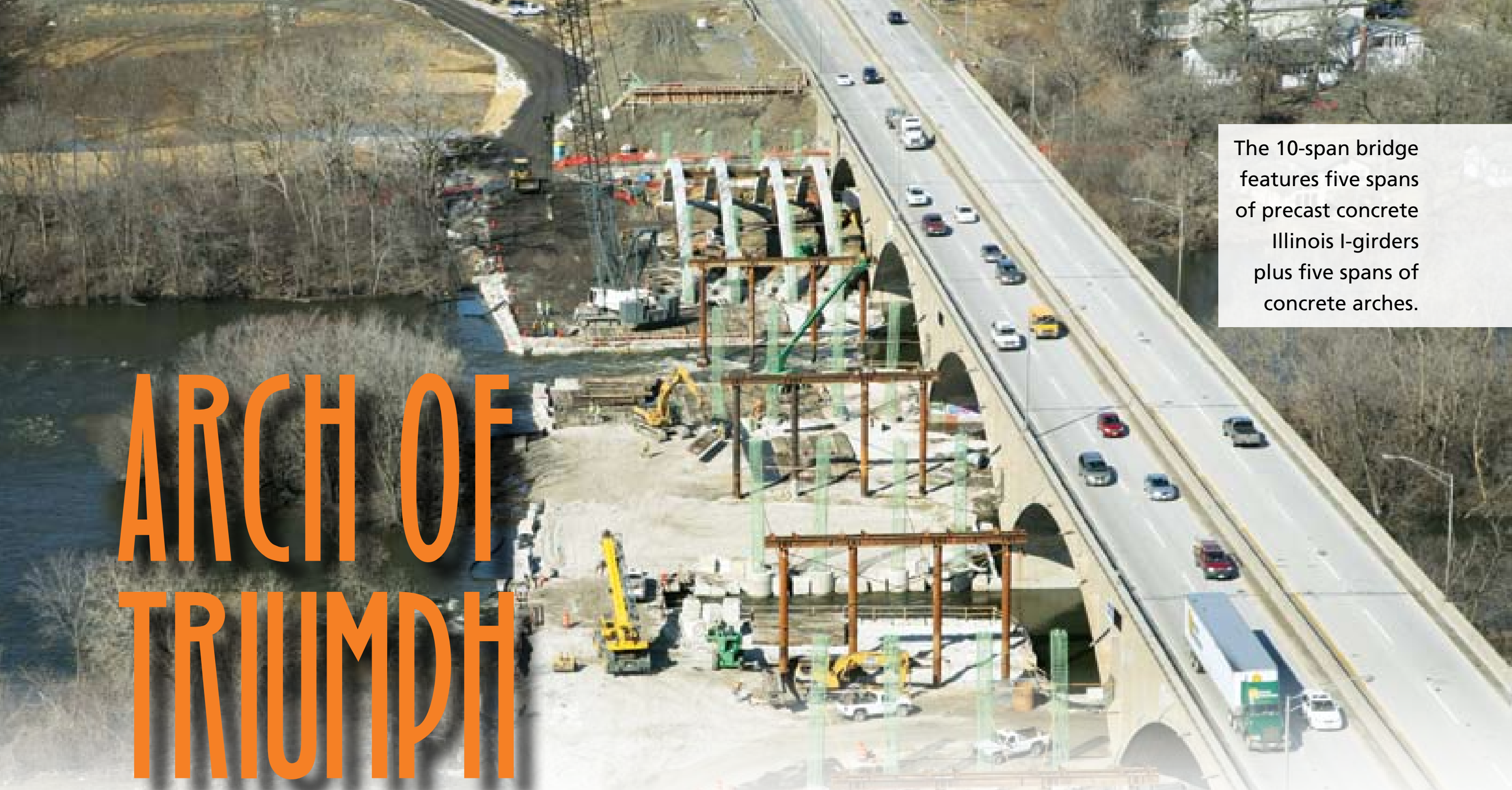

The 10-span bridge features five spans of precast concrete Illinois I-girders plus five spans of concrete arches.

ARCH OF TRIUMPH

by Brian Slagle, Janssen & Spaans Engineering Inc. and Michael Gould, James McHugh Construction Co.

Concrete design replicates existing arch bridge so well that officials also replace original

Illinois State Toll Highway Authority officials faced a key challenge in planning to widen and rebuild portions of the I-88 Reagan Memorial Tollway in North Aurora, Ill. The roadway's bridge over the Fox River featured the tollway's only arch bridge, and they hoped costs would prove economical enough that they could add a second bridge with a similar design alongside for the extra lanes. Ultimately, the selected concrete design proved so impressive that the Illinois Tollway decided to replace the existing bridge with a new one, too.

The project's goal was to increase capacity on the tollway in each direction to three lanes from two. The plan was to use the existing arch bridge, which opened in 1958, to carry three lanes of westbound traffic, while the new structure would carry three lanes of eastbound vehicles. To achieve this economically, the Illinois Tollway used a performance-based delivery system similar to the design-build format used in other states and requested two distinct bid alternatives from design-build firms.

One design bid alternate provided parameters for an arch bridge that would closely match the shape and construction of the existing arch bridge. The second design bid alternate was to focus on a simple concrete bridge consisting of typical beams and piers, with no elaborations. But that bid also had to include a $3-million noncompensable adjustment for selecting the simple bridge type.

McHugh/Janssen & Spaans investigated both alternatives and concluded that the arch structure could be designed and constructed within the $3-million premium allowed for the more aesthetically pleasing arch structure. They submitted this alternate in their bid package, which was selected as the best combination of aesthetics and economics. McHugh served as the team leader for the project.

Five Arch Spans

The new 1345-ft-long bridge comprises 10 spans. Five spans use cast-in-place columns and bent caps supporting 10

profile

FOX RIVER BRIDGE / NORTH AURORA, ILLINOIS

ENGINEER: Janssen & Spaans Engineering Inc., Chicago, Ill., and Bowman, Barrett & Associates Inc., Chicago, Ill.

GENERAL CONTRACTOR: James McHugh Construction Co., Chicago, Ill.

PRECASTER FOR GIRDERS: Prestress Engineering Corp., Prairie Grove, Ill., a PCI-certified producer

AWARDS: *Top 10 Bridges in North America,* Roads & Bridges *magazine*

Construction sequencing had to accommodate a very stringent set of geometric restraints.

lines of 42-in.- and 54-in.-deep precast, prestressed concrete Illinois I-girders. The other five use four lines of concrete arch ribs with a span length of 178 ft. Each arch supports two cast-in-place intermediate spandrels. Columns and bents are provided above each arch support. The bents in turn support 9 lines of 36-in.-deep precast, prestressed concrete I-girders. The bridge has nine intermediate piers including two in the river and one on an island in the middle of the river. Forty drilled caissons were used, with 28 in the river and 12 on land. Each caisson, 6 ft in diameter, was socketed into solid rock at depths up to 28 ft. The cast-in-place bridge deck has a thickness of 8 in.

Each precast concrete arch was fabricated in two pieces about 1½ miles from the site in a yard established by McHugh. The arches, which are conventionally reinforced were cast on their side and then lifted and rotated into a vertical position using a device constructed for the project. The pieces were delivered using special heavy-load semitrailers with 13 axles, rear steering, and 90-ft-long flatbeds.

Each precast arch section was cast with polystyrene at its center to reduce weight without compromising structural integrity. Even so, each arch section weighed approximately 92 tons and contained approximately 48 yd^3 of concrete with a specified compressive strength of 7000 psi.

McHugh began installing the arches from each end, eventually meeting in the center. Placement of the arched sections required a choreographed crane operation. To maintain river flow and leave the river channel open during construction, a crane-pick location plan was developed to accommodate the erection of the arches. A temporary bridge, capable of supporting more than 1 million lb, was built to give workers access to the island and to support tractors and trailers with the arch segments to the erection points.

Arch Geometry Was Critical

Constructing the arch sections required the project team to monitor each arch during every stage of erection to ensure the structure functioned properly at all times. Sequencing the construction had to accommodate a very stringent set of geometric restraints inherent in creating an arched design that acts as a true arch.

Designers ran two models, a two-dimensional analysis that took into account time-dependent properties of the concrete components, and a 3-D analysis to model the load distribution for the arches. These analyses ensured the construction team could sequence the construction process to optimize the arch design's inherent benefits during each stage by slightly manipulating the activities.

Precast concrete I-girders frame the approach spans and span between the spandrel bents. (top)

The concrete arches were fabricated in two pieces and supported on the substructure and falsework tower before closures were cast. (middle)

Precast concrete half-arch in transit to the construction site. (bottom)

10-SPAN PRECAST CONCRETE I-GIRDER BRIDGE INCLUDING FIVE PRECAST CONCRETE ARCH SPANS / ILLINOIS STATE TOLL HIGHWAY AUTHORITY, OWNER

BRIDGE DESCRIPTION: 1345-ft-long, 10-span bridge incorporating five 178-ft-long concrete arches, precast concrete Illinois I-girders, and a cast-in-place concrete deck

BRIDGE CONSTRUCTION COST: $44.5 million (including Route 31 ramps and overpass)

The new 1345-ft precast concrete arched bridge over the Fox River along I-88 in Illinois, designed to add lanes alongside an existing arched bridge, proved so successful that the project was extended to replace the original bridge, too.

As each arch half was delivered to the site, it was placed on temporary falsework, with one end supported on the substructure and the midspan end supported by a falsework tower. Cast-in-place closures at the arch crowns and thrust blocks were then added to establish continuity. The arch was released from its falsework support so it would begin to behave as an arch. After the arch deflected due to its self weight, it was shimmed tight to the falsework tower, near the center of the arch, to minimize the anticipated design moments during the stages of construction. This approach reduced the amount of structural reinforcing that was needed, saving money.

Anticipating arch deflection during the construction sequencing and establishing the necessary geometry for support elevations represented the biggest design challenge for the project. A key concern was supporting the superstructure from the intermediate spandrel supports, which also move up and down during construction. Designers had to anticipate future deflections of the arch and the movement of the supports over the arch to establish proper beam seat elevations.

Site Conditions Added Challenges

In addition to creating the unique geometry of the arched design, the project also faced key challenges due to the site. The Fox River is not navigable where the bridge crosses it, but it still is subject to strong currents and rapid water flows. During construction, McHugh's crews persevered through a 500-year flood event and two 100-year flood events. Under normal conditions, the river flows at approximately 500 to 700 ft^3/sec; during the construction period, it was measured at more than 15,000 ft^3/sec.

Even before these historic flows were reached, the team had to maintain the river's flow while ensuring it could easily transport materials, leading to the creation of the temporary bridge as well as additional temporary access structures. Environmental standards also had to be maintained, including ensuring that no construction materials or debris entered the waterway. All materials, the cranes' support bases, and other equipment had to be secured against the fast-moving and rising waters. The river's active recreational uses also meant that the team had to be cognizant of kayakers and canoers, especially those who were drawn to the river when its waters were most active.

Original Bridge Replaced

The challenges faced on this project made McHugh better prepared for understanding the changing dynamics of the Fox River during subsequent construction projects, which came in handy almost immediately. Upon seeing the quality and design of the new structure, Tollway officials decided to replace the existing arch bridge in lieu of the planned rehabilitation. This new westbound span now is scheduled for completion in summer 2010.

McHugh is acting as general contractor for the additional project, with Teng & Associates serving as engineer of record and Janssen & Spaans providing construction engineering. A key challenge for the second phase was demolishing the existing 1958 structure. To ensure balance and stability during demolition, the bridge deck's weight first was reduced as much as possible. Each arch barrel then was removed in sequence, carefully reducing each arch's width while maintaining its stability. The new bridge's design is virtually identical to the earlier structure in length and span configuration, speeding construction.

Both projects required considerable coordination among a number of public agencies and private interests, since the bridge spans areas with a variety of stakeholders. The team had to coordinate and communicate with officials from the tollway, the Village of North Aurora, City of Aurora, Burlington Northern Santa Fe Railroad, Illinois Commerce Commissions, Fox Valley Park District, Fox Metro Sanitary District, Army Corps of Engineers, and several utilities.

These two projects together expand the functionality of the crossing and extend the crossing's service life significantly. They also retain the distinctive look that the original bridge provided to this segment of the tollway, and it will continue to do so for many decades to come, even though its original inspiration has been replaced.

Brian Slagle is a vice president at Janssen & Spaans Engineering Inc. in Chicago, Ill., and Michael Gould is vice president of infrastructure at James McHugh Construction Co. in Chicago, Ill.

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

2009 PCI 55th annual CONVENTION EXHIBITION

PCI NATIONAL BRIDGE CONFERENCE

september 12-15

MARRIOTT RIVERCENTER
& henry b. gonzalez
convention center
SAN ANTONIO, TEXAS

EXPANDING KNOWLEDGE INTO EXPANDING MARKETS

Invest in your future at the Premier Event for the Precast Concrete Structures Industry

- 40+ Education Programs (accredited & peer-reviewed)
- Countless Networking Events
- Hundreds of Exhibits

Need help solving the complex challenges of weathering the economic downturn? Join other industry colleagues to learn strategies for adapting and thriving in today's market through relevant education programs and networking functions.

September 12–15, 2009

Marriott Rivercenter &
Henry B. Gonzalez Convention Center,
San Antonio, Texas

REGISTER EARLY AND SAVE!

Register online at
www.pci.org/convention
by July 31 for the Early Bird Discount

PCI™ Precast/Prestressed Concrete Institute

209 West Jackson Boulevard | Suite 500 | Chicago, IL 60606
Phone: 312-786-0300 | Fax: 312-786-0353 | www.pci.org

Two bids were requested, one based on a typical bridge design with a second using an arch design similar to the existing bridge.

Nine piers were built, including two that were located in the river and one on an island in the middle of the river. The existing bridge is in the background.

Constructing the arch sections required the project team to monitor and survey each arch during every stage of erection to ensure the structure functioned properly at all times.

Construction crews persevered through a 500-year flood event and two 100-year flood events.