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Bending around (Sprint) Center



BY DAVID LANDIS, P.E., AND GEORGE WENDT

More than 700 tons of curved steel shapes
Kansas City's Sprint Center.





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ELTON JOHN'S SOLD-OUT CONCERT IN KANSAS CITY LAST FALL RECEIVED RAVE REVIEWS.

And so did the concert venue. The performance was the opening act for Sprint Center, Kansas City's newest landmark and the centerpiece of its downtown revitalization.

This 18,500-seat multipurpose arena will host more than 100 events per year. Designed to be the epitome of flexibility, Sprint Center will accommodate NBA basketball, NHL hockey, AFL arena football, concerts, circuses, and other performances and special events. With retractable and variable-rise seating to optimize sight lines, the arena can be reconfigured quickly to accommodate different events.

A Flexible Roof

That flexibility extends to Sprint Center's steel roof structure, which facilitates multiple stage configurations and show-rigging capabilities during a wide array of event types. In addition to code live and snow loads, the long-span steel roof was designed to support up to 425,000 lb of show rigging for concerts, plus an 80,000-lb scoreboard, four 8,000-lb speaker clusters, over 40,000 lb of hoisting equipment, and nearly a half-mile of catwalks loaded with sports lighting, spotlights, and electrical and sound equipment.

Open and spacious concourses, framed in HSS, provide views of the surrounding city.

Long-span steel roof trusses taper to 32 ft deep and span 334 ft over the seating bowl. The truss configuration provides an efficient low-profile roof, with truss top chords forming the roof surface and truss bottom chords supporting the rigging grid and catwalks. The trusses utilize A913 Grade 65 W14 chords and A992 W12 webs, and their connections were made with compact gusset plates shop-welded to the chords and field-bolted to the webs. In addition, W21 roof beams and W14 rigging beams span between trusses. Even with the considerable show loading, Sprint Center's long-span roof steel weighs about 25 psf overall, including primary and secondary structural elements, rigging grid, catwalks, hoist platforms, connections, equipment supports, bracing and bridging, deck support plate, etc.

Curving around the Arena

Sprint Center's most notable aesthetic design feature is its faceted cladding system that curves both vertically and horizontally. The system allows dramatic views both for people inside looking out at the city and those outside the arena looking in at the activity. The cladding suggests a pillowed crystal bowl. The faceted glazing, with its varied frit patterns, transforms the building's appearance as sun angles and light conditions change throughout the day. At night



Walter P Moore

Each roof truss was erected on a shoring tower in two halves. Once a truss was completed and stabilized to the adjacent framing, the tower was moved to the next truss location.

the arena glows like a colorful ornament, exhibiting the activities inside and beckoning to the surrounding city.

Numerous schemes for structurally supporting the cladding were considered. In response to the architect's desire for an elegant and unobtrusive support structure, a system of curved vertical and horizontal steel pipe was selected. Curved horizontal 16-in.-diameter hollow structural sections (HSS) span up to 50 ft and are supported by curved vertical 16-in.-diameter HSS spanning up to 48 ft. The horizontal HSS are moment-connected with end plates to reduce deflections. Using moment connections enabled the engineer to economically minimize member sizes while still meeting strength requirements and deflection limits. End plate connections with oversized holes accommodated the geometry and allowed for reasonable fabrication and erection tolerances.

The steel curtain wall support frame was designed and detailed such that it did not provide support for any of the floors or the roof. Since the curved frame supports only the cladding system, it was not required to be fireproofed. However, the curtain wall system did need to accommodate floor and roof live load deflections and building drifts due to wind and seismic loads, and these building drifts and support frame movements were outlined on the structural drawings.

Bending Together

Schuff Steel Midwest was responsible for the entire structural steel package and engaged Hillsdale Fabricators (an Alberici Enterprise) in St. Louis for fabrication of the curved steel curtain wall support frame. Chicago Metal Rolled Products earned the contract from Schuff Steel and Hillsdale Fabricators to curve 750 tons of the 16-in. round HSS that gives the structure its unique shape. According to the site architect, Craig Milde of DADT, "The steel

really helped give the glass enclosed arena its unique shape. Refining the geometry to attain the desired enclosure shape was most challenging; nine radius points in each of the four arena quadrants."

Chicago Metal was able to minimize construction time and cost by using both its Chicago and Kansas City plants. For example, raw material more readily available in Chicago was curved in Chicago and then sent to Hillsdale in St. Louis, which in turn shipped the parts to Kansas City to be erected. On the other hand, material purchased in Kansas City that was to be shipped to Schuff's facility in Ottawa, Kan. was curved in Kansas City. As the project progressed, Chicago Metal was in frequent contact with the fabricators to ensure that everything was fitting up well. Having two plants curving the HSS allowed for quick response, lower freight costs, and on-time delivery.

The project team held numerous planning meetings to discuss fabrication and erection issues, including geometry coordination, acceptable tolerances, erection sequence, and support frame movements expected due to thermal changes and construction progress. Clips for the curtain wall mullion attachments were welded to the curved horizontal HSS in Hillsdale's fabrication shop. Ensuring that the geometry of the fabricated curved steel and the curtain wall matched when erected was critical to the project's success.

The steel curtain wall support frame was primed in the fabrication shop, and the final coating was applied in the field, following erection.

From Bay to Bay

During design, structural engineer Walter P Moore developed an erection sequence to minimize the cladding support frame deflections during curtain wall erection; adjacent bays of curved horizontals and their moment connections had to be

completed prior to erecting a bay of curtain wall. Erection of the 2,204 varying trapezoidal fritted glass panels of multiple sizes lagged erection of the steel frame by several bays.

To simplify erection, Walter P Moore designed compact connections that allowed for reasonable fabrication and construction tolerances. The bases of the curved verticals are connected with pin assemblies. Connections to the upper concourse floor and roof are made with slip-critical bolts in oversized holes. The curved horizontals are moment-connected with end plates with slip-critical bolts in oversized holes and shim plates. With few exceptions, erection of the curved steel frame proceeded smoothly.

Construction tolerances for the frame were reduced from those in the AISC *Code of Standard Practice* to facilitate connection of the cladding system. Any point along the steel support frame had to be erected to within 1 in. of the design location in any direction. Due to the meticulous attention to detail of the project team, the HSS fit their fixtures perfectly.

MSC

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The cladding system consists of 750 tons of 16-in. round HSS.

Owner

City of Kansas City

Developer

Anschutz Entertainment Group and
ICON Venue Group

Construction Manager

M.A. Mortenson Company

Architect

Downtown Arena Design Team (HOK
Sport + Venue + Event, Ellerbe Becket,
360 Architecture, and Rafael Architects),
Kansas City

Structural Engineer

Walter P Moore, Kansas City

Steel Fabricator

Schuff Steel Company, Ottawa, Kan.
(AISC Member)
Hillsdale Fabricators (an Alberici
Enterprise), St. Louis (AISC Member)

Steel Detailer

Dowco Consultants, Surrey, BC, Canada
(AISC Member)

Steel Erector

National Steel Constructors, Plymouth,
Mich. (AISC Member)

Bender/Roller

Chicago Metal Rolled Products, Chicago
and Kansas City (AISC Member)