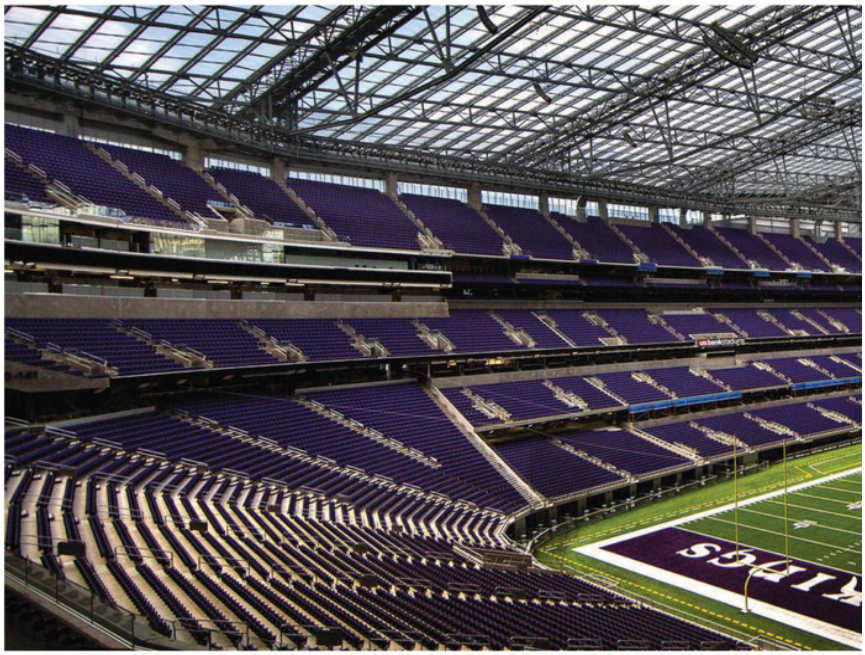
OVER $75 MILLION | MERIT AWARD

U.S. Bank Stadium, Minneapolis



U.S. BANK STADIUM in Minneapolis is reminiscent of a Viking longship—though at 1.7 million sq. ft and able to seat more than 66,000, it is a bit larger.

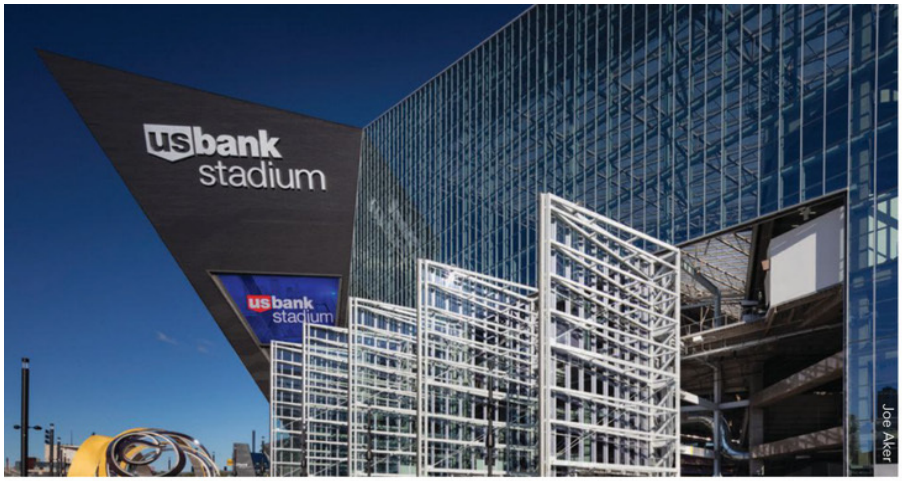
The new home of the Minnesota Vikings, which just hosted Super Bowl LII, the stadium is defined by its complex geometry, innovative transparent ethylene-tetra-fluoro-ethylene (EFTE) roof, iconic pivoting doors and panoramic-view concourses. Although operable walls exist in a few other stadiums, the five 55-ft-wide by 75- to 95-ft-high, curtain wall-clad structural steel hydraulic mechanized pivoting wall panels at U.S. Bank Stadium are unprecedented in both scale and operation.

The structural steel design and use of materials and technology transforms an enclosed facility into a light-filled, dynamic space, as the transparent roof and moveable panels admit abundant natural light, creating an outdoor feel while protecting occupants from the elements. Comprising more than 240,000 sq. ft, with some panels measuring more than 420 ft in length, the three-layer Texlon ETFE polymer film, air-pressure-stabilized pillow system covering the south-sloping roof of the stadium is the largest transparent ETFE roof in North America. The lightweight ETFE allowed the structural engineers to provide primary roof support with a single 970-ft steel ridge truss, resulting in cost savings and a striking visual lightness.

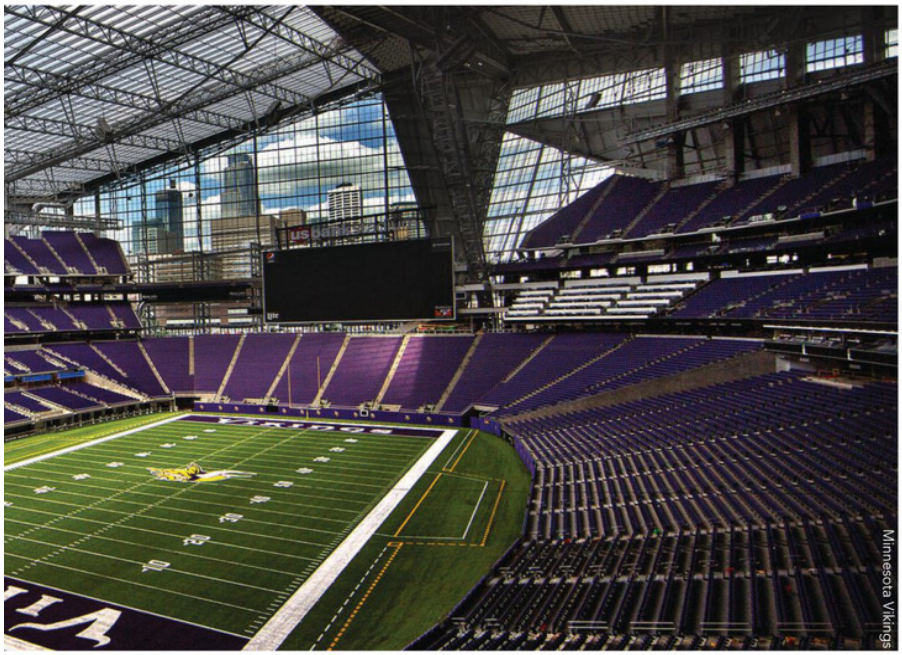
The final roof geometry was formed and optimized through highly detailed collaboration between the design team and the wind consultant. The orchestration of such a large and complex structure required the use of Rhino software with the parametric plug-in Grasshopper. The parametric model created via Grasshopper allowed for the exploration of key design issues and solutions while considering consequent effects to the entire structure. The design team used Grasshopper to optimize the roof pitch and slope to minimize snow accumulation and reduce roof snow loads, a crucial parameter when considering the loading of the structure. As a result, climate consultant RWDI rendered a nearly 25% reduction in roof snow loads, equating to more than $8 million in roof steel cost savings, and one of the lightest structural steel NFL stadium roofs.

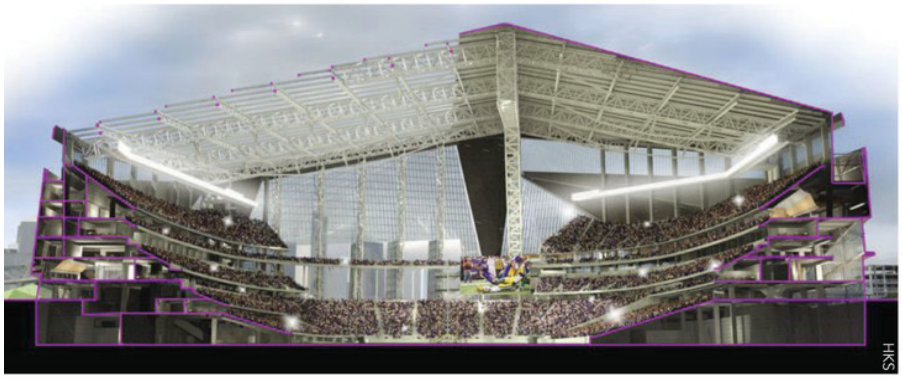
The engineering and construction engineering teams collaborated closely with Mortenson Construction, architect HKS, steel fabricator LeJeune Steel and steel erector Danny's Construction to design, model, detail, procure, fabricate and erect the long-span steel roof.

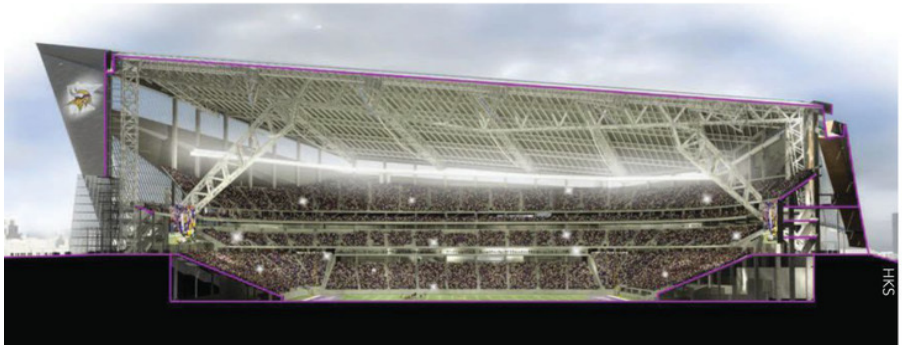
Paramount to transferring design information to the construction team was the integration of connection design during the structural design pro-



Joe Aker


Minnesota Vikings


HKS


HKS

cess. Thornton Tomasetti's Advanced Project Delivery (APD) approach employs specialized connection design engineers and steel detailers working side by side with the structural design team to conceptualize the connections early in the design phase once member geometry is set and initial force magnitudes are available. These early connection concepts were formulated with fabrication and erection considerations.

Transfer of connection design information was validated for constructability by Thornton Tomasetti's modeling of the connections in Tekla Structures. Weekly steel desktop coordination meetings were held between LeJeune Steel, Danny's Construction, Mortenson, steel detailer LTC and Thornton Tomasetti, where the modeled connections and progress were shared and reviewed with all parties. Coordination items were addressed in real time through the use of a shared live Tekla model using a cloud-based Panzura system that allowed Thornton Tomasetti's engineers to work side by side with LTC. The APD approach facilitated the transfer of information, led to a greater understanding and visualization of the project requirements and reduced RFIs considerably while ensuring that the project budget and schedule would be maintained. This coordination allowed for an expedient shop drawing review process, enabling the design team, fabricator and erector to focus on issues pertaining to erection plans, possible connection modifications and the construction time line prior to the release of shop drawings, thus enabling proactive information review.

The integrated proactive steel delivery process resulted in a collaborative cloud-based long-span steel roof design, streamlined submittal review process, timely fabrication, swift erection and eventual delivery of a 11,100-ton steel project nearly one month ahead of schedule.

Owner
Minnesota Sports Facility Authority, Minneapolis

General Contractor
Mortenson Construction, Minneapolis

Architect
HKS, Inc., Dallas

Structural Engineer
Thornton Tomasetti, Dallas

Steel Team

Fabricator
LeJeune Steel Co., Minneapolis

Erector
Danny's Construction Co., Shakopee, Minn.

Detailer
LTC, Inc., West Salem, Wis.