Highway Braid Made From Steel

BY JIM WERST, P.E.

When space is tight, the adaptability of steel enables the design to minimize the inconvenience of construction.

HOW CAN YOU ACCOMMODATE large volumes of vehicles merging and weaving in dense rush hour traffic when you run out of real estate? And how could highway planners do this without traffic moving at a snail's pace? For this busy segment of I-435 in Overland Park, Kan., the solution was to construct "braided ramps" to allow cars and trucks to move toward different destinations without having to yield to each other. The challenge of fitting these crisscrossing (or braided) lanes into a small space adjacent to Indian Creek, an existing golf course, and a residential neighborhood was a significant one for the highway and bridge designers at the Kansas Department of Transportation and HNTB Corporation.

These braided ramps are situated for the westbound entrance-ramp for traffic entering I-435 at the new interchange at Antioch Road. This new five-span steel girder bridge allows traffic to join I-435 without weaving with vehicles exiting I-435 to get to US 69. Key challenges for the bridge designers included limited space (both horizontal and vertical), an extremely large skew angle at the intersecting roadways, the sequence of bridge erection, and minimizing adverse impacts to the adjacent creek, golf course, apartment complex, and park trail.

The solution chosen to unclog a potential bottleneck without taking new right-of-way was part of a larger $130 million highway improvement administered by the Kansas DOT in cooperation with the city of Overland Park and constructed by Kansas City-based Clarkson Construction Company. Improvements built over a three-year period, beginning in the middle of 2006, included a new interchange at I-435 and Antioch Road, widening of I-435 between Antioch Road and Metcalf Avenue, and capacity enhancements via collector-distributor (CD) lanes and new ramps at the US 69 interchanges with I-435 and 103rd Street.

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Using steel girders helped control the cost of temporary falsework supports and facilitated construction of integral post-tensioned concrete cap beams. Note the narrow site.

By intertwining ramps in a braid-like fashion, designers were able to add entrance and exit ramps in the narrow space between an existing apartment complex and highway without endangering motorists with crisscross traffic patterns.

Steel plate girders achieved the multiple objectives that designers established for this bridge solution. The bridge girders needed to be relatively light to control costs of temporary falsework supports. And the girders needed to be continuous over three interior pier supports to accommodate another feature of this bridge—inte-

Clarkson Construction Co.

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▲▼ The steel girders were supported by falsework (above) until the concrete cap beam was cast and cured and post-tensioning was completed.

gral post-tensioned concrete cap beams. In order to reduce the height of the bridge by several feet, the steel I-girders were framed in with the concrete cap beams at three of the four interior piers. Steel girders were supported by falsework until the concrete cap beams were cast and cured and post-tensioning was completed. Post-tensioning provides extra strength, limits beam deflections, and provides crack control where the steel girders pass through the cap beam.

The east and west tee-piers (Piers 1 and 3) adjacent to the straddle bent also use this configuration of steel girders framed within the post-tensioned concrete cap beam. This was done to allow the pier cantilever to extend out over the ramp shoulder without requiring additional vertical separation of the upper and lower profiles. This geometry maintains a favorable perpendicular alignment between substructure and superstructure and reduces the span length required to braid the two ramps. With the crossing angle of nearly 80°, the interior spans would have to be lengthened more than 50% to position the outside piers clear of the lower roadway.

The 38-ft-wide bridge roadway carries two lanes of traffic and crosses a two-lane

➤ Use of a straddle bent permits vehicles to exit without having to merge right through traffic entering the highway.

roadway underneath at a skew angle of almost 80°. With this extreme angle at the intersecting lanes, a structure length of approximately 700 ft was required to provide vertical separation and associated clearances. Span lengths for the welded plate I-girders are 131.2 ft, 167.3 ft, 167.3 ft, 131.2 ft and 98.4 ft. A web depth of 67 in. was used for the composite steel girders spaced at 8.6 ft on center. All steel was painted Grade 50.

Although the innovative choice of three integral framed-in pier cap beams added a higher degree of complexity to the erection of the bridge superstructure, it also provided appealing benefits. Traffic on the lower roadway passes through a "straddle bent" at Pier 2 and underneath the overhanging cantilevers of the "tee" piers at the end of each adjacent span. This arrangement offered relatively shorter spans and reduced the overall height of the bridge while allowing all pier and abutment supports to be positioned normal to the bridge. This uniform substructure arrangement resulted in a very regular geometry for the steel framing system and provided a cost savings over alternate schemes that would have used longer spans, unbalanced spans, and/or variable skews with unequal girder lengths.

It was important to strategically plan the sequence of construction for the entire project early in the design phase with careful attention to requirements of this unique grade separation before deciding on the final bridge type. Most importantly, traffic could not be placed on the new lower roadway until temporary falsework for the new bridge could be removed. Also, an objective established by the Kansas DOT required that traffic conditions improve as each stage of construction was completed. HNTB designers were able to develop a construction sequence that accomplished both of these objectives.

HNTB produced a 3D computer animation during the design phase to help state and city officials, as well as the public, better visualize how this segment of the highway system would appear from the driver's perspective. One important design objective was to avoid a "tunnel effect" for drivers that would create a sense of claustrophobia or discomfort resulting from limited sight distance. Public input was proactively sought throughout the process, resulting in context-sensitive solutions consistent with the goals of the project. Ultimately, the project's success was founded on dedication to partnering from beginning to end.

Much planning went into the desired aesthetics for the improvements for this busy highway corridor in a growing suburb of the bi-state Kansas City metropolitan area. It was important that the bridge type selection at this site also provide continuity of architectural features that would ensure that it fit in well with the overall surroundings. This was achieved with concrete form liner and color coatings used on the bridge piers, barriers, and for the mechanically stabilized earth (MSE) retaining walls that meet the bridge at both ends. Surface texture and dark earth tones were applied to the precast concrete sound barriers that helped provide both a noise and visual screen for the heavily treed neighborhoods along the highway.

Working with the engineer and the contractor to construct the new interchange at Antioch Road, widen I-435, and modify the I-435/US 69 and 103rd Street/US 69 interchanges, the Kansas DOT and the city were able to reduce congestion, increase safety and improve access along this very important corridor. Through early and ongoing collaboration among these project planners and builders, the completed project now benefits state and city agencies, the local community and the commuters who use the facility every day. MSC

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Owner

Kansas Department of Transportation

Designer

HNTB Corporation, Overland Park, Kan.

Steel Fabricator

Hirschfeld Industries - Bridge, Colfax, N.C. (AISC and NSBA Member)

General Contractor

Clarkson Construction Company, Kansas City, Mo.