BRIDGING THE GAP

The Nation's Most Compact Double-Teardrop Interchange

by David A. Day and Andrea B. Emerson, American Structurepoint Inc.

Keystone Parkway's teardrop interchange configuration is the tightest in the nation. This is the 106th Street Bridge. All photos: American Structurepoint Inc.

Carmel, Ind., is an affluent community to the north of Indianapolis and contains one of Indiana's largest business districts. It has grown substantially over the past 10 years, adding 50,000 residents. The explosive growth spurred many traffic challenges, with Carmel's most heavily traveled road—Keystone Avenue—growing increasingly sluggish and, as drivers tried to beat traffic lights, more dangerous.

Since the late 1960s, Keystone Avenue, also known as Indiana State Road 431 and controlled by the Indiana Department of Transportation (INDOT), had been a four-lane, divided roadway with seven at-grade signalized intersections—two of which were rated as "failing" at peak travel periods, according to a state-led analysis. The corridor, now renamed Keystone Parkway, averaged 200 accidents each year.

From Planning Gridlock to Fast Track

Seeking a minimally disruptive, long-term solution, City Engineer Michael McBride proposed to introduce grade separations at intersections using teardrop roundabouts. Meanwhile, Carmel Mayor Jim Brainard asked the state to relinquish control of the corridor—a request the city had been making for more than a decade.

Taking their cue from "Major Moves"—an aggressive program by Indiana Governor Mitch Daniels calling for much faster execution of road and bridge projects—the state agreed that Carmel was in a better position to meet the deadlines. Keystone Avenue was turned over to Carmel, which then partnered with American Structurepoint Inc. to refine and implement its plan.

Driven to Teardrops

As the engineers began shaping the design, it was clear roundabouts would be key ingredients to the solution, and with good reason. Studies point to roundabouts as one of the safest, most efficient intersection control techniques. Not only do accidents occur less frequently, but the severity of accidents at roundabouts is far less than stop-controlled or signalized intersections. "Anytime you remove conflict points, you improve safety," McBride explained. "A two-lane, four-way signalized intersection has more than 30 conflict points," he added, "but a typical single-lane roundabout has only eight."

As the design progressed, a unique teardrop interchange configuration—the tightest in the nation—emerged as the silver bullet. When measured center to center of the teardrop, the ramp termini are less than 290 ft apart, with

profile

KEYSTONE PARKWAY INTERCHANGES–106TH AND 126TH STREET BRIDGES / CARMEL, INDIANA

BRIDGE DESIGN ENGINEER: American Structurepoint Inc., Indianapolis, Ind.

PRIME CONTRACTOR: Milestone Contractors LP, Indianapolis, Ind.

CONCRETE SUPPLIER: Irving Materials Inc., Greenfield, Ind.

GIRDER PRECASTER: Prestress Services Industries LLC, Lexington, Ky., a PCI-certified producer

BRIDGE CONSTRUCTION COST: $3,081,160 (without MSE walls and approaches)
Superstructure and deck $76.01/ft^2; Substructure $39.78/ft^2

maximum right-of-way width less than 300 ft. The payback was a much smaller footprint and drastic reduction in the amount of right-of-way that had to be purchased. No residential homes and only one commercial building had to be relocated for the first two interchanges. Had a traditional tight-diamond design been used, dozens of homes would have been relocated.

Bridging the Gap

Part of Keystone Parkway's design hinges on two bridges carrying the roundabout traffic at the 106th and 126th Street intersections, connecting Carmel from east to west. The two-span, continuous, composite bridges feature precast, prestressed concrete AASHTO Type II beams with cast-in-place concrete deck slabs. Span lengths for the 106th and 126th Street bridges are 50 ft 9 in. and 50 ft 6 in., respectively. The 106th Street structure has a 15-degree skew right and the 126th Street structure has no skew. Each of the bridges' framing consists of 15 beam lines, with the 11 interior beams parallel to each other and each outside two rows of beams splayed to fit the copings, which are curved to follow the geometry of the roundabouts. The concrete decks were cast in halves due to the varying width of the deck with the curved overhangs.

Adding to the complexity of the project were specialty items such as stamped concrete, patterned formliners, hand-stained color patterns, ornamental handrail, and custom signage attached to bridge structures. Full-size, mock-up pieces were created for client approval of colors and patterns.

Raised median curbs and outside sidewalks are cast-in-place, colored concrete with pattern stamping. The cast-in-place barrier railing reflects an inset brick pattern on the pedestrian side. The exterior face of the railing has multiple circle shapes canted 2 in. inside the face of the railing at the bottom, and 2 in. outside of the face of the railing at the top. The railings have masonry coatings to accentuate the patterns. An ornamental steel railing was added to the top of the concrete railing to meet pedestrian and bicycle height requirements.

The bridges' end bents are cast-in-place concrete pile caps on driven piles, made integral using INDOT standards. They sit atop a mechanically stabilized earth (MSE) abutment with precast concrete facing panels with a random ashlar finish. The panels were stained to produce a tri-color, earth-toned finish.

The center piers are cast-in-place concrete frame bents on driven piles with architectural effects of circular openings canted 20 degrees to reflect the circular pattern in the outside face of the bridge railings. The piers have masonry coatings with the interior of the circular openings colored to match the circles in the railings.

Despite the intricate, custom design, speed was imperative: In order to expedite construction, specialty forms were fabricated off site and erected on site, enabling the center pier to be completed within 1 week, start to finish. Prefabricated Styrofoam blockouts were used to build the circular cutouts, saving time and avoiding complex forming inside the center pier. Wall panel formliners, barrier rail formliners, a city logo formliner, and ornamental railing materials were all saved to maintain architectural consistency throughout the corridor and reduce costs.

The design of the two interchanges was completed in approximately 4 months, and construction began in April 2008, and opened to traffic in April 2009. The project, dubbed "Carmel Link,"

The double-teardrop interchange resulted in a 78% reduction in personal-injury accidents at these intersections. This is the 126th Street Bridge.

TWO-SPAN, CONTINUOUS, COMPOSITE, PRECAST, PRESTRESSED CONCRETE I-BEAM BRIDGES WITH CAST-IN-PLACE CONCRETE SUBSTRUCTURES SUPPORTING DOUBLE TEAR-DROP INTERCHANGES / CITY OF CARMEL, OWNER

BRIDGE DESCRIPTION: Two concrete bridges with lengths of 103 ft 7 in. and 102 ft 6 in., each with two equal spans that create grade separations and support unique tear-drop interchanges. The bridges vary from approximately 111 ft to 220 ft wide.

STRUCTURAL COMPONENTS: 30 AASHTO Type II I-beams in each bridge, cast-in-place concrete decks, center piers, and end bents with the pile caps made integral with the piles, and precast concrete MSE wall panels

AWARDS: *American Consulting Engineers Council 2010 Engineering Excellence Award; 2010 Portland Cement Association Concrete Bridge Award for excellence in design and construction; American Concrete Institute Award; FHWA Excellence in Highway Design; Indiana Partnership for Transportation Quality Award*

The finished bridges provide ample space for pedestrians and bicyclists.

Update of Progress

There were seven at-grade intersections on Keystone Avenue. Six have been removed and replaced with grade-separated interchanges like the first two featured in this article. All use AASHTO Type II or Type III precast, prestressed concrete beams. Of the other four, two others (136th Street and 131st Street) are completely finished and opened to traffic. The other two (116th Street and Carmel Drive) are still under construction and scheduled to open by the end of 2010.

The seventh intersection (98th Street) has been left as is for the time being. INDOT is in the midst of another major project that may impact 98th Street. The City of Carmel elected to leave the intersection alone until INDOT finishes their plan.

One additional bridge, Keystone Parkway over Cool Creek, was included with the interchange project at 136th Street. The bridge needed major repairs, so the superstructure was removed, the substructure widened, and the superstructure replaced with AASHTO Type II beams as well. It is 148 ft 11 in. long and varies from approximately 126 ft to 145 ft wide.

The grade separations along Keystone Parkway allow traffic to flow smoothly underneath the bridges supporting the roundabout interchanges. From the driver's viewpoint, the new, double-teardrop configuration functions the same as standard roundabouts. (View a video simulation at www.carmellink.org/Keystone.swf.)

Carmel residents followed the bridges' progress through an aggressive public outreach campaign at www.carmellink.org.

included an aggressive public outreach campaign and website (www.carmellink.org) offering detailed information and updates to residents.

Outcomes

Within months of unveiling the new interchange, city officials reported a 78% reduction in personal-injury accidents at these intersections. What's more, motorists are able to navigate the corridor without having to stop at traffic signals; thereby reducing travel times on both sides of the streets. That's good news for the environment, considering less power is required for signals and, without the starting and stopping, emissions are lower. Additionally, the removal of traffic lights along the corridor helped reduce noise levels, electricity consumption, and pollution. In addition to improved safety, "this context-sensitive solution," said Brainard, "has provided a very aesthetically pleasing result for the surrounding neighborhoods."

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For more information on this or other projects, visit www.aspirebridge.org.

Center piers are cast-in-place concrete frame bents on driven piles.

Hand-stained MSE panels and circular cutouts reflect the bridges' intricate, custom design.

Unique detailing is the hallmark of these bridges. MSE wall panels with ashlar hand-stained finish are punctuated with smooth circle panels where the circles are canted 2 in. in and out from the panel surface. Photos: Henry G. Russell Inc.

The completed 126th Street overpass bridge. Photo: Henry G. Russell Inc.

Each of the bridges' framing consists of 15 beam lines, with the 11 interior beams parallel to each other and each of the outside two rows of beams splayed to fit the copings. Photo: American Structurepoint Inc.