Barton Creek Bridge

By Mark W. Holmberg, P.E.

Figure 1: Concrete Fin-Back Bridge Crossing 80-feet Above Barton Creek.

This concrete fin-back bridge rises eighty feet above the streambed that carries Barton Creek into Austin, Texas and eventually to the Colorado River (*Figure 1*). The bridge is the main entrance to The Estates of Barton Creek subdivision, a country club community of million dollar plus homes. The bridge was constructed during 1985 to 1987, and was opened for traffic in 1988. The design and construction of the bridge was perhaps the first application of a fin-back, balanced cantilever, cast-in-place, post-tensioned bridge in the world.

The bridge is 686 feet long and consists of three spans: 156-feet, 340-feet, and 190-feet. The unsymmetrical span arrangement was dictated to respect the environmentally sensitive gorge and stream buffer/greenway area adjacent to the creek. The basic superstructure form is a triangular box with concrete ribs and struts supporting a concrete deck. The fin-back name derives from the central fins, or walls, which rise from the triangular box to peak over each intermediate pier. The fins encase post-tensioning ducts, which take advantage of the large eccentricity of the post-tensioning force in the negative moment regions of the structure. The bridge provides a two lane roadway with central median barrier required to accommodate the fin.

Project History

During 1983, the developer of The Estates of Barton Creek, Barnes Connelly Investments, negotiated with Travis County for permission to build a new road, including a landmark bridge that would minimize visual and environmental impacts to the steep slopes and flood plain of the Barton Creek gorge. The primary need for the road and bridge was to provide the shortest route from the subdivision to downtown Austin. In May 1984, the developer hired engineers, including Atlanta based Tony Gee + Quandel, Inc., to study a cost effective solution for the bridge.

The developer and engineer were aware of problems and expense experienced by the Texas Department of Transportation (TxDOT) in 1981 during construction of a multi-span pre-stressed concrete (PSC) girder bridge over Barton Creek, approximately six miles downstream from the proposed crossing. Due to environmental constraints, the TxDOT contractor was required to use over-the-top methods for erection of the PSC girders. This required a costly girder launching gantry in order to place the PSC girders from above.

The developer and Travis County wanted to minimize the number of piers in the area near the creek. The following alternates were considered:

- Single-span cable-stay bridge
- Single-span suspension bridge
- Three-span cable-stay bridge
- Three-span conventional variable depth box girder bridge
- Three-span concrete fin-back bridge

The three-span fin-back bridge was ultimately recommended because it was the most economical alternate, limited disturbance of the creek flood plain due to balanced cantilever construction, accommodated the required unsymmetrical span arrangement, and provided a novel gateway for the subdivision.

Design

The central location of the main pre-stress force presents design challenges for the fin-back bridge. Conventional hollow box sections require internal struts to carry loads to the center web/fin. This is a similar design situation for cable-stayed bridges with a single plane of stays, such as the Sunshine Skyway Bridge in Tampa, Florida. To overcome the internal strut issue that would complicate cast-in-place segmental construction, the Barton Creek Bridge designers developed a constant depth triangular section with external struts supporting transverse ribs, which in turn supported an eight-inch slab spanning between the ribs (*Figure 2*). The triangular section allowed the central fin to start at the apex of the triangular section. This junction also provided a sufficient area in which to anchor the pair of main post-tension tendons required for each segment.

The bridge was designed to be built as a cast-in-place balanced cantilever using a form traveler. A typical segment length of 11feet 4 inches was selected to accommodate a reasonable size form traveler. The deck ribs and struts were located near the leading edge of each segment, again primarily for support of the form traveler.

A unique aspect of the design is that the fin was raised as a series of lifts above the deck. The initial lift made by the form traveler included starter bars for the fin. As balanced cantilever construction advanced, the fin was raised following completion of three pairs of segments.

Longitudinal analysis of the superstructure indicated that shear lag, or concentration of post-tensioning force at the center of the section, was a concern during initial stages of construction. To overcome this

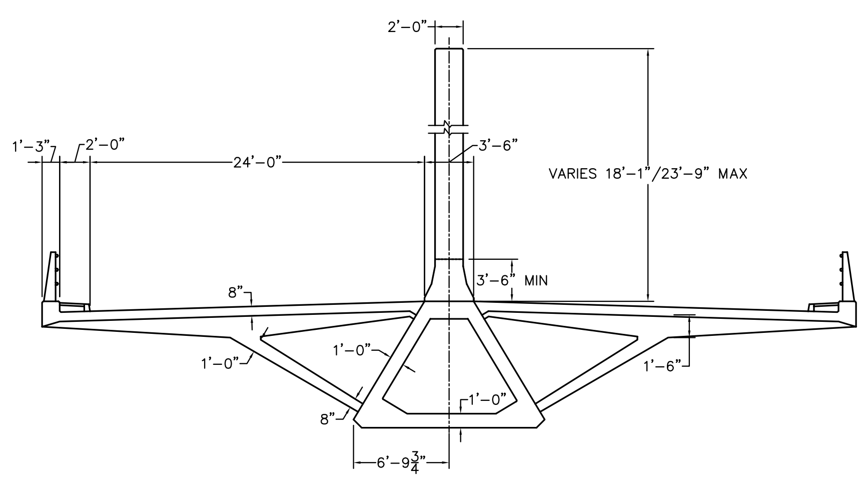

Figure 2: Barton Creek Bridge Typical Section.

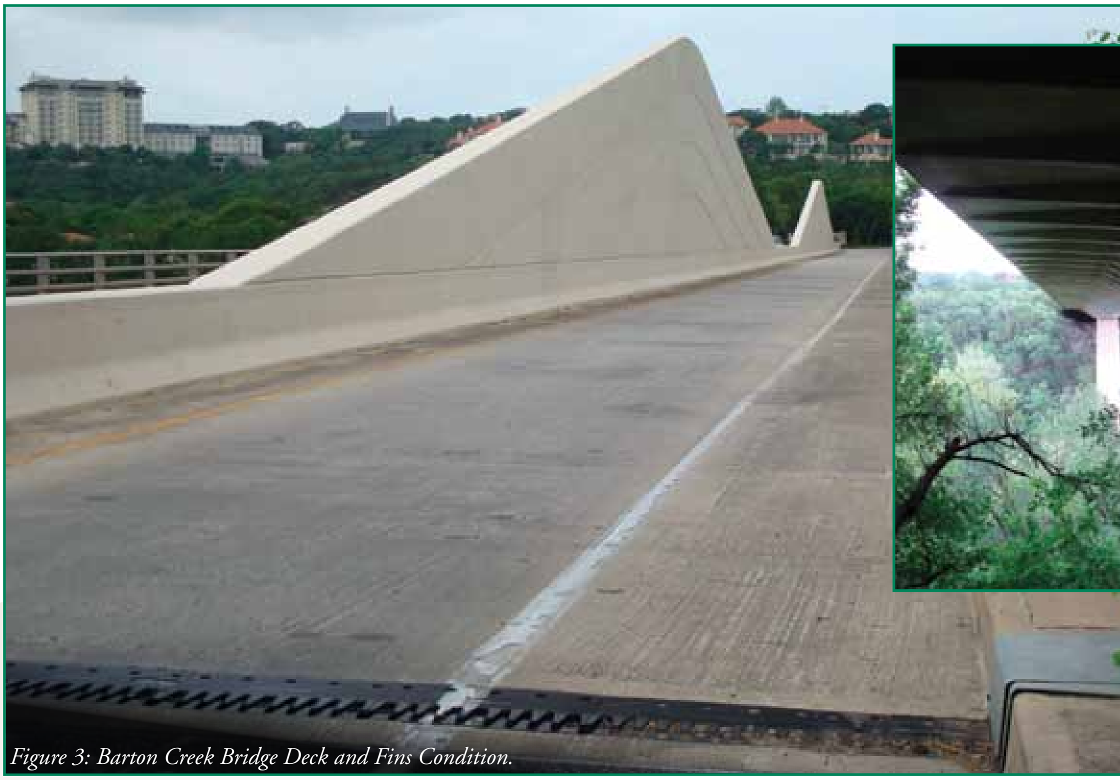

Figure 3: Barton Creek Bridge Deck and Fins Condition.

Figure 4: Underside of Barton Creek Bridge with Struts and Water Lines on Overhang and Twin Shaft Piers in the Distance.

situation, a high strength post-tensioning bar was added to a beam/parapet at the exterior edges of the deck. This progressively coupled bar was stressed following casting of each segment.

To overcome the tension created by the strut geometry, the ribs were post-tensioned transversely with a four 0.6-inch strand tendon, and the main triangular webs were post-tensioned with two high strength bars located at the struts.

The bridge substructure consists of two abutments and two main piers comprised of pairs of flexible rectangular shafts, 3½ feet thick and 11feet 4 inches apart to match the superstructure segment length. The shafts are integral with the superstructure. The twin shaft design supported out-of-balance construction loads in addition to final wind, live loads, and shrinkage and creep forces anticipated during the life of the structure.

Foundations for the abutments and piers consist of drilled shafts founded in sound limestone. Abutments are supported on four 36-inch diameter shafts between 15 to 25 feet deep. Each pier is supported on six 60-inch diameter drilled shafts, approximately 30 feet deep.

Following completion of the design and contract documents in late 1984, Travis County hired HNTB to perform a design review of the unusual project. No major comments resulted from this review and the project was advertised to a group of pre-qualified contractors.

Three bids were received for the bridge, with the successful contractor being Prescon Corporation, a subsidiary of a large French contractor, Campenon Bernard. The bid price was $3.6-million.

Construction

Following execution for the construction contract in October 1985, the contractor immediately began design of the form traveler system. Foundation construction began in November 1985. Superstructure construction began in March of 1986 with construction of the east pier table.

Following construction of the pier table, the form travelers were erected. Due to the limited length of the pier table (34 feet) the travelers were linked together to provide out-of-balance stability for the first two pairs of segments on each side of the pier table. Following post-tensioning of the first two pairs of segments, the form travelers were separated and moved independent of one another. The travelers were anchored to each rib by means of high strength post-tensioning bars placed in small deck block-outs.

There were two disadvantages of the external ribs and struts. The first involved the distance required for dropping the deck forms to clear the just-cast segment. The final form traveler developed by the contractor combined partial disassembly of web, rib, and strut forms and lowering of the deck to clear all obstructions.

The second disadvantage involved casting and consolidating concrete in the relatively long, slender struts. To overcome this potential problem, the designer allowed a pre-cast strut option, which the contractor ultimately chose to use for all pier table and segment struts.

Twenty Years after Construction

The author visited the bridge site in May 2009. The bridge appeared to be in excellent condition, with no obvious signs of distress. The wearing surface is sound with no evidence of cracks. It appeared that the fins had recently been painted and new deck joints had been installed at each end of the bridge (*Figure 3*). The bridge carries water lines on each side of the main triangular section (*Figure 4*), as well as a pair of conduits inside the main section.▪

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