



Segments were offset by one-half segment length to reduce the out-of-balance moment.

Photo: Traylor Bros.

I-45 Galveston Causeway

by Jon Holt, Texas Department of Transportation and Scott Turnpaugh, Traylor Bros. Inc.

Utilizing concrete to avoid corrosion issues

The new I-45 Galveston Causeway Bridge, which crosses Galveston Bay in Texas, replaces two existing structures that had outlived their useful service life. The new bridge uses a combination of precast, prestressed concrete I girders and a cast-in-place concrete, variable-depth, double-cell, segmental box girder. Replacing the bridges, however, required overcoming some significant challenges due to the difficult site and the need to remove all existing substructure components down to 2 ft below the mud line.

By the time of their replacement, the original bridges featured a complex mix of construction materials and techniques that had been used to make economical repairs to keep the structures in service. The oldest bridge, built in 1938, featured 121 cast-in-place concrete spans plus a steel bascule span at the Gulf Intracoastal Waterway (GIWW). That bridge was supplemented in 1961 with an adjacent structure, consisting of precast, prestressed concrete girders and structural-steel plate girders for the center span at the GIWW.

At the time the second bridge was added, a portion of the original bridge had spans replaced with precast, prestressed concrete

girders and a steel section to replicate the newer adjacent structure. After some years, due to the high level of exposure to chlorides in the marine environment causing corrosion and the advancing age of the structures, interim repairs to the structures were required. In 1979, footing repairs were completed, and in 1999, temporary repairs were made by installing steel girders beneath the deteriorated superstructure to provide additional support. Ultimately, it was decided that the structures could not be economically rehabilitated and needed to be replaced.

In considering options for the new structures, designers focused on the benefits and experience of the local construction community. Bridge projects in the Galveston area rely heavily on the precast concrete industry to provide materials for the bridges, which has resulted in no corrosion issues similar to those that arose on the bridges built many decades ago. The least cost construction method consists of precast, prestressed concrete I-beams, which have an approximate cost of \$65/ft².

As a result, AASHTO prestressed concrete girders were specified for the long approaches on either side of the waterway,

which make up most of the structure's 8592-ft length. A segmental box girder was used for the main spans over the waterway. Twin parallel bridges, built in multiple phases, were proposed in order to maintain traffic flow and avoid major impacts to adjacent right-of-way.

Navigation Span Features Box Girders

The main section of each bridge over the GIWW features a three-span, 740-ft-long section consisting of a cast-in-place concrete, double-cell box girder varying in depth from 8 ft to 19 ft. The three spans consist of two 195-ft-long end spans and a 350-ft-long center span. Twelve segments were used in the end spans and 19 segments were used in the center span.

The bridges were constructed using the balanced cantilever method. The design provided minimum vertical clearance of 73 ft at the edges of the 125-ft-wide navigational channel limits, and 310 ft horizontal clearance to the face of the pier bulkheads. The goal was to open the horizontal clearance as much as possible within the limits available.

profile

I-45 GALVESTON BAY CAUSEWAY BRIDGE / GALVESTON COUNTY, TEXAS

ENGINEER: Texas Department of Transportation

PRIME CONTRACTOR (INCLUDING POST-TENSIONING): Traylor Bros. Inc., Galveston, Tex.

REDESIGN ENGINEER: Summit Engineering Group Inc., Littleton, Colo.

PRECASTER: Traylor Bros. Inc., Galveston, Tex.

CONCRETE SUPPLIER: Dorsett Bros. Concrete Supply Inc., Pasadena, Tex.

POST-TENSIONING MATERIALS: VSL, Fort Worth, Tex.

The segmental unit was designed using ADAPT-ABI software with CEB-FIP factors included for shrinkage and creep. The contract plans detailed 15-ft-long typical segments, but the contractor suggested modifying that length to 5 m (16.4 ft) to optimize the benefits of their chosen form traveler and reduce the total number of segments. A production rate of two segments a week with a pair of travelers on each pier was achieved.

The three top slab cantilever tendons per segment were anchored over each web and utilized seventeen ½-in.-special strands per tendon. The bottom-slab continuity tendons were anchored adjacent to each web and utilized seventeen or twenty-five ½-in.-special strands per tendon. The concrete segmental unit was designed for a 28-day concrete compressive strength of 6000 psi.

The segmental main span pier substructure consists of two columns per bent founded on a continuous multi-pile footing. The columns are hollow, cast-in-place concrete and taper slightly. The footings are continuous between the two bents constructed in a phased sequence. They extend to the mud line. Each footing has a combined total of one hundred and fifty-four 24-in.-diameter steel pipe piles that are 109 ft long.

The design is similar to two previous bridges designed by the Texas Department

of Transportation (TxDOT), in their Austin Headquarters Bridge Division office and Houston District office. This allowed the design geometry to be reused, with the number of cells in the girders doubled to provide the 74 ft width required for three lanes of traffic in each direction, an auxiliary lane, and two full shoulders.

Approach Spans Feature Precast Beams

Each bridge is comprised of 35 approach spans north of the GIWW and 22 spans south of the GIWW. Typical spans consist of eight 72-in.-deep precast, prestressed concrete AASHTO Type VI beams at 9.44-ft spacing. The concrete design compressive strength is 6600 psi. The maximum bent spacing is 134.33 ft. The span lengths were based on increments of the existing bridge spans to avoid conflicts with the existing foundations. The bridge includes a 9-in.-thick deck comprised of 5 in. of composite concrete topping cast on 4-in.-thick precast, prestressed concrete stay-in-place deck panels. The deck has 2-in.-clear concrete cover over the reinforcement on top and slightly more than 1¾-in. clear cover on the bottom.

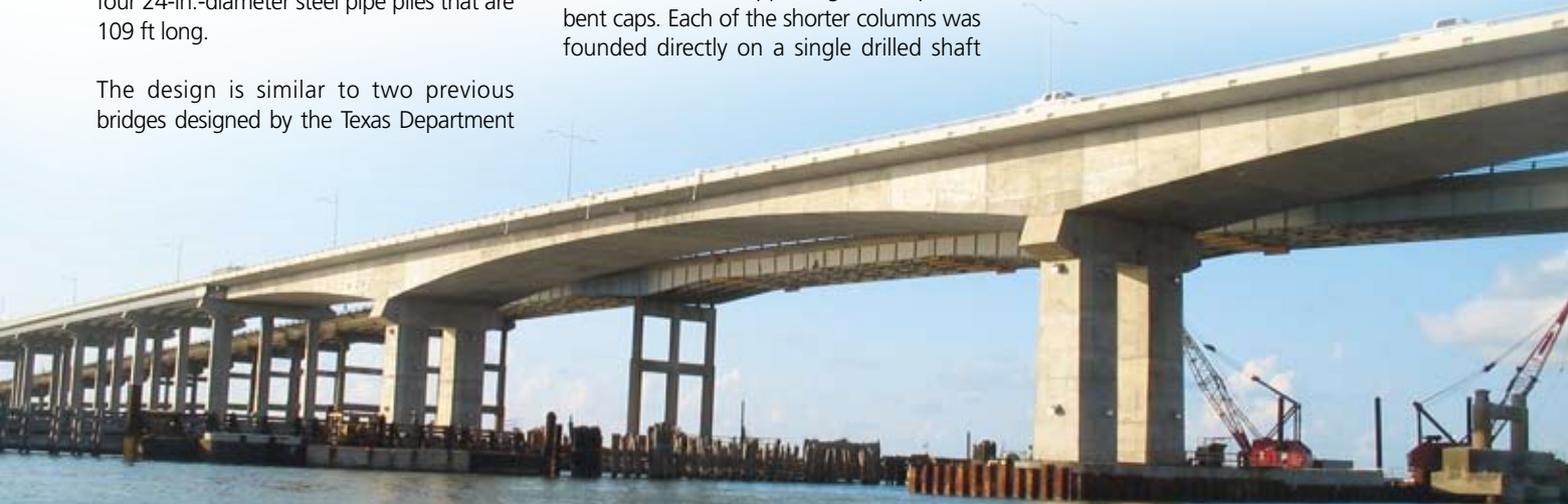
The shorter bents for each bridge consisted of four columns supporting two separate bent caps. Each of the shorter columns was founded directly on a single drilled shaft

up to 78 in. in diameter and up to 108 ft in length. Taller bents for each bridge used three columns and one large hammerhead bent cap. All columns on the taller bents are founded on footings with multiple drilled shafts up to 60 in. in diameter and up to 114 ft in length. Variable-depth concrete seal slabs with steel fiber reinforcement were incorporated in the footings to help resist vessel impact.

Rigorous permitting applications were required for the project, to ensure minimum impact to the environment, maximum safety, and careful consideration of all stakeholders' concerns.

Three Phases of Construction

Construction was accomplished in three phases, to continuously maintain three lanes of traffic in each direction during the project. In the first phase, the northbound bridge was constructed, erecting the concrete approach spans north and south of the GIWW and the navigation span concurrently. Once this bridge was completed, both northbound and southbound traffic was relocated to the new structure and the existing bridges were demolished. In the third phase, the second structure was erected directly adjacent to the first.



The new I-45 Galveston Causeway Bridge over Galveston Bay features three main spans 740-ft long consisting of cast-in-place concrete, double-cell, segmental box girder units that were constructed using the balanced cantilever method. Photo: Traylor Bros.

PARALLEL BRIDGES WITH PRECAST CONCRETE I-GIRDER APPROACH SPANS AND THREE-SPAN CAST-IN-PLACE SEGMENTAL BOX GIRDERS/ TEXAS DEPARTMENT OF TRANSPORTATION, OWNER

REINFORCEMENT SUPPLIER: Sunbelt Works Inc., Dayton, Tex.

HYDRAULIC GIRDER ERECTION TRUSS: DEAL, Italy

BRIDGE DESCRIPTION: Twin, parallel concrete replacement bridges, 8592 ft long and 74 ft wide, each consisting of 57 approach spans comprising precast concrete AASHTO Type VI girders and three center spans using a cast-in-place, two-cell, segmental box girder erected using the balanced cantilever method

BRIDGE CONSTRUCTION COST: \$136 million (\$107/ft²) that includes demolition and a small amount of roadway and landscaping to tie to the original roadway



End segments for the main spans were precast on the footing below their final location and lifted into position. Photo: Traylor Bros.

Phase 1

Multiple crews worked simultaneously, with the foundation crews followed by the substructure and superstructure crews in a fairly linear fashion. The segmental cantilever spans were cast-in-place separately, using overhead form travelers. The cantilever sections presented no unusual challenges. Each pier section was offset by one-half segment length to minimize the out-of-balance moment. The crews alternated between launching the form traveler on one side and then the other to complete each span. The two piers for these sections were placed adjacent to the GIWW, with backspan piers required on each side.

Most of the approach structures were built from barges, but nearly 2500 ft of the 8592-ft-long bridge were inaccessible by barge. The TxDOT evaluated several construction alternatives to facilitate construction in the shallow areas of Galveston Bay. Difficulties ruled out all options except construction from a temporary trestle bridge. This required permits from both

the U.S. Army Corps of Engineers and the U.S. Coast Guard.

Even with the trestle bridge, the reach of the crane was limited to setting only three of the eight 155,000 lb girders in a span. For these spans, a hydraulic erection truss was used to distribute the girders on the piers beyond the reach of the crane.

Phase 2

Demolition of the existing bridge was a critical and time-consuming aspect of this project. The TxDOT required the removal of all existing structures to a minimum of 2 ft below the mud line with eight elements adjacent to the waterway removed to 20 ft below the mud line to avoid any potential conflicts with vessel traffic. Structures that had to be removed included 234 cast-in-place concrete beams and slab spans, 238 two-column bents with tie-beams, 121 footings with two 9-ft-diameter concrete caissons per footing, 117 footings with two multi-pile footings and four 4-ft-diameter cased drilled shafts, and two 40-ft by 60-ft bascule pit foundations and walls founded

on piles. The TxDOT worked with the Texas Parks & Wildlife Department (TPWD) to create an option for transforming this debris into an artificial reef, but it ultimately did not prove to be cost effective in this case (see the sidebar).

Phase 3

Constructing the second bridge presented significantly more challenges than constructing the first one. The initial phase provided limited access on both sides. However, the second bridge was built with only a 1-in.-wide gap between it and the first bridge, which created difficulties for access and traffic control.

Aesthetics

Aesthetics treatments were focused on the bridge approaches in order to provide the most visual impact to the traveling public. Significant effort was put into design of the retaining wall enhancements and approaches, which had rustications added and were painted to follow the Houston District's Green Ribbon urban design scheme.

Additional visual interest was applied above the deck. This work included vertical undulations added into the bridge barrier's appearance to tie it to the district's "wave" pattern designs. Luminaires also were placed down the center of the roadway rather than at the edges, and the arms on the polls that support this lighting included the same wave designs.

The work was difficult, but necessary, and had to continue smoothly, even after Hurricane Ike hit the area. The result is two attractive, functional structures that will serve Texas and the City of Galveston for many decades to come.

Jon Holt is assistant district bridge engineer in the Houston District of the Texas Department of Transportation and Scott Turnpaugh is the project manager for Traylor Bros. Inc. in Galveston, Tex.

For more information on this or other projects, visit www.aspirebridge.org.

Recycled Reefs

In an effort to provide the most environmental benefits for the I-45 project as possible, the Texas Department of Transportation (TxDOT) for the first time varied from its bidding process to require contractors to supply two bids: one that included basic demolition and removal, and another one that reused a portion of the debris to create artificial reefs in the Gulf of Mexico.

The goal was to make efficient use of this mass of debris by placing it in a site in the Gulf of Mexico to create artificial reefs, as has been done in the past with other materials to good effect. The contract called for one bid to include costs for disposing of the materials as desired, while the other had to factor in dismantling 25% of the bridge materials and shipping them 25 miles offshore to be placed in the reef site.

The TxDOT worked with the Texas Parks & Wildlife Department officials as well as other organizations to determine which components could be barged easiest to the site for sinking. Designers also looked at how the components could be disassembled and placed on barges to find the most efficient approach.

Unfortunately, separating and shipping these components added costs to the project for all bidders, which caused the reef bids to be uniformly higher. As the TxDOT was required to accept the lowest bid, this artificial reef concept was not used in this case. But it remains a possibility for future bridges where environmental benefits could be achieved.



Webinar July 27

11:00 a.m. CT and 2:30 p.m. CT

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CE credits: 1LU, 1PDH

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I-45 GALVESTON BAY CAUSEWAY BRIDGE / GALVESTON COUNTY, TEXAS



The new I-45 Galveston Causeway Bridge over Galveston Bay features three main spans 740-ft long consisting of cast-in-place concrete, double-cell, segmental box girder units that were constructed using the balanced cantilever method. Top left photo was courtesy of Traylor Bros in ASBI SEGMENTS Vol. 48.



The main spans were constructed using the balanced cantilever segmental method.

I-45 GALVESTON BAY CAUSEWAY BRIDGE / GALVESTON COUNTY, TEXAS

Shorter bents had eight columns with four small bent caps and were built in two phases. Each column was founded directly on a single drilled shaft up to 78 in. in diameter and up to 108 ft long.



In areas where precast girders were erected from the temporary trestle bridge, a hydraulic girder erection truss was used to distribute girders laterally on the piers to compensate for the crane's limited reach.

Rigorous permitting applications were required to minimize environmental impact and maximize safety.



I-45 GALVESTON BAY CAUSEWAY BRIDGE / GALVESTON COUNTY, TEXAS

The bulk of the structures were built from barges, but some areas of Galveston Bay near the embankment were inaccessible, requiring a temporary trestle bridge.





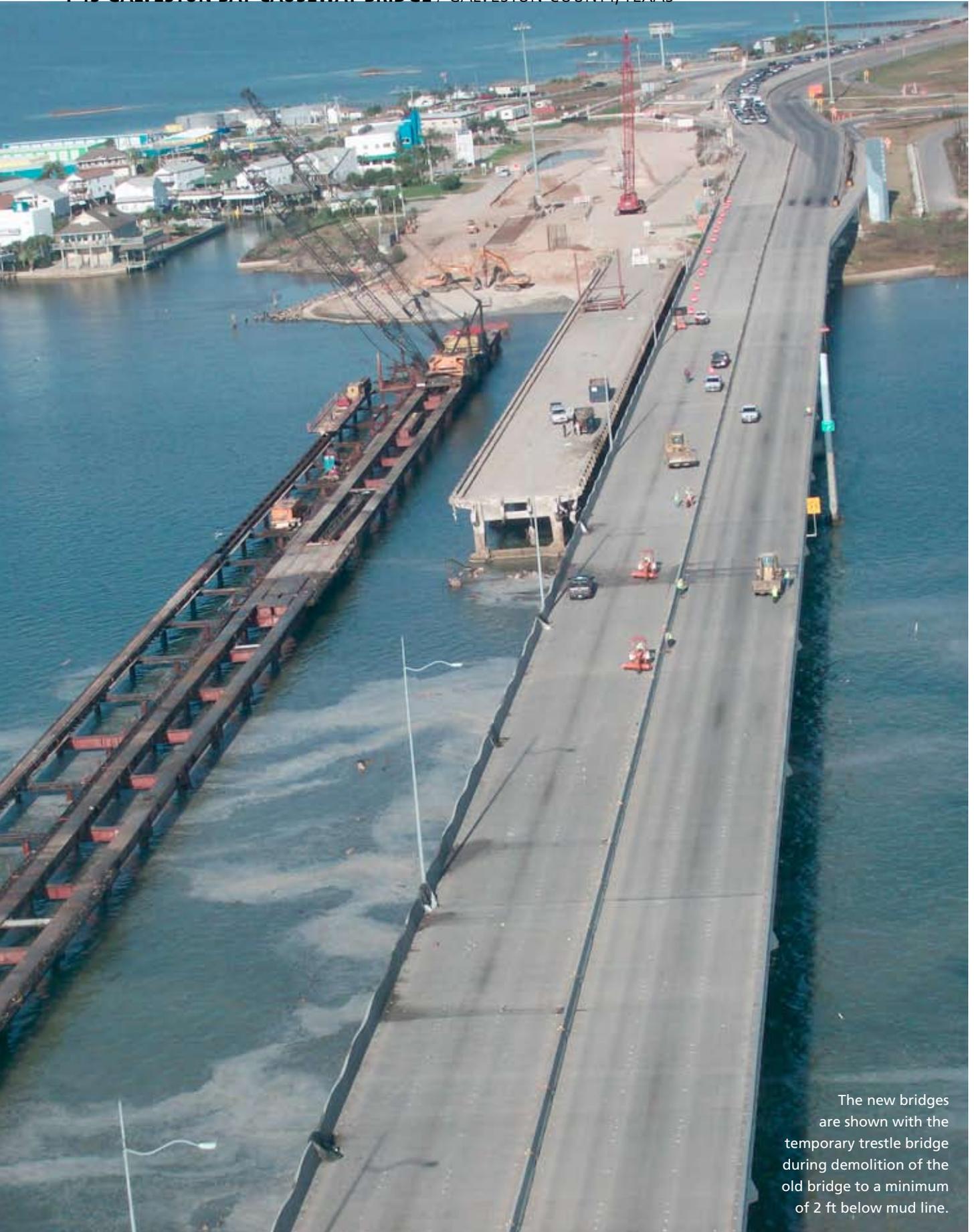
The construction was accomplished in three phases, to maintain existing traffic.

There were a total of 57 approach spans, with eight 72-in.-deep AASHTO Type VI girders comprising each span..

Visual interest was concentrated along the deck and approaches, including incorporating a wave pattern in the retaining walls that reflects the district's core design scheme.



I-45 GALVESTON BAY CAUSEWAY BRIDGE / GALVESTON COUNTY, TEXAS



The new bridges are shown with the temporary trestle bridge during demolition of the old bridge to a minimum of 2 ft below mud line.

I-45 GALVESTON BAY CAUSEWAY BRIDGE / GALVESTON COUNTY, TEXAS

