a one-size-fits-all box-girder core section. Additionally, the use of external continuity tendons eliminated the integration of the blisters and internal tendons, which allowed for a smaller box core to accommodate the smaller bridge widths.

The box girders have a single core form with a linear haunch over the piers to increase the segment depth and maximize the span lengths while providing an aesthetically pleasing appearance.

External Tendons—the Right Solution for the Project

The use of external tendons for continuity



Cross section of precast box girder showing how width and depth variations were accommodated with a single core. All Photos and Figures: FINLEY Engineering Group.

PT allowed the box-girder section to be minimized, and the associated reduction in the segment weight permitted the use of a single box-girder section to achieve the required span lengths for all box-girder widths. Simplification of PT details through the use of external continuity PT reduced the continuity PT to just two deviators per span. This approach simplified casting and allowed for the smaller box-girder cross section by eliminating internal tendons in the bottom slab and generating a significant vertical shear resistance component. These details allowed the smaller box core to accommodate the Louisiana Department of Transportation and Development's live loadings.

Using Diabolos

Another critical decision that greatly simplified the PT details was the use of diabolos, which allowed for a single form void in the segment deviators to accommodate the wide range of tendon geometry for the entire project. The use of diabolos streamlined segment fabrication by eliminating the commonly used bent steel pipes that require custom fabrication for each tendon's geometry and made PT installation easier by allowing the use of a continuous (unspliced) external PT duct between the anchorage diaphragms (see the Concrete Bridge Technology article in the Fall 2015 issue of *ASPIRE*®). This simplified PT detail reduced duct installation costs, provided for a better overall quality in the production of the precast concrete segments, and required fewer and more easily accessible fabrication and inspection points, which reduced the overall effort required to produce each box-girder segment.

Conclusion

In this $670 million project, the integration of the requirements for all three ramps into a single box-girder cross section maximized design, fabrication, and construction efficiencies. The philosophy of simplifying complexity through all stages of design proved successful. The bid for the precast concrete segmental design alternate was lower than the steel alternative. The project was successfully completed October 2018.

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Each of the three segmental concrete box-girder ramps has a horizontal curve and a linear haunch over the piers to increase the segment depth and maximize the span lengths while providing an aesthetically pleasing appearance.

Precast concrete box-girder segments were fabricated and stored at the project site. This view of ramp EN segments was taken from ramp SE. The segment fabrication plant is at the far left of photo.

External continuity tendons within the box-girder core. The same box-girder core was used for all three of the interchange's segmental concrete ramps.