Damen Avenue Arch Bridge

Chicago, Illinois

Jurors Comments

The use of bent, steel pipes for the arches without lateral bracing is innovative...aesthetically pleasing

The bridge, located six kilometers northwest of downtown Chicago, is part of a $12.6-million improvement project along a section of North Damen Avenue. The mixed-use properties surrounding the site are rapidly transitioning from factories to mini-malls and condominiums. In view of this redevelopment, the city of Chicago proposed to build a signature bridge at this site to act as the focal point for the overall public and private revitalization of the area.

Among the project's innovations are the arch ribs, which are freestanding and constructed without lateral bracing. Additionally, the arch is not tied. Tied arches represented potential durability and safety concerns for both the Federal Highway Administration and the city of Chicago, concerns which were avoided by eliminating the tie.

Bridge Description

The new structure spans 94 m over the river and carries two lanes of traffic, with sidewalks along each side, in each direction. The two ribs are fabricated from 1.2 m-diameter steel pipe that is formed into a compound circular curve using induction heat bending. Each rib lies in a vertical plane and is located between the roadway and sidewalks. The ribs have a constant wall thickness of 25 mm throughout their length, and is filled with concrete over a distance of 8 m at each end in order to resist the higher thrust and moment near the spring points.

The superstructure is comprised of a longitudinally post-tensioned, cast-in-place concrete deck and stiffening girders that are supported by transverse steel box beams. The transverse beams act compositely with the deck. The beams are supported from the ribs by structural strand hangers anchored at the bottom flange and attached to the ribs using steel gusset plates and an open socket. The gusset plates penetrate the rib and are welded to stiffener plates and bolted to angles to transfer the hanger forces into

the rib.

The semi-integral abutments and rib thrust blocks are founded on a common reinforced concrete cap. Each cap is supported by six 2.1 m-diameter drilled shafts that extend to bedrock.

Innovations

The structure is a unique blend of materials and components that are designed to result in a rapid speed of construction, an aesthetically pleasing appearance and excellent long-term durability. The concrete deck is post-tensioned and overlaid with a latex modified concrete wearing surface to improve the rideability and durability of the bridge deck system. The longitudinal concrete stiffening girders are connected to the transverse steel floor beams using continuous post-tensioning clamping the two components together to achieve structural continuity. This innovative method of connecting the steel floor beams to the concrete stiffening girders greatly simplified the fabrication and construction of the floor system and allowed each material to be used where it is most effective.

The ribs are freestanding and constructed without lateral bracing. This eliminates the traditional cross bracing associated with the design of conventional arch bridges, which detracts from the clean appearance and elegance of a soaring arch rib, increases the construction cost and represents a maintenance and performance problem to the owner.

The ribs are unique in that they were fabricated from 1.2 m-diameter pipe instead of a traditional box section that is fabricated using welded plates. Use of a pipe section resulted in a significant reduction in wind pressure on the ribs and resulted in improved aesthetics.

The ribs were fabricated using an induction heat bending process. Induction heat bending is commonly used to fabricate large diameter utility pipes but is not typically used to fabricate structural bridge steel. After investigating several concepts for fabrication of the ribs, it was concluded that induction heat bending should be specified as the preferred method.

Induction bending utilizes an induction-heating coil to create a narrow, circumferential heated band around the material to be bent. Once the heated band has attained the desired temperature the material is moved through the coil at a predetermined speed. A radial arm that rotates about a central pivot point, and is clamped to the leading edge of the pipe, applies the bending moment.

After the material passes through the coil, an air or water spray quenches it.

Social and Economical Considerations

The project was driven by the owner's desire to build an aesthetically pleasing structure that added value to the surrounding community. The bridge has become a catalyst for the overall public and private revitalization of the area and stands as an identifier or signature of the community as a whole.

This crossing of the Chicago River provided an important access point to the river, as well as to the city's riverwalk development program, which is a long term project ment to provide a continuous linear parkway and bike trail system along both sides of the river. The bridge span was adjusted to provide for the riverwalk along both banks.

The existing bridge represented a functional traffic problem to the city, due to the importance of Damen Avenue as a transportation arterial. The existing bridge was in such poor structural condition that traffic was restricted from four to two lanes until it was replaced. A new bridge was needed, and was needed soon, as residential and retail developers were advancing new projects in the area. The design and detailing of the bridge were tailored to maximize the opportunity for off-site construction and large component erection in order to minimize construction time. This allowed the contractor to complete the construction and reopen the bridge to traffic in just eight months.

The new bridge provides the public with a safe and reliable structure that at the same time livens up their journey with its dramatic appearance.

Design Problems and Solutions

The owner's goal of designing an arch bridge that could be opened to traffic within eight months created a complex design and construction challenge.

Arch structures generally take longer to build than conventional bridges because of the long lead-time required to procure and fabricate the steel ribs. Therefore, in an effort to speed the construction process, the bridge configuration was optimized to minimize falsework requirements and strive to make the bridge self-supporting during each stage of construction. This resulted in the completion of rib erection, hanger and beam erection, superstructure casting and post-tensioning, approach slab placement and traffic control installations in approximately one-and-a-half months. This is a remarkable construction scheduling and engineering achievement on behalf of the contractor that, in our opinion, was facilitated by the configuration and details of the structure.

Arches are exceptionally sensitive to placement of unsymmetrical loads during construction. The deck placement procedure was developed in such a way as to maximize the contractor's options for deck placement, and minimize the potential for overstressing the ribs during the deck pour. The contractor ultimately elected to utilize dual finishing machines and pumps working symmetrically from the center of the bridge outward, as originally conceived by the team.

The bridge foundations were complicated considerably by the presence of existing underground structures, including a maze of timber piles supporting the existing retaining walls. The new foundations had to be designed to account for

the difficulties of working around these existing piles. Drilled shafts with sufficient diameter were selected to deal with interference with the existing piles.

Although the owner's goals created a complex design and construction challenge in the optimization of the structure and meeting the project schedule, the final design resulted in a simple form that utilizes conventional methods of construction.

Aesthetic Considerations

A successful design is one that maintains a careful balance between technological and aesthetic considerations. The ultimate goal must be to achieve harmony with the surroundings with simple forms and minimal current, as well as future resources. When this goal is achieved bridges can be a vital part of the community. Vital not only from the standpoint of commerce, safety and mobility, but also as a landmark or tribute to the creativity, fortitude and technological proficiency of the people who design, build, and use them. The city of Chicago recognizes this principle and uses bridges and other public works beautification projects as a tool to stimulate commerce and revitalization of a community or area. Therefore, the visual and functional friendliness of the site received considerable attention from the design team.

All architectural features were designed to enhance or compliment the natural elegance of the arch form. The ribs are painted red and are highlighted at night with underlighting located in the deck. Precast abutment towers with carved granite caps are located at opposite corners of the bridge. Belvederes are located at the other two corners to provide a location for pedestrians to stop and look out over the river. A staircase was constructed at the northwest corner of the bridge to allow access to the future riverwalk below. Ornamental handrails are located along both sides of the sidewalks and will be painted red to match the color of the ribs.

Careful attention was given to the specifications regarding finish and color of the precast and cast-in-place concrete on the bridge and approaches to ensure consistent or complimentary textures and colors. The color of an existing retaining wall was integrated into the overall structure using a concrete stain. The contractor was required to construct mock-ups for approval of all critical concrete elements prior to starting production.

Meeting Client Needs

The Damen Avenue Arch Bridge represents the successful integration of all of the clients project goals relating to aesthetics, speed of construction, constructability, durability and cost. The final contract documents were delivered to the client on schedule.

The design facilitated the contractor meeting the owner's schedule of opening the bridge to traffic within eight months. The bridge has also received numerous awards and a very favorable architectural critique by the Chicago Tribune.

Project Team

Owner
City of Chicago Department of Transportation

Designer
J. Muller International

Steel Erector
Steppo Construction

General Contractor
Walsh Construction Company of Illinois

Engineering & Erection Procedures
Danny's Construction Co.

Consulting Firm
TranSystems Corp.