

DESIGN AND CONSTRUCTION OF THE I-10 TRINITY RIVER BRIDGE

by Michael D. Hyzak, David P. Hohmann, David Collins, and Brian Merrill, Texas Department of Transportation



By February 2011, traffic was using the westbound bridge. The total project was 75% complete. All photos and drawings: Texas Department of Transportation.

A combination of concrete solutions

The Trinity River Bridge carries heavily traveled I-10 over the Trinity River between Houston and Beaumont. The existing bridge built in the 1950s consisted of twin structures with a combined roadway width of 52 ft for two lanes in each direction. The existing bridge also had steep 4% grades to provide for 73 ft of navigation clearance. The main span consisted of fracture-critical steel through-girder systems. The existing bridge represented a choke point for the current traffic volume of 47,000 vehicles/day. The roadway to the west had already been widened to three or more lanes in each direction, and similar work is being done to the east. For these reasons, the project will provide welcome relief to a vital route.

Design Solution

An original concept was conceived using twin continuous steel plate girders

with piers in the water for the main river crossing and precast, prestressed concrete I-beams on the approaches. On the river crossing, this would have necessitated a significant amount of river access for construction. In addition, construction and maintenance of the pier fender systems would be required. With a river opening of 400 ft and environmental and navigational reasons to span the entire waterway, the most viable option became a segmental box girder bridge built using the balanced cantilever method. To minimize project costs, the approach spans remained precast, prestressed concrete I-beams. With the resulting reduced length of segmental spans, a cast-in-place segmental box girder cast with form travelers was the preferred structure type.

The project was let to contract in 2006. In February 2011, the project was approximately 75% complete. The new Trinity River Bridge has twin structures 3636 ft long with approach spans of 72-in.-deep precast, prestressed concrete I-beams supported on

reinforced concrete bents using 18-in.-square, precast, prestressed concrete piles. Twin 990-ft-long segmental box girder units carry traffic over the navigable Trinity River with 50 ft of vertical clearance. Each cast-in-place concrete box girder unit consists of a 450-ft-long main span flanked by two 270-ft-long end spans. The girder depth varies between 25 ft at the piers to 10.5 ft at midspan. This span arrangement with a back span-to-main span length ratio of 0.60 required a nominal amount of shored construction at each end. This was required to avoid conflict with existing multi-pile footing foundations from the existing structure.

The twin cell box girder structures are 62 ft wide at the top slab level. The 60 ft roadway width provides space for four lanes plus shoulders for each of the twin structures, for a total of eight lanes of capacity. The project phasing dictated the complete construction of the westbound bridge. Then, all traffic was rerouted onto the new structure to permit removal of the existing bridge

profile

TRINITY RIVER BRIDGE/ BETWEEN HOUSTON AND BEAUMONT, TEXAS

BRIDGE DESIGN ENGINEER: Texas Department of Transportation, Bridge Division, Austin, Tex.

SEGMENTAL CONSTRUCTION ENGINEER: Summit Engineering Group, Littleton, Colo.

PRIME CONTRACTOR: Williams Brothers, Houston Tex.

PRECASTER: Valley Prestress Products Inc., Eagle Lake, Tex.

POST-TENSIONING CONTRACTOR: Williams Brothers, Houston, Tex.

POST-TENSIONING HARDWARE AND SERVICES: VSL, Grand Prairie, Tex.

There were environmental and navigational reasons to span the entire 400-ft-wide waterway.

and construction of the eastbound bridge on the footprint of the former bridge.

The bridge features twin wall piers 42 ft tall spaced 20 ft 0 in. out-to-out in the longitudinal direction. Inclined pier table "A-frame" diaphragms 2 ft 9 in. thick, provide a requisite load path to the top of the piers during the balanced cantilever construction. The piers have sufficient longitudinal flexibility to reduce stresses from substructure restraint.

Post-Tensioning Provisions

The primary longitudinal post-tensioning includes both cantilever and continuity tendons. To simplify construction, balanced cantilever segmental bridges in Texas typically have each set of cantilever tendons anchored within the top slab at the stiff web to flange junction. Having the cantilever tendon anchorages at this location at the bulkhead face simplifies the traveler formwork in each typical segment. For each segment that is constructed, a single cantilever tendon containing thirteen 0.6-in.-diameter strands in each web is stressed with the live end at the bulkhead face of the segment previously cast and the dead end at the free end of the last segment in the opposite cantilever. As such, each segment has two anchorages in each web-to-flange joint. The end result is a series of cantilever tendons that increase in number as the construction progresses with the maximum number of tendons occurring at the pier table and decreasing in each segment moving away from the pier.



Nearing closure of the 450-ft-long main span of the eastbound bridge. The girder is 10.5 ft deep at midspan.

Sustainability

In Texas, alkali-silica reaction (ASR) is a very real problem that threatens the service life of concrete structures. Nearly 90% of the fine aggregate sources and over 60% of the coarse aggregate sources have the potential to develop ASR. To combat this problem, TxDOT uses prescriptive specifications, based on over \$8M in research, to mitigate ASR. These specifications go hand-in-hand with the specifications used for high-performance concrete (HPC), which provides low-permeability concrete. The result is very high-quality concrete in all structural elements to ensure long-term performance.

The prescriptive approach provides mix design options for contractors without the need for additional material testing. TxDOT's ASR mitigation options include the following:

- various supplementary cementitious materials (fly ash, silica fume, or ground-granulated blast-furnace slag)
- lithium nitrate admixture
- cement-only mixes with a limit on the total alkali content
- custom mix designs based on aggregate test results

In addition to the ASR mitigation requirements, TxDOT also has the following special requirements for mass concrete used for the footings and twin-wall piers:

- a maximum concrete temperature at time of placement of 75 °F
- a maximum temperature differential between the central core and the exposed surface of 35 °F during the heat dissipation period
- a maximum core temperature of 160 °F during the heat dissipation period

The contractor supplied several different concrete mixes for this project. The two main concrete mixes used for the segmental superstructure and the main pier substructure had a Class F fly ash content of 25% and 30%, respectively, of the total cementitious materials content to comply with TxDOT's ASR mitigation requirements. Both mixes produced concrete compressive strengths greater than 9000 psi during trial batch evaluations. The additional strength was not required by the design but was desired to keep the casting and stressing operations on schedule. These strengths were obtained with only 464 lb/yc³ of cement and 155 lb/yc³ of fly ash and a water-cementitious materials ratio of 0.40.

TWIN BRIDGES USING BOTH CAST-IN-PLACE CONCRETE BALANCED CANTILEVER SEGMENTAL MAIN SPANS AND PRECAST, PRESTRESSED CONCRETE BEAM APPROACH SPANS / TEXAS DEPARTMENT OF TRANSPORTATION, OWNER

CONCRETE SUPPLIER: ANT Enterprises, Baytown, Tex.

FORM TRAVELERS: Mexpresa, Mexico City, Mexico

BRIDGE DESCRIPTION: Twin bridges, 3636 ft long, 62 ft wide with a 990-ft-long, three-span, cast-in-place concrete segmental, variable-depth box girder unit (270, 450, and 270 ft span lengths) and 2646 ft of precast, prestressed concrete I-beam approach spans with AASHTO Type VI beams, up to 150 ft long, and 18-in.-square precast, prestressed concrete piles

BRIDGE CONSTRUCTION COST: \$67 million total project cost, \$37.5 million for bridges (\$164/ft² for segmental units and \$53/ft² for I-beam approaches)



This is one of the first TxDOT segmental bridges to incorporate an integral wearing surface.

The westbound bridge was completed first followed by demolition of the existing bridge and construction of the eastbound bridge in its footprint.

by four 0.6-in.-diameter strand tendons in flat ducts, used in conjunction with nonprestressed reinforcement for the cantilever and interior spans of the bridge deck. Three webs, 20 in. thick with nonprestressed reinforcement provide requisite shear capacity without the need for additional web post-tensioning to limit principal tensile stresses.

Integral Wearing Surface

The Trinity River Bridge is one of the first TxDOT segmental bridges to incorporate an integral wearing surface. The bridges are constructed with 3-in.-thick clear cover to the top mat of reinforcing steel in the deck, providing a maximum of 1 in. available for grinding to obtain the final surface profile and grading. The segmental superstructure called for a concrete design compressive strength of 6000 psi at 28 days.

Approach Spans

Approach spans on the bridge utilize conventional precast, prestressed concrete AASHTO Type VI beams with spans that range from 116 ft to 150 ft. Span lengths were dictated by the locations of existing substructure piles and footings combined with the desire to maximize span lengths and minimize footprint in the environmentally sensitive wetlands.

Conclusion

The new Trinity River Bridge on I-10 between Houston and Beaumont provides a significant increase in traffic capacity for this vital east-west route in Texas. The selection of twin, balanced cantilever segmental bridges also provides a solution that completely spans the 400-ft-wide commercial waterway while maintaining navigational clearances. When compared to alternative structure types, segmental construction provides better long-term durability in the

Forming of a pier segment showing cantilever tendon ducts and transverse deck tendon ducts.

aggressive environment found in the coastal regions of Texas. Long-term maintenance of the bridges is also enhanced through the elimination of labor intensive inspections required with certain other structure types. Economical precast, prestressed I-beam approach spans help limit the overall length of the more costly segmental portion of the bridge thus reducing the overall cost. This also provides the economic advantage of proven long-term durability of precast, prestressed concrete.

Michael D. Hyzak is transportation engineer, David P. Hohmann is the Bridge Division director, Brian Merrill is the Construction and Maintenance Branch manager, all with the Texas Department of Transportation in Austin, Tex., and David Collins is assistant area engineer with the Texas Department of Transportation in Beaumont, Tex.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

A nominal amount of shoring was required for the ends of the 270-ft-long end spans as they approached the transition to the I-beam approach spans.



The continuity tendons resist the relatively smaller positive moments from subsequent dead loads (and eventual live loads and long-term effects) once full continuity in the structure is achieved. The continuity tendons are anchored in blisters that rise out of the bottom slab at the stiff web-to-bottom flange junction. The Trinity River Bridge used 18 tendons each consisting of eleven 0.6-in.-diameter strands for the back spans and 30 tendons with the same configuration for the main span tendons.

The Texas Department of Transportation (TxDOT) specifies the use of plastic polypropylene ducts for internal post-tensioning. Compared to corrugated galvanized steel ducts, the plastic ducts are noncorrosive, provide better encapsulation of the grouted bonded tendons, and exhibit lower friction losses. The plastic ducts being used on the Trinity River Bridge require larger bending radii because of the stiffness of the ducts as compared to metal ducts and to avoid excessive abrasion when stressing the tendons.

Transverse post-tensioning is provided



PROJECT / TRINITY RIVER BRIDGE



One cell of the twin cell box girder showing the post-tensioning anchorage blisters for the continuity tendons. Forming is being installed for the deck closure pour between the ends of the main span cantilevers.



Forming of the inclined pier segment diaphragms in the twin cell box girder that is 25 ft deep at the pier and the pier segment after casting.



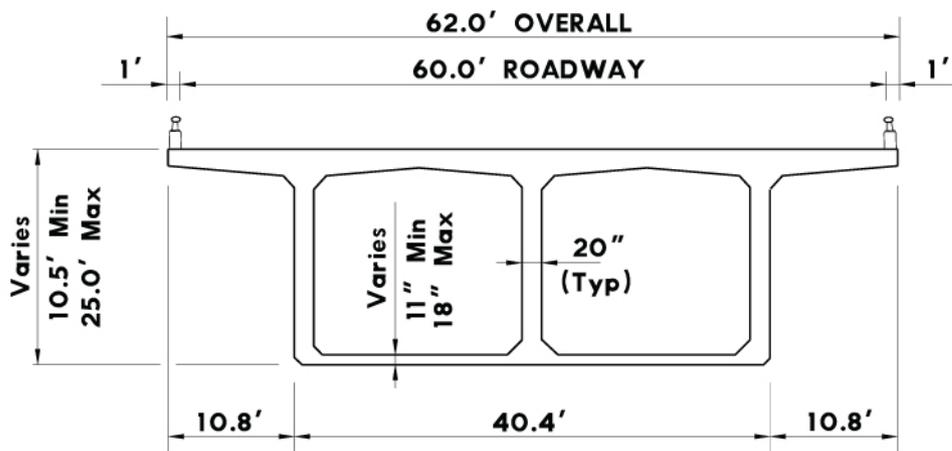
A form traveler was used to cast the 15-ft 6-in.-long segments.



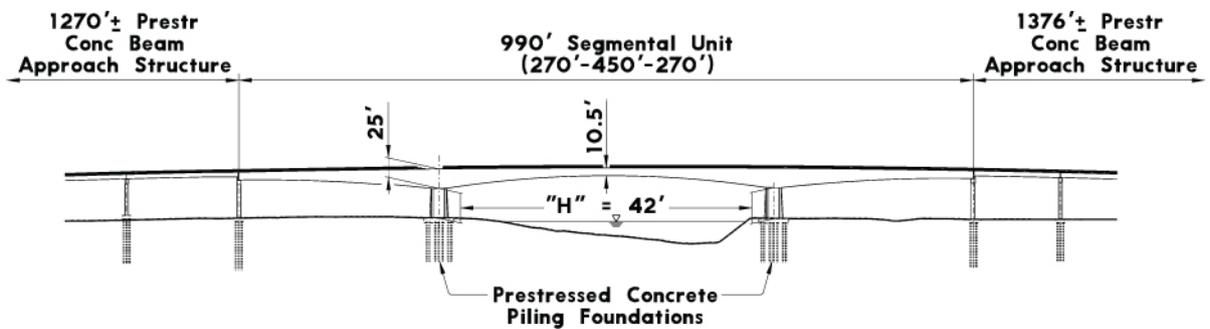
The Trinity River Bridge has cast-in-place concrete flared, double wall piers.



Approach spans for the Trinity River Bridge ranged from 116 ft to 150 ft and used precast, prestressed concrete AASHTO Type VI beams.

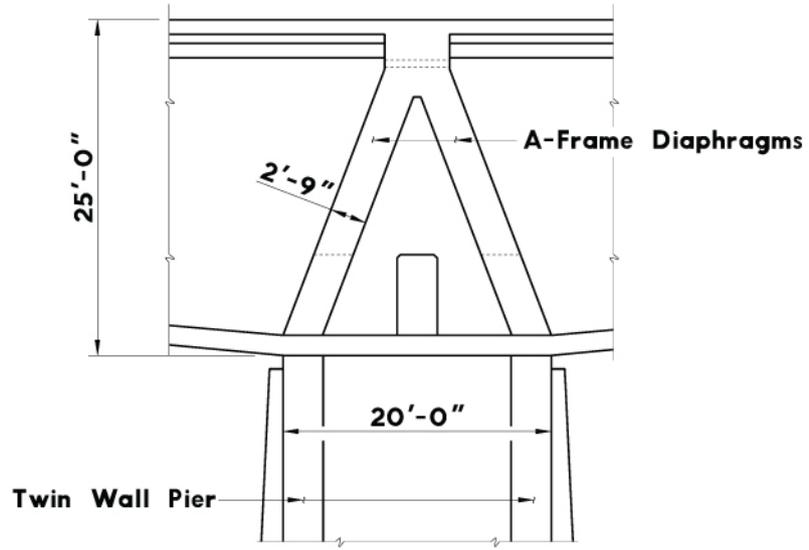


Cross section of the twin cell cast-in-place concrete box girder for the Trinity River Bridge.



Elevation of the 990-ft-long segmental concrete section of the Trinity River Bridge.

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Longitudinal section of the pier table segment with "A-frame" diaphragms and double wall piers.





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