

Arapaho Road Bridge Blends Steel Arch with Prestressed Beams

By Cliff R. Hall, P.E.

The award winning Arapaho Road Bridge carries four lanes of traffic and a pedestrian walkway over Midway Road and adjacent parking lots. This 1575-foot long, 52-foot wide bridge is comprised of 13 approach spans and a 170-foot signature arch main-span. The main span deck, comprised of prestressed U-beams and deck panels, is suspended by a series of nine steel hangers supported by two unbraced steel pipe arches. Triangular reinforced concrete thrust blocks, over 24 feet tall, rise towards the deck to support the arch-ribs. The thrust blocks are founded on three 60-inch diameter drilled shafts. The approach span U-beams are supported on single column bents, founded on single 8-foot diameter drilled shafts.



Workers stressing the hanger at the center diaphragm over the temporary bent.

Design Competition

When the Town of Addison needed to construct the Arapaho Road Bridge over the highly congested Midway Road, the Town knew it didn't want a "typical" highway bridge. They wanted to maintain a budget of \$5 to \$6 million for this bridge, but were looking for a landmark structure that would help define the Town. Using a design competition between three short-listed firms, the Town was able to select a concept from several unique designs. The winning concept was presented using 3-D computer renderings and videos. This concept depicted a structure that utilized twin steel pipe arches to support a prestressed U-beam superstructure. While the architectural enhancements and specialty lighting created a visually stunning bridge, the innovative engineering approach that combined these prestressed and steel elements created a design that could be constructed with minimal impacts to the commuters below.

Innovative Design

During the development of the design, the engineers recognized that, in order to minimize costs, the bridge would need to use standard materials and construction methods as much as possible. Therefore, the design used four lines of prestressed U-beams, an inexpensive yet aesthetically

The Arapaho Road Bridge was presented a Merit Award, Bridges and Transportation Structures, in the 2006 NCSEA Excellence in Structural Engineering Awards Program.



The 170-foot Arapaho Bridge is illuminated with specialty lighting. Courtesy of www.dave-lawrence.com.

pleasingsuperstructure, along the entire length of the bridge. For the 170-foot main span, this was accomplished by taking advantage of the median in Midway Road and the structural support of the pipe arches.

Prestressed U-beams are typically used in Texas highway bridges to span up to 120 feet. Transport lengths of bridge girders are also usually kept below 150 feet. Therefore, the designers specified a spliced U-beam that would be temporarily supported in the median of Midway Road. By ultimately supporting the superstructure from the arch ribs, these beams would easily span the required 170 feet. The beams and the cast-in-place transverse diaphragms were designed for the temporary conditions, the final configuration and for consideration of hanger replacement or loss. The arch ribs were designed to be self supporting during construction, to accommodate the change in forces during the hanger stressing as well as support the deck under normal loading conditions and hanger replacement or loss. The arch ribs were also designed for global buckling, local buckling effects considering ovalization of the pipe.

Construction of the Bridge

The construction of the bridge proceeded using the suggested methods of the designers. First the thrust blocks, which also serve as the main span bents, were constructed adjacent to Midway Road. Once completed, the north arch rib was erected. These arches were fabricated using induction bending to create the required compound curvature. The arches were erected in two pieces and welded to-

gether. A temporary bent was then constructed in the median to support the four pairs of 84-foot prestressed U-beams. These beams were made continuous by welding the reinforcement protruding from the ends of the U-beams and casting a concrete closure pour that also served as the transverse diaphragm. Next, the south arch was erected in similar fashion. The remaining transverse diaphragms were then cast. Afterwards, prestressed deck panels were placed on top of the U-beams and a 4-inch thick reinforced, cast-in-place concrete deck was added. Once the concrete diaphragms reached sufficient strength, the structural steel hangers were installed and stressed in a specified sequence to ensure that the final desired hanger forces and deck profile were met. This sequencing also lifted the bridge off of the temporary bent.

The pipe arch-ribs were designed to be self supporting during construction, which eliminated any need for temporary bracing. The use of standard U-beams and deck panels allowed the construction to proceed without much additional disruption to the traffic under the bridge. Intermittent overnight road closures were used for the erection of the arches, beams and deck panels.

The Arapaho Road Bridge was constructed in 18 months and opened to traffic in January 2006. The entire structure was constructed for \$5.26 million. Specialty lighting on the arch span and roadway lighting along the length of the deck added another \$700,000 to the cost of the bridge. ■

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