Concrete Bridges in Texas

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The State of Texas has a long history of successful implementation of concrete bridges, from simple I-beam spans to graceful segmental elevated freeways. Texas itself has a wide variety of geographic areas—plains, mountains, rivers, and coastline—each demanding different construction methods and durability considerations. With 33,000 on-system and 17,000 off-system bridges, the Texas Department of Transportation (TxDOT) finds it imperative to maintain economy, durability, and function. Using precast concrete, Texas continues to report one of the lowest bridge costs in the country.

TxDOT has been in the precast, prestressed concrete arena for over 50 years. The first bridge of this type, the San Bernard River Bridge in Austin County, was a post-tensioned, cast-in-place slab span built in 1952. This was followed by the first precast concrete beams on the Corpus Christi Harbor Bridge in 1956. Notable structures now abound all across the state.

TxDOT builds one segmental bridge every two years.

Standard Prestressed Concrete Elements

Precast, prestressed concrete beams are the predominant element used in Texas bridges. This is a reflection of the durability, low cost, and adaptability of prestressed concrete. A key factor in TxDOT's widespread use of precast, prestressed concrete beams is cross-section standardization, facilitating economical mass production of these bridge elements. No one cross-section is optimal for all bridges, leading to variations of beam type and size, each targeted to address specific bridge geometries and construction challenges.

I-beams are the most frequently used beam section due to their adaptability to a wide variety of span lengths, skew angles, and bridge curvatures. TxDOT uses five specific cross sections—its own Types A, B, and C beams along with AASHTO Types IV and VI. TxDOT's I-beam bridges are a case study in simplicity—the beams rest on elastomeric bearings, no permanent diaphragms between beams are used, and a deck slab, formed with precast sub-deck panels, is placed continuously over a number of spans, forming multi-span units. This simplicity results in TxDOT's low bridge costs.

Box beams are employed by TxDOT when the section depth of an I-beam exceeds specific bridge constraints and on rapid construction projects. These beam sections are TxDOT's own and have widths of 4 and 5 ft. They can be made with four depths ranging from 20 to 40 in. Placed side by side on bent caps and set normal to the roadway, the large shear keys are typically filled with concrete and the beams are then topped with either a concrete deck or an asphaltic concrete pavement (ACP) overlay. Transverse post-tensioning is applied only to the beams that will be topped with ACP.

Similar to box beams, TxDOT uses nonvoided slab beams, without shear keys and with a cast-in-place concrete deck. Details are provided for beam widths of 4 and 5 ft, allowing them to be fabricated on box beam precasting beds. They are available in depths of 12 and 15 in. Slab beams are excellent for short span bridges and especially when high span-to-depth ratios are necessary.

The TxDOT standard beam section best suited for rapid construction is the double tee. Details are provided for three depths ranging from 22 to 36 in. and widths of 6, 7, and 8 ft. Beam to beam connections have evolved over the years and the current connection utilizes a longitudinal bar welded in a v-groove formed by steel plates in the flanges. When speed of construction is imperative, the beams are topped with an ACP overlay; otherwise the beams are covered with a concrete deck.

The most unique standard sections are U-beams, developed in the mid 1980s by TxDOT in close collaboration with industry. These beams are tub-shaped with sloping webs and provide a more aesthetic option than I-beams. Standard depths are 40 and 54 in., with maximum span lengths of 105 and 120 ft, respectively. Although more expensive than I-beams, U-beam bridges require fewer beams—due to their high structural efficiency—which can result in an economic advantage. U-beams are being used in urban settings and, when coupled with an aesthetic substructure, present an attractive, clean appearance.

Prestressed concrete panels (PCPs) used as stay-in-place forms for bridge decks have become the main forming system for most beam-type bridges built in Texas. Approximately 85 percent of the prestressed concrete I-beam bridges use stay-in-place PCPs. This currently amounts to over 4.5 million ft^2 per year. The panels effectively replace the bottom half of the bridge deck and act as a safe and convenient work platform. The use of PCPs, first researched by TxDOT in the early 1960s and with widespread use in the early 1980s, represents a major improvement in the speed, cost, and safety of superstructure construction.

The new beam section can vary in depth from 70 in. on the left to 28 in. on the right.

New Generation Beams

Recently TxDOT began developing a new I-beam with the goals to improve the span-to-depth ratio, facilitate wider beam spacings, have a stable beam that is safe to handle and erect, and to take advantage of material improvements. The precast concrete industry joined TxDOT in the beam development process, providing valuable insight into beam production needs.

The new beam sections have a wide top flange resembling a bulb tee, but with a substantially larger bottom flange. Seven depths were created, covering all the sizes TxDOT uses from 28 to 70 in. The new beam has options to use 1/2- or 0.6-in.-diameter strand and the 7-in.-thick web allows for additional clear cover over the shear reinforcement to increase durability.

Numerous parametric studies were conducted during the preliminary development. Results from the studies indicate that, when compared to TxDOT's current I-beams, the new beams frequently allow for the elimination of at least one beam line from a given span. At a given span length, the new beams require a lower initial concrete strength than the current I-beams. Span-to-depth ratios are increased, with the greatest benefit being achieved in the shallower beam sections.

Precast bent caps produced cost savings, reduced traffic disruption, and improved work zone safety on the Jim Cowan Bridge, Lake Belton.

Innovation and Rapid Construction

TxDOT repeatedly looks to innovative solutions for both rapid construction projects and unique site constraints. Combining precast elements with existing standard beams increases the flexibility of construction and aesthetic options. Precast bent caps have gained popularity over the past 15 years, being used in applications over both water and busy interstate traffic.

The Jim Cowan Bridge over Lake Belton features both prestressed concrete U-beams and precast concrete bent caps. This 3800-ft-long structure won a Precast/Prestressed Concrete Institute (PCI) Design Award in 2005. The bridge employed an innovative cap-to-column connection. This connection facilitated the use of a precast concrete design, which featured relatively large precast hammerhead bent caps. Precasting the large, aesthetically pleasing caps produced significant cost savings, reduced traffic disruption, and improved both work-zone safety and product quality. The bridge has 54-in.-deep U-beams, topped with PCPs and a cast-in-place topping. Cast-in-place twin columns, which facilitated underwater construction, support the precast caps.

In 2004, the pretopped U-beams debuted. The beams were developed at the initiative of the Texas precast concrete industry to provide an alternative section for rapid construction projects. The pretopped U-beam is a version of the standard U-beam. Instead of using PCPs to form the deck, a 7-in.-thick slab is cast on the beam by the fabricator, providing a total beam depth of 34 in. The beams are spaced with a 1- to 8-in.-wide gap between flanges, and the deck is completed with a closure pour over the gap and a 4-in.-thick topping. The pretopped U-beam is best suited for long-span structures that require a shallow superstructure.

The pretopped U-beam was first implemented on a totally prefabricated bridge project, Loop 340 over I-35 in Waco, Texas. Because I-35 is a major interstate route through Texas, minimizing impact on the traveling public was of utmost importance. Along with the pretopped U-beams, unique precast columns that support each beam line were designed for the project. A direct result of the speed of construction emphasis was beam placement with only one traffic closure. The precast deck also reduced the amount of forming that must be done over the traffic lanes, making a safer environment for the workers.

Another beam developed for rapid construction is the decked slab beam. This beam falls into a class with box beams, double-tee beams, and slab beams—well suited to off-system replacements that must be opened quickly to minimize disruptions caused by long detours.

The decked slab beam was developed for an off-system bridge project built in February 2006. This bridge, over Battleground Creek near Austin,

Pretopped U-Beams provide an instant work surface as illustrated in the bridge project, Loop 340 over I-35 in Waco, Texas.

Texas, won a 2006 PCI Design Award. The decked slab beam is a standard 5-ft-wide, 15-in.-deep slab beam with an integral 8-in.-thick, 7-ft 6-in.-wide slab on the top creating a T-shaped beam. The bridge was completed in just six weeks.

The advantages of the decked slab beam are a reduction of cast-in-place concrete in the bridge, quick installation, a very shallow superstructure, and a wide cross-section that minimizes the total number of beams. All of these benefits were essential to the success of this particular project. The weight of these beams, 1700 plf, required special considerations for transporting and erecting. Also, the project used precast abutments connected to steel piles, an ACP overlay, and bolted rails, all aimed at simplifying installation.

Segmental Concrete Bridges

Texas leads the nation in the number of concrete segmental bridge spans. The first precast segmental structure, built in 1972, was the John F. Kennedy Memorial Causeway in Corpus Christi. Currently, TxDOT builds approximately one segmental bridge every two years. Segmental

The decked slab beam was developed for rapid construction (completed in just 6 weeks) in the County Road 453 Bridge over Battleground Creek.

bridges are very economical for spans of 300 ft or greater, and have found much favor along the Texas coast, where seven structures are built or under construction. Segmental structures have also been beneficial in urban settings when repetition of spans can be achieved. Long, elevated segmental structures have been built in Wichita Falls, Austin, and San Antonio. After solving some grout placement issues in the early years, the durability of segmental bridges has proven excellent.

The only precast concrete segmental cable-stayed bridge in Texas is the Veteran's Memorial Bridge spanning the Neches River near Port Arthur. The bridge was built in 1991 and has a main span of 640 ft. The pier towers and bridge superstructure are made from precast, post-tensioned segments and the bridge is a tribute to the efficiency and durability of precast concrete construction.

Bridges in Texas

Concrete bridges are a hallmark of the Texas transportation system. In fiscal year 2005, Texas placed almost 1 million linear feet of precast, prestressed concrete beams, enough to stretch from Dallas to Austin laid end-to-end. Prestressed concrete beams and panels help Texas maintain one of the lowest bridge construction costs in the United States. Excellent durability of the precast elements minimizes life-cycle costs. Increased speed of construction minimizes the impact to the traveling public and increases safety in the work zone for both motorists and construction personnel. The development of standard beam designs and a constant look toward innovative solutions will ensure that precast concrete will continue to meet the needs of the Texas bridge building efforts.

For more information on Texas' bridges, visit www.dot.state.tx.us/bridge.