

# Efficient Design and Spectacular Effects

BY GEORGE F. WENDT

A translucent, lightweight canopy on minimal framing energizes downtown entertainment venue.

**A LIGHTWEIGHT AND SEMI-TRANSPARENT COVERING** supported by a relatively open, curved steel framework creates a protected, yet light and airy, outdoor courtyard inside Kansas City's new mixed-use development known as the Power and Light District. The nine-block area is anchored by the "KC Live!" block, which is covered by a single-layer ethylene tetrafluorethylene (ETFE) membrane.

Structurflex, LLC, Kansas City, Mo., built the membrane system, the first single-layer ETFE system to be executed in North America. It is the same system used on the Beijing National Stadium—also known as the "Bird's Nest." ETFE systems differ from fabrics in that they are much like a film or foil, rather than a woven fabric that is composed of a coated scrim.

Pneumatic ETFE membrane systems have been used extensively in Europe for the past decade. One well known example of such a structure is the Allianz Arena in Munich.

The German firm Seele, formerly known as Covertex, pioneered

the application of ETFE films for true tensile membranes where it was first used in large scale on the AWD Arena in Hanover, then more recently at the Beijing National Stadium. In all applications, the accuracy and sophistication of the structural steel support system is of paramount importance for the successful performance of the membrane system.

The Kansas City Live! canopy was designed to provide protection from rain and snow, to offer some shading and to define the space. The original concept of a glass roof greatly exceeded the project's budget. A conventional steel canopy was then considered, but the large and heavy structure coupled with a galvanized metal deck would zap away the energy that the space was meant to generate. The client had obvious requirements for lightness and transparency.

Structurflex proposed a turnkey system for the design, engineering, membrane, structure and construction of the canopy. Being able to offer both fabric and ETFE was a definite advantage: both options required less structure—and therefore less cost—than a glass or metal-clad canopy. The steel weight—about 100 tons—is 30% to 40% lighter than that needed for a glass canopy or that needed for a steel deck due to the fact that no purlins were needed. Using cables instead reduced not only weight but also the fabrication and installation costs. The cables also enhance the filigree appearance of the structure. The total cost was substantially less than a metal deck canopy and less than half the price of a glass canopy.

After extensive design collaboration with the owner and architect, ETFE was settled upon. The notion that this would be the first single-layer ETFE system in the Americas was actually an incentive for the owner to be a part of a groundbreaking system.

The canopy is 191 ft by 138 ft in plan; the arc of the top chord is 142 ft in length; the truss is 7 ft deep; the large bay has a 45-ft span while other bays have 36-ft spans; and the end overhangs have an 18-ft cantilever at each end. With a 65-ft elevation from street level to apex, the membrane covers some 27,000 sq. ft.

The membrane has a silver fritted reverse dot print in order to provide a certain level of shading. The fritting was also important to achieve nighttime lighting effects through an LED lighting system that covers the entire color spectrum. This design allows for the canopy to constantly change its color throughout an evening to provide a truly lively and dynamic feel. It was also important to maintain enough transparency to see the surrounding downtown high rises as



An ETFE membrane, the first installed in North America, provides 75% transparency revealing the surrounding skyscrapers in downtown Kansas City. Fabricated by Novum Membranes GmbH (formerly KfM) and installed by Structurflex, the membrane required far less structural support than a glass or metal-clad canopy.

**Right:** Chicago Metal Rolled Products rolled angles and 48 sections of 10-in.-sq. HSS rolled on complimentary radii that facilitated their integration by Collins & Hermann into the top chord of the framing for the canopy over Kansas City Live!

**Inset:** Using 10-in.-sq. HSS simplified both the erection of the steel and the subsequent attachment of the canopy fabric. Photo: James Visser.

**Below:** In erecting the Kansas City Live! framework, two cranes each having a reach of 170 ft, used radio communication for blind lifts of 11,000 lb truss sections from surrounding streets and over two-story buildings. Photo: James Visser.



well, so that the feeling of being in the urban core was not lost. The reverse dot print provides approximately 75% translucency and achieves all of the aforementioned design criteria.

With 336 cable assemblies ranging from  $\frac{5}{16}$  in. to  $\frac{7}{8}$  in. diameter and all 1x19 construction integrated into the membrane and with stainless steel end fittings, the system can easily handle the live loading conditions that will be imposed by dramatic Midwest seasons.

Chicago Metal Rolled Products (CMRP) curved the roof members for the structural steel fabricator using both its Kansas City and Chicago plants. A number of different sections were considered for the structure including 12-in. standard pipe and 10-in. square hollow structural sections (HSS). To simplify the connections and the interface from the membrane system to the structural steel, the design settled on 10 in. x 10 in. x 0.3125 in. HSS.

Chicago Metal's Chicago plant provided 28 sections of the HSS rolled to a 160-ft 8.5-in. outside radius and 20 sections of the same size tube rolled to a 153-ft 8.5-in. outside radius. Material arrived on a Friday and on the following Tuesday two truckloads delivered the 32-ft to 48-ft-long curved sections to the fabricator, St. Louis-based Collins & Hermann.

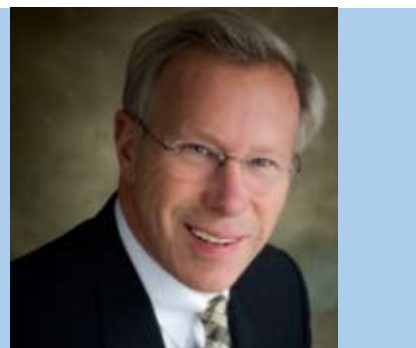
The top chord required angles to be integrated in order to accept the cables and facilitate a seamless method of clamping the membrane. Chicago Metal's Kansas City plant rolled 41 pieces of 5 in. x 3 in. x  $\frac{1}{4}$  in. angle and eight pieces of 3 in. x 3 in. x  $\frac{1}{4}$  in. angle, 40 ft to 43 ft long, to a 160-ft 11.5-in. outside

radius leg and sent them directly to the jobsite. Using two plants minimized transportation costs and saved time.

Erecting the structure was also done by Collins & Hermann and was the most challenging construction element of the \$275 million development: two cranes were required, each with a reach of 170 ft from the surrounding streets. Always lifting over the top of surrounding two-story buildings, the crane operators did the lifts "blind" while relying on radio communication. To avoid vehicular and pedestrian traffic, much of the work was done on Friday nights and over weekends. Another challenge was managing the weight of man lifts within the structure because a parking garage had been constructed below.

An advantage to the membrane installation was that it was sectioned into 12 panels thereby allowing other construction trades to work beneath in other areas of the structure. The system installation was so efficient that it did not hinder any other trades on the project.

*George Wendt is president of Chicago Metal Rolled Products ([www.cmrp.com](http://www.cmrp.com)), which in 2008 celebrated 100 years of curving steel. He frequently writes and lectures on curving structural steel for architects, engineers, and structural steel fabricators.*







James Visser

The arched trusses were fabricated with beams curved by Chicago Metal Rolled Products. The accuracy and the sophistication of the structural steel support system is of paramount importance for the successful performance of the membrane covering this canopy.

The single-layer translucent ETFE membrane system over a steel frame has become a Kansas City landmark that defines the city's most vibrant gathering point. KC Live! borders the new Sprint Arena with its transparent glass curtain wall framed by 16-in. pipe that was also curved by Chicago Metal Rolled Products (MSC, July 2008). The views of activities both inside and outside the Power and Light District contribute to the excitement of an area adjacent to the city's tallest sky scrapers. This oasis attracts locals and tourists at the end of a work day, before and after major sporting events and concerts, or simply for a night on the town. According to the Kansas City Business Journal, more than 6 million people visited the venue in 2008, its inaugural year.

The architectural effects of the project have resonated well throughout the Kansas City architectural community and beyond. Architects, designers, owners and contractors now see this as an efficient and smart alternative to other systems. An inherent virtue of the system is that it incorporates "green" and sustainable attributes, key issues for the owner. This project won the highest award of the Industrial Fabrics Association International for 2008 in the category of commercial canopies.

MSC

**Owner**

The Cordish Company, Baltimore

**Structural Engineer**

Wayne Rendely, P.E., Huntington Station, N.Y.

**Architect**

William E. Johnson, AIA, 360 Architects, Kansas City, Mo.

**General Contractor**

Structurflex LLC, Kansas City, Mo.

**Cable Fabricator**

Ronstan International Inc., Portsmouth, R.I.

**Roller/Bender**

Chicago Metal Rolled Products, Kansas City, Mo., and Chicago

**Steel Fabricator and Erector**

Collins & Hermann Inc., St. Louis (IMPACT and TAUC Member)

**ETFE Membrane Fabrication**

Novum Membranes GmbH, Menomonee Falls, Wis.