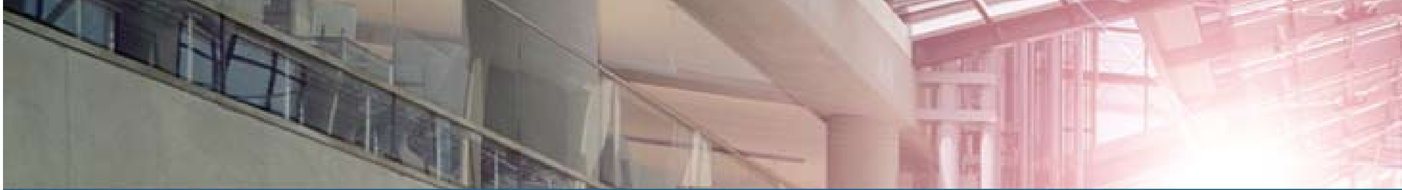

Award-winning Iowa bridge uses new UHPC pi-girders

The Jakway Park Bridge in Buchanan County, Iowa, is the first North American highway bridge built with a new generation of ultra-high-performance concrete (UHPC) pi-girders, the first highway bridge to incorporate batching of UHPC in a ready-mix truck, and the third in North America and second in Iowa built with UHPC girders.

This combination of leading attributes was the winning recipe for a 2009 PCI Design Award for bridges with main spans up to 75 ft (23 m) and an Iowa Quality Initiative Structures Research Merit Award from the Associated General Contractors of Iowa and the Iowa Department of Transportation (DOT).

The pi-girders were designed by the Federal Highway Administration (FHWA) and optimized to use the UHPC. The girders are named for their cross-section profiles, which resemble the Greek letter π, with bulbs at the bottoms of the stems. Lafarge's UHPC, Ductal, was used for this project and provides compressive strengths up to 30,000 psi (210 MPa) and flexural strengths up to 6000 psi (42 MPa).

Dean Bierwagen, methods engineer for the Iowa DOT Office of Bridges and Structures, says, "Because of the large amount of salt or salt brine that we place on our decks for deicing and the heavy loads that cross them daily, corrosion and durability are an ongoing problem. With the higher strength, durability, and low permeability that I've seen with the UHPC, it could improve the performance of our bridge decks if used there."

The Jakway Park Bridge in Buchanan County, Iowa, uses pi-girders made with ultra-high-performance concrete to make the bridge more durable. Courtesy of Iowa Department of Transportation.

The completed Jakway Park Bridge in Buchanan County, Iowa, opened in November 2008 after about two months of construction. Courtesy of Iowa Department of Transportation.

Several challenges influenced the design process and drove the eventual development of the second-generation pi-girder. "Testing of the full-scale prototype pi-girder validated the flexural and shear capacity in the longitudinal direction but also demonstrated that the stresses in the transverse direction of the deck were unacceptable for service loading," says Benjamin Graybeal, FHWA research structural engineer. "The deployed pi-girder used on the Jakway Park Bridge addresses this concern while allowing for a simplified fabrication process compared with the prototype. The UHPC pi-girder concept presents new opportunities in terms of addressing critical issues, such as the need for rapid bridge replacements and extended bridge service lives."

The UHPC's unit material costs are high compared with conventional, normalweight concrete, so the need to optimize the quantity of material was an essential economic consideration. This led to a special customized design that permitted the superstructure and deck to be partially cast in place and partially precast concrete.

The 24 ft 3 in. × 112 ft 4 in. (7.4 m × 34.2 m), $600,000 bridge was designed by the Office of Bridges and Structures at the Iowa DOT and the Bridge Engineering Center at Iowa State University. The pi-girders were produced at Lafarge's precast concrete manufacturing facility in Winnipeg, MB, Canada.

Beam fabrication began in September 2008, and the bridge opened to traffic on November 26, 2008.
—Source: Lafarge North America and Iowa DOT

Precast trumps CIP for remote mountain bridge

After a slide closed the main highway linking the resort town of Wrightwood, Calif., and Los Angeles, Calif., in March 2005, the California Department of Transportation (Caltrans) needed a bridge solution that would take into account the active nature of the slide and the precarious location.

The side of the mountain continued to slump more than 500 ft (150 m) to the valley floor, and efforts to stabilize the mass of rock proved ineffective. It became evident that the best solution was to place abutments on stable soil comfortably outside of the slide limits.

This decision meant that the bridge span would reach more than 200 ft (60 m) long. A cast-in-place structure was eliminated from consideration because falsework could not be placed on the sliding mass of rock and soil, and steel was more expensive and required a six-month delivery schedule. After careful consideration and planning with industry representatives, an 8 ft (2.4 m), spliced, precast concrete bulb-tee girder was selected for the new Angeles Crest Bridge No. 1 on state route 2 in Wrightwood.

The girder had to be fabricated in pieces short enough to maneuver the two-lane mountain roads that led to the site. It was divided into three pieces: two 56 ft (17 m) end sections, which housed the post-tensioning anchorages, and one 92 ft (28 m) center section with a 2 ft (0.6 m) cast-in-place closure pour between the segments.

Girder transport was extremely difficult because of the tight radius curves, which also had significant amounts of superelevation. Girders of this size and length can become laterally unstable when subjected to cross slopes that place the center of mass of the girder offset from the support. To compensate for this, special hauling rigs called platform trailers were constructed. These trailers were equipped with hydraulics that allowed the support on which the girder sat to be automatically adjusted for the superelevation and could maintain the girder in a vertical position.

In addition to logistical challenges, the bridge site included weather concerns.

With the site at over 6500 ft (1980 m), the bridge needed to be protected from corrosion and the freeze-thaw cycles. The required design strength for the girders was 8500 psi (2.6 MPa) at 28 days. This, coupled with the requirement for 6% air content, necessitated the development and testing of special concrete mixture designs. To improve corrosion resistance, all of the reinforcement in the deck, including the girder stirrups, was treated with epoxy.

The bridge geometry further complicated the design due to the significant grade and the tight radius curve

The Angeles Crest Bridge No. 1 on state route 2 in Wrightwood, Calif., pitted designers against location and weather challenges. Courtesy of Pomeroy.

To transport the girders for the Angeles Crest Bridge No. 1 on state route 2 to the construction site, trailers were equipped with hydraulics that allowed the support on which the girder sat to be automatically adjusted for the superelevation and could maintain the girder in a vertical position. Courtesy of Pomeroy.

of the original highway profile. Designers increased the curve radius by choosing a slightly wider deck than the two-lane roadway would require. The center of the road curved as it proceeded across the bridge and allowed the traffic to maintain speed while negotiating the steep grade through a gentler curve that was now independent of the existing mountainside terrain.

Although the road was closed because of damage in March 2005, the bid date wasn't until May 2008. Girder fabrication then began in July 2008, and the bridge officially opened on May 20, 2009.

Pomeroy was the precaster that worked on the \$2.6 million, 208-ft-span × 42-ft-wide (63 m × 13 m) mountain-pass bridge with the Caltrans district staff and its bridge design group. The bridge is a 2009 recipient of the PCI Design Award for bridge with a main span of more than 150 ft (46 m).

—Source: Pomeroy

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