Walking Tall

BY DAVID EKSTROM, S.E., P.E.

Economical structural steel framing expedited construction of Davenport, Iowa's newest long-span pedestrian walkway.

DOWNTOWN DAVENPORT IOWA ALREADY FEATURED SEVERAL ELEVATED WALKWAYS IN 2002 WHEN THE CITY CALLED FOR THE DESIGN OF A PEDESTRIAN BRIDGE TO CONNECT A DOWNTOWN PLAZA TO A PARK ALONG THE MISSISSIPPI RIVER. The new pedestrian bridge would be part of the city's "River Renaissance" development plan.

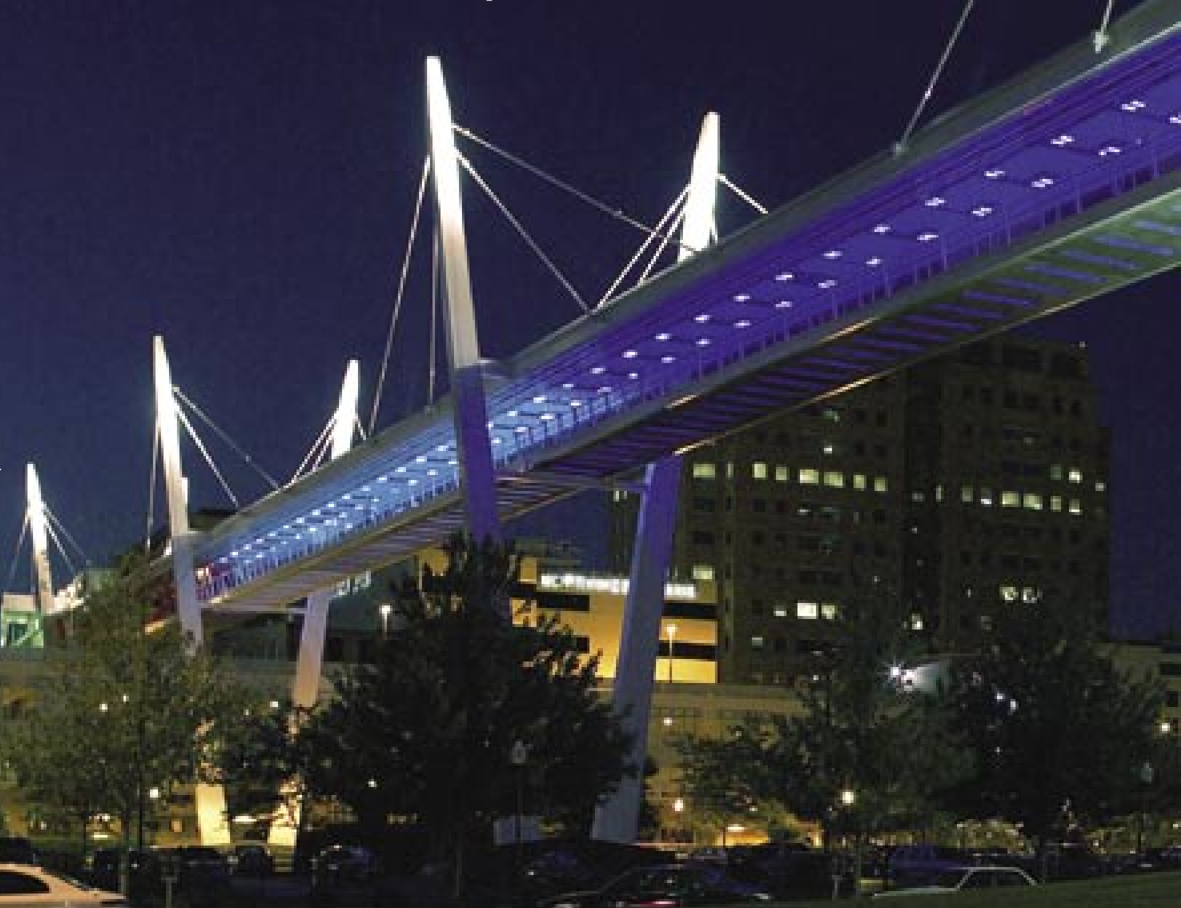
Holabird & Root, an integrated architecture, engineering, interior design, and planning firm, was one of several firms invited by the city to submit conceptual designs for the new walkway. Their steel-framed "Skybridge" design was chosen for its views of the city, river, and a nearby park and for its sensitivity to the design of the new Figge Art Museum, also nearby.

Early in conceptual design, Holabird & Root focused on structural steel framing for the bridge. Not only was steel was the most economical long-span system, but also it was the best solution to expedite construction at the site. The pedestrian bridge would cross a heavily traveled roadway and busy railroad tracks—neither of which could be shut down for long periods of time. Alternatives, such as a concrete structure, would have required forming, shoring, and placing that would have been difficult, expensive, and disruptive.

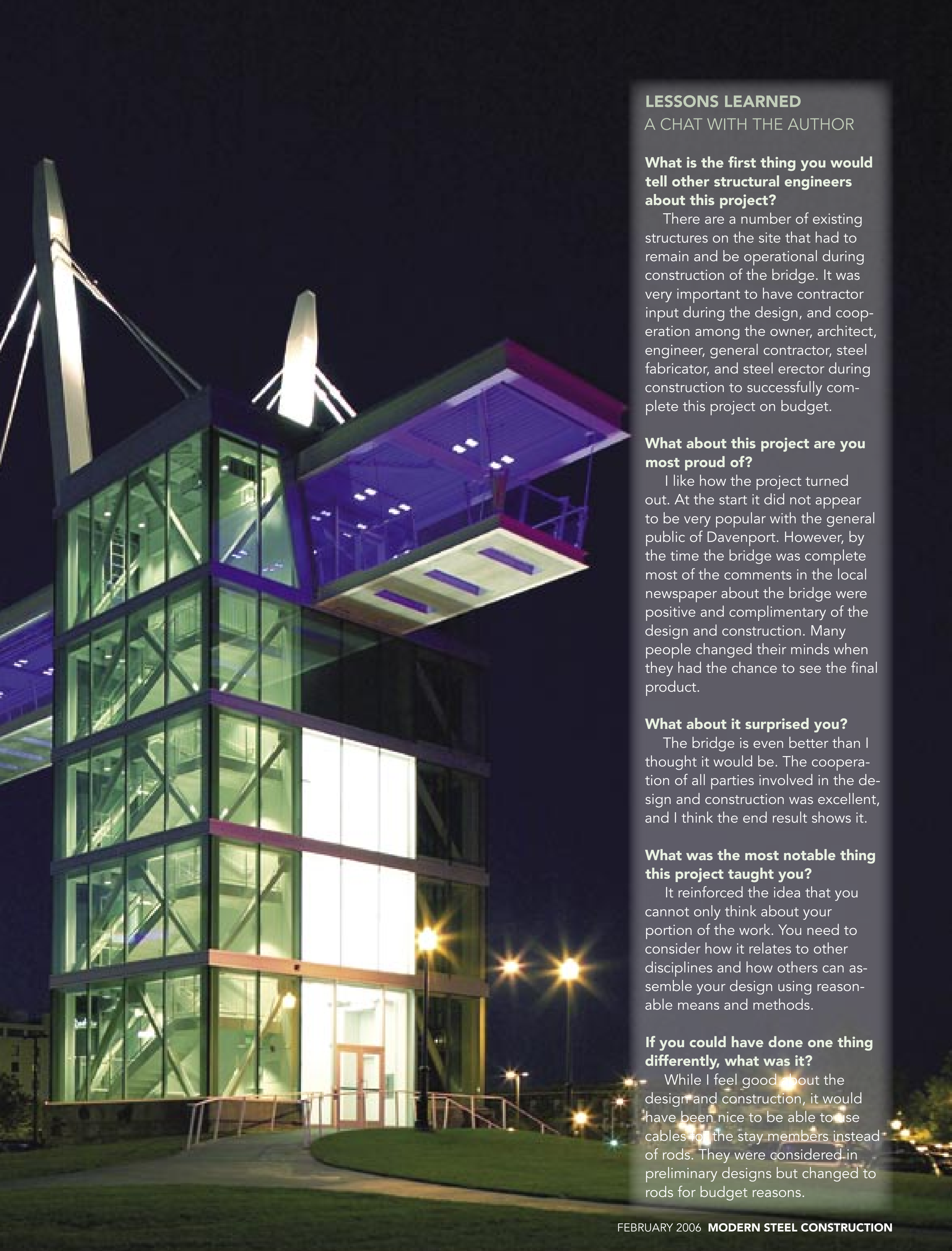
Architectural Design

Holabird & Root's architects wanted a light, open structure, with floor-to-roof glass exterior walls and light structural elements. Four pairs of 100'-tall masts support three bridge main spans of 160', 170', and 160'. The structure spans 570' over an existing four-level parking garage, four-lane highway, and frequently used railroad tracks. The masts' location minimizes their effect on existing site improvements.

David Ekstrom is the Director of Structural Engineering for Holabird & Root, LLC in Chicago. In 2005, Holabird & Root celebrated its 125th year of continuous practice.



Photographer Dale Photographics



LESSONS LEARNED

A CHAT WITH THE AUTHOR

What is the first thing you would tell other structural engineers about this project?

There are a number of existing structures on the site that had to remain and be operational during construction of the bridge. It was very important to have contractor input during the design, and cooperation among the owner, architect, engineer, general contractor, steel fabricator, and steel erector during construction to successfully complete this project on budget.

What about this project are you most proud of?

I like how the project turned out. At the start it did not appear to be very popular with the general public of Davenport. However, by the time the bridge was complete most of the comments in the local newspaper about the bridge were positive and complimentary of the design and construction. Many people changed their minds when they had the chance to see the final product.

What about it surprised you?

The bridge is even better than I thought it would be. The cooperation of all parties involved in the design and construction was excellent, and I think the end result shows it.

What was the most notable thing this project taught you?

It reinforced the idea that you cannot only think about your portion of the work. You need to consider how it relates to other disciplines and how others can assemble your design using reasonable means and methods.

If you could have done one thing differently, what was it?

While I feel good about the design and construction, it would have been nice to be able to use cables for the stay members instead of rods. They were considered in preliminary designs but changed to rods for budget reasons.


By Neumann Monson, P.C.

The rods from the top of the masts are 4" and 4½" diameter. The main longitudinal roof beams are exposed 27"-deep wide-flange beams spaced 15'-0" apart.

Access towers with overlooks are located at each end of the bridge. Each tower has a stair and two elevators. The south tower accesses only the bridge floor and the ground level. The north tower provides access to the ground floor, the bridge deck, and each level of the parking structure. Grades at the south stair and elevator tower are raised to keep the entrance above the 100-year flood level.

The bridge is wider at the roof than at the floor, which allows the glass exterior walls to angle outward, reducing glare and solar heat gain. Eleven-inch by 6'-8" translucent glass panels are set into the precast floor slab of the walkway and provide a soft glow at night, illuminating the streetscape below.

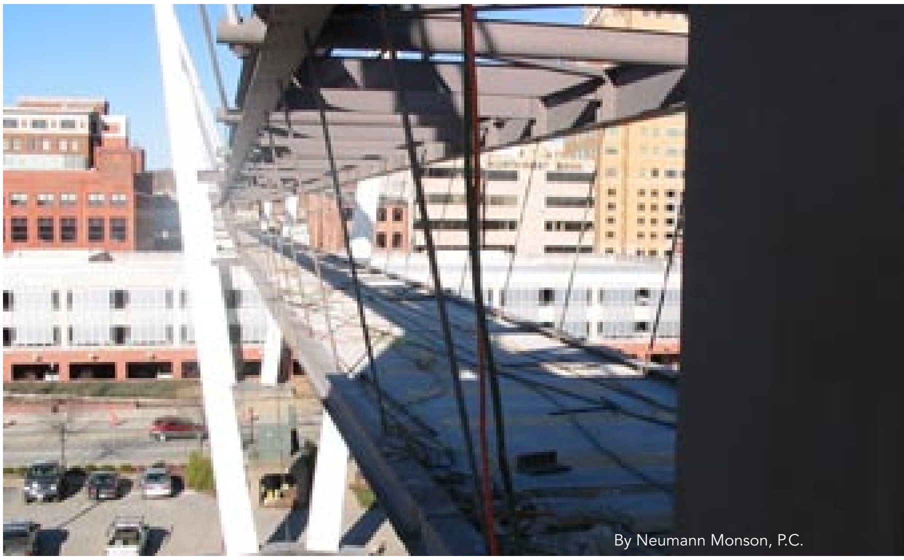
Structural System

To lighten the appearance of the structure, the engineering team selected a stayed structural roof system. Initial designs used cables for the stays, but ultimately the team selected rods, which are more cost-effective. The rods from the top of the masts are attached to the roof longitudinal beams spaced 30' to 40' apart along the length of the bridge. The main longitudinal roof beams are exposed 27"-deep wide-flange beams spaced 15'-0" apart. Transverse purlins that support a 3"-deep metal roof deck are typically 16"-deep wide-flange beams spaced 10'-0" apart. The longitudinal and transverse beams, together with double angle diagonal bracing in the plane of the roof, form a horizontal truss spanning between the masts to resist lateral loads.

Ten-inch diameter solid steel rods span between and extend 2' through the 27"-deep roof beams to receive the stay rods on the bridge exterior. The 4" and 4.5" stay rods pass through and are attached to the 10" rods.

The bridge floor hangs from the roof structure with 1¼" diameter rods spaced 10' apart along the length of the bridge. A 9½"-thick concrete slab spans between 14" wide-flange beams spaced 11' apart. Tension tie rods, spaced at 10' intervals along the length of the 14" beams, are cast into the slab and align with the hanger rods above. Dowel bar anchors attach the 14"-deep edge beams to the reinforced concrete slab that spans between the beams. Additional reinforcing around the slab openings creates a horizontal frame that spans between the masts to resist lateral forces.

Bridge support masts resist both gravity and lateral loads. The masts are built-up hollow box-shaped elements fabricated from steel plates and are internally stiffened with horizontal plates at the bridge floor and roof elevations. The axis of each mast cants at an angle of approximately 7 degrees from the vertical. The top elevation of the masts, bridge floor, and roof elevations are constant. Bottom elevations of the masts vary with site and foundation elevations. All masts taper from a 5'-0" by 2'-6"-wide base to a 2'-6" square at the top with an additional tapering cap. End plates of the box shape are 1¼" thick for the full height, while the side plates vary from 1-¾" thick at the base to 1¼" thick at the top. All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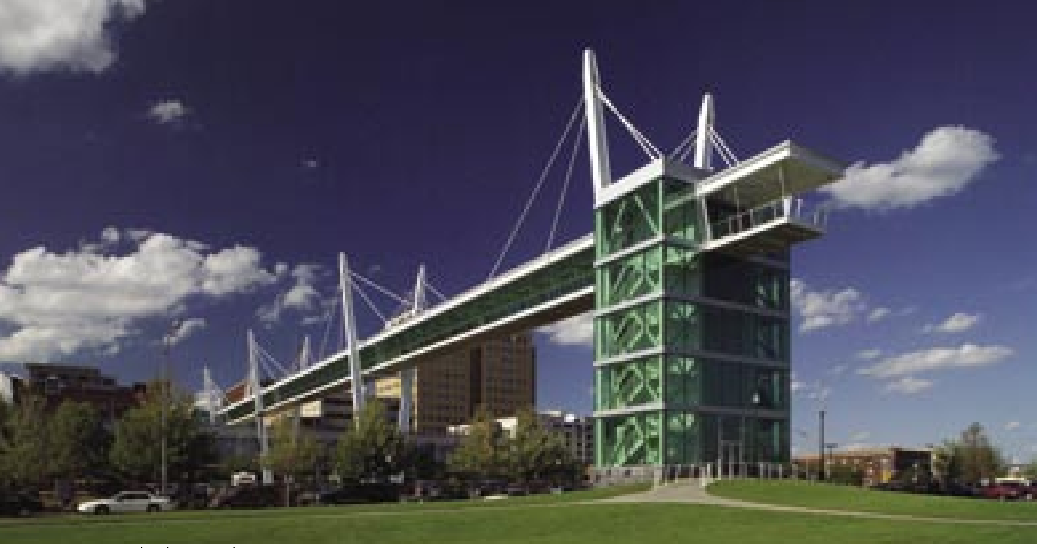

By Dale Photographics

joints and splices of the plates are full penetration welded and all welds are ground smooth.

The access towers have structural steel frames with diagonal bracing for lateral loads. Beams and columns are wide-flange sections and diagonal bracing is double angles. Anchor stay rods from the end masts attach to the roof structure of the towers. The towers must resist the vertical uplift and lateral forces from the anchor stays, in addition to the tower gravity and wind loads. The tower columns are anchored to pier foundations, which are drilled into rock to resist the uplift from the stay anchorage. Access towers are clad with a glass curtain wall, exposing the structural steel frame to view. The stair tower's floors are composite metal deck and concrete.

Holabird & Root used RAM Advanse software for the structural analysis and design of the Skybridge. The analysis included gravity loads, wind loads, seismic loads, and the effects of thermal loads because the bridge structure has no expansion joints.

The design team consulted with local steel and precast concrete fabricators during the design process to assess the feasibility of shop assembling sections of the bridge and erecting them as a unit. After bidding and selection of a contractor, the team further reviewed these issues and incorporated them as cost- and time-saving measures.

Fabrication and Erection

AISC member fabricator Zalk Josephs Fabricators worked with the steel erector and the concrete precast firm to develop a fabrication and erection sequence and schedule. Adherence to design dimensions and tolerances and the scheduling and sequencing of deliveries was critical to the successful completion of the structural framing for the bridge.

Working over active railroad tracks was difficult. The construction team had to notify railroad officials when equipment was crossing the tracks or when materials were hoisted over them. They had to suspend work over the tracks while the trains passed by, sometimes every hour.

Erection of the steel started with the south access tower. Zalk Josephs shop assembled full height sections of the braced frames. The erector placed the braced assemblies as a single unit and erected the remaining tower framing members. The erector then placed the first pair of masts adjacent to the south tower.

As planned, the erector placed the roof structure of the bridge prior to erecting any bridge floor sections. Zalk Josephs shop assembled 80'-0" long by 19'-6" wide sections of the roof structure and shipped them to the site as a single unit for erection. Highway officials required special permits that restricted the time and routes for shipment of these elements. A 300-ton crawler crane lifted the roof section into position and held it in place while a smaller crane lifted the stay rods for installation.

Because it was so large and heavy, special precautions were required when the 300-ton crane had to be moved. In order to reduce traffic congestion, moving was restricted to nights. The railroad required 1"-thick plates to be placed over the railroad tracks to protect them when the crane was crossing. Then, the plates had to be removed immediately so trains could pass uninterrupted. City officials also had to close the street and reroute traffic any time the erector lifted steel into place over the street.

Zalk Josephs shipped 14"-deep wide-flange beams to a precast concrete fabricator to cast the 11'-wide by 30'- to 40'-long concrete and steel floor panels. The crane moved south from the north access tower erecting the precast slab panels. After the precast panels were positioned under the roof deck, the erector dropped the crane rigging between the roof framing members and lifted the panels into position to attach the hanger rods from the roof.

Completed in June 2005, the $7.4 million Skybridge project was recognized later that year by the National Council of Structural Engineers Association in its Excellence in Structural Engineering awards program. Holabird & Root received a merit award for the Skybridge design in the program's bridges and transportation structures category.

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Architect and Structural Engineer
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Engineering Software
RAM Advanse Version 5.0

Structural Steel Fabricator and Detailer
Zalk Josephs Fabricators, LLC, Stoughton, WI, AISC member

Structural Steel Erector
Azco Integrated Construction, Inc., Appleton, WI, NEA member

General Contractor
Russell Construction Company, Davenport, IA