CREATIVE CONCRETE CONSTRUCTION

Precast Concrete Components Save Time and Money on Texas Bridge Replacements

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Precast concrete bent caps and abutments were part of the accelerated bridge construction strategy that allowed the construction team to deliver the project under budget and ahead of schedule. All Photos and Figures: Texas Concrete Partners, LP.

When the Texas Department of Transportation (TxDOT) planned the replacement of the last five timber-pile supported bridges in the state-owned bridge inventory, the agency designed traditional prestressed concrete girder bridges to capitalize on their standardized details and durability (see the Project article on page 18). The prestressed girders were planned to be topped with cast-in-place (CIP) concrete decks and supported by conventional CIP substructure elements. However, the site constraints and long detour lengths led TxDOT to promote accelerated bridge construction (ABC) techniques for the completion of the two bridges on U.S. Route 83 (U.S. 83) and three bridges on Texas State Highway 15 (SH 15). After the plans went to bid, the contractor and precaster collaborated with TxDOT to maximize the use of precast concrete components, reducing both costs and duration of construction.

Contractor's Perspective

Collaboration and innovation were two key factors in the success of this bridge replacement project. ABC techniques using precast concrete components, including Northeast Extreme Tee (NEXT) D beams as well as precast concrete abutments and caps, allowed the construction team to deliver this project under budget and ahead of schedule.

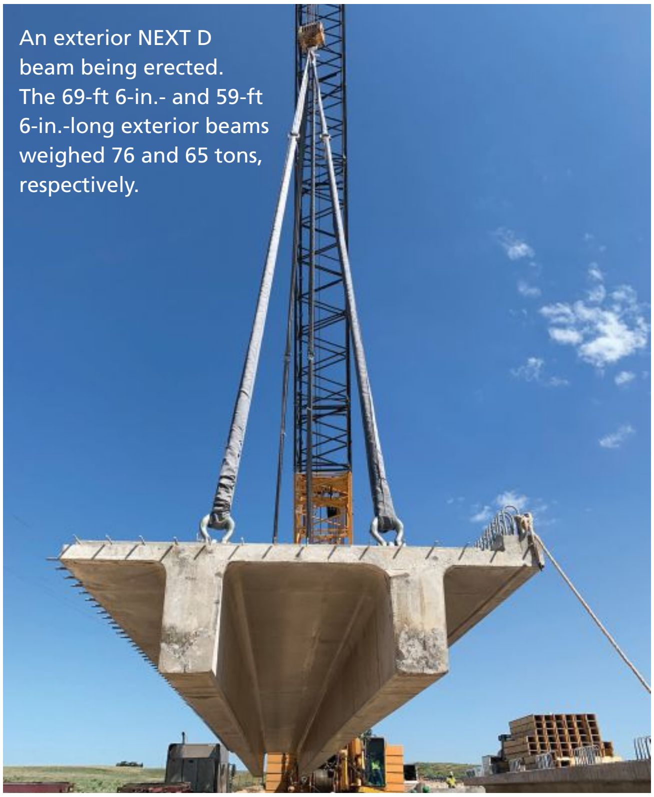
Minimizing Road Closures

The project involved replacing five existing bridges during extremely short traffic closures. Webber, the contractor, was able to demolish and rebuild each bridge with just 11 days of full traffic closures—40% faster than the allotted time.

Contractor's Proposed Innovation

The original contract plans included four decked-beam units that would be connected with ultra-high-performance concrete (UHPC) connections. Each unit included two Tx28 girders with a CIP concrete deck. The contractor proposed NEXT D beams in accordance with TxDOT's *Alternate Precast or Accelerated Bridge Structure Standard Operating Procedures*.[1] The contract had an incentive/disincentive clause, so the contractor chose NEXT D beams mainly to reduce schedule risk.

The superstructures of the bridges were built with NEXT D beams, which are precast concrete double-tee beams with integral $9\frac{1}{8}$-in.-thick top flanges that compose the structural bridge deck. This enabled the 46-ft-wide superstructure to be built with only four beams joined together by UHPC closure pours. Additionally, the use of precast concrete abutment walls, wingwalls, and bent caps helped reduce road closures and construction impacts on motorists.



An exterior NEXT D beam being erected. The 69-ft 6-in.- and 59-ft 6-in.-long exterior beams weighed 76 and 65 tons, respectively.

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Preparing to place concrete for the approach slab and the ultra-high-performance concrete longitudinal closure pours between NEXT D beams.

Setting a precast concrete abutment on the drilled-shaft foundations. Reinforcement extending from drilled shafts fits into ducts in the precast concrete cap, which are then grouted.

NEXT D beams stored at the precaster's plant. The top and bottom transverse reinforcement project from the sides of the top flange for the ultra-high-performance concrete closure pour. The top and bottom bars are staggered to avoid conflicts during erection. The notch in the top flange at the end of the beam is for a closure pour to make the flange continuous and avoid an open joint.

Webber improved upon the original design provided by TxDOT and coordinated their innovative ideas with the various players: project team, consultants, precaster, and TxDOT. Webber credits the success of this project to the joint efforts of everyone involved and the willingness of TxDOT to consider these innovative, alternate proposals.

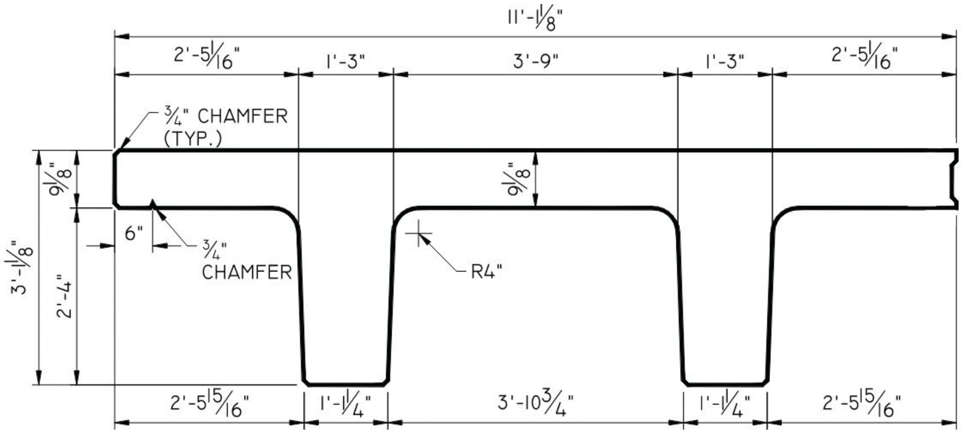
Precaster's Perspective

The project allowed the precaster, Texas Concrete Partners, an opportunity to invest in new forms to fabricate the precast, prestressed concrete NEXT D beams. The NEXT D beam self-stressing form can be customized to allow the top-flange thickness, top-flange width, and beam height to vary. The beam height can vary between 2 ft 4 in. and 3 ft 4½ in. Shallower beam heights can be fabricated by adding fillers inside the stems in the form. This flexibility allows the NEXT D beam section to be designed and fabricated to meet varying roadway widths, span lengths, or both.

The NEXT D beam section for all beams used on this project had a height of 3 ft 1⅛ in. and top-flange width of 11 ft 1⅛ in. The stems had a fixed spacing of 5.0 ft. For this project, the four NEXT D beams required for each span were able to accommodate a two-lane roadway transverse section with 10-ft shoulders and an out-to-out bridge width of 46 ft. The five bridges included a total of 4326 ft of nonskewed NEXT D beams: twenty-eight 69-ft 6-in.-long beams and forty 59-ft 6-in.-long beams.

The top flange of the beams functions as the deck and the final riding surface. The top flange thickness was increased from a more typical 8½ to

The 2¾-in.-thick elastomeric bearing pads are beveled 0.25 in. to match the 2% roadway cross slope and allow level bearing seats.



The NEXT D beam section used for all beams on this project. The NEXT D beam self-stressing form can be customized to allow the top-flange thickness, top-flange width, and beam height to vary. Given this flexibility, the NEXT D beam section can be designed and fabricated to meet varying roadway widths, span lengths, or both. The stem spacing is held constant at 5.0 ft. As shown here, the left side is an exterior face and the right side is an interior joint, which will receive an exposed aggregate finish for the ultra-high-performance concrete closure pour.

9⅛ in. to allow for diamond grinding after completion to meet TxDOT's Ride Quality for Pavement Surfaces requirements (Item 585).[2] The top and bottom transverse reinforcement in the top flange projected out of the side forms for the UHPC closure pour connection and consisted of hot-dip galvanized no. 5 bars at 9-in. spacing. The top and bottom bars were staggered to avoid conflicts during erection.

The shorter-span NEXT D beams contained thirty 0.6-in.-diameter prestressing strands with six debonded strands. The longer-span NEXT D beams had forty 0.6-in.-diameter prestressing strands with 10 debonded strands. All NEXT D beams had four fully tensioned, 0.6-in.-diameter prestressing strands in the top flange to reduce the top-flange tensile stresses at transfer (see the Concrete Bridge Technology article in the Summer 2018 issue of *ASPIRE*®). The 2¾-in. elastomeric bearing pads were tapered transversely 0.25 in. to match the 2% roadway cross slope. Whereas the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*[3] does not allow tapering of elastomeric bearing pads, TxDOT permits it in certain situations. In this case, tapering the pads allowed the bearing seats of the precast concrete bent caps to be level (but with varying heights), which facilitated fabrication.

The same self-consolidating concrete (SCC) mixture proportions were used for all NEXT D beams. The SCC design strengths were 6.0 ksi at transfer and 8.5 ksi at 28 days. The average 28-day concrete strength achieved was 10.15 ksi (19.4% greater than required). The only difference between the exterior and interior NEXT D beams was the projecting reinforcement for the Type T223 traffic rail for the exterior beams.

For the UHPC connection, Texas Concrete Partners applied a surface retarder to the sides of the forms of the top flanges to provide an exposed-aggregate finish according to TxDOT's *Surface Finishes for Concrete* (Item 427).[4]

The NEXT D beams had no embeds other than lifting loops and coil-loop inserts that were provided in the bottom of the top flanges to facilitate forming of the UHPC connection.

Because camber was an important design and construction consideration, it was monitored with camber measurements taken at transfer and again each week at the plant. As-built elevations were taken after the NEXT D beams were erected to finalize the deck grinding plan.

The precast reinforced concrete interior bent caps were fabricated to meet a 4.6-ksi concrete design strength. A total of 12 precast reinforced concrete interior bent caps were fabricated. The cap dimensions were 4.5 × 5.5 × 50 ft with the shear keys and bearing seats placed monolithically with the cap. The bent caps were fabricated using a lightweight concrete with a unit weight of 126 lb/ft^3. This reduced the overall cap weight from 106 tons (if normalweight concrete were used) to 86.4 tons, which minimized lifting requirements and transportation costs.

From the precaster's perspective, several factors motivated the use of NEXT D beams and precast concrete bent caps for this project: no skew, similar span configurations with only two beam lengths for the five bridges (seven 70-ft spans and ten 60-ft spans), same out-to-out bridge widths, and the same NEXT D beam section.

Conclusion

TxDOT was willing to consider and ultimately construct an alternate design that met the original contract requirements, although the girder section was not standard in Texas. This owner agency's flexibility and collaboration allowed the contractor to complete the project with less than 11 days of full traffic closures at each bridge location.

References

1. Texas Department of Transportation (TxDOT). 2019. *Alternate Precast or Accelerated Bridge Structure Standard Operating Procedures*. Austin: TxDOT.
2. TxDOT. *Item 585. Ride Quality for Pavement Surfaces Requirements*. https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/specs/2014/standard/s585.pdf.
3. American Association of State Highway and Transportation Officials (AASHTO). 2020. *AASHTO LRFD Bridge Design Specifications*, 9th ed. Washington, DC: AASHTO.
4. TxDOT. *Item 427. Surface Finishes for Concrete*. https://ftp.txdot.gov/pub/txdot-info/cmd/cserve/specs/2014/standard/s427.pdf.

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Using lightweight concrete for the bent caps reduced transportation costs and lifting requirements.