An intricate triple-truss mast travels across the country to become the final piece of a new northern California hospital.

Signature SPIRE

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Sutter Health/Devenney Group/Christopher Skow Photography

SUTTER HEALTH, of course, wanted its new Eden Medical Center hospital replacement building in Castro Valley, Calif., to stand out in terms of care and advanced technology—but also as an iconic visual element.

Architect Devenney Group answered with the "spire," an abstract steel assembly representing a strong man holding a tall flag. The spire's installation was the last main element of the project to be completed prior to hospital opening—the cherry on top, or rather on the side of the building, if you will. Stakes and expectations were very high for successful and on-time design and delivery of the spire, and it required extensive and continuous collaboration between the owner, architect, structural engineers, general contractor and steel team.

Design and Support

The spire is 125 ft tall, with complex geometry consisting of three trusses attached to a vertical mast. The truss members are rolled hollow structural sections (HSS)—HSSA500Gr.B 10×0.375—while the mast is a tapered round section with varying outer diameter over the height. The three trusses are arranged geometrically in a way that the forming triangular shape appears to "twist" and "arch" when viewed from above and below the structure. There are three access panels for servicing its lighting fixtures: one near the top, one in the middle and one near the bottom. An exterior, translucent membrane fabric covers the steel trusses as a permanent component of the spire and allows for interior lighting to shine through. The material used was Sheerfill II-HT membrane, which is made of fiberglass and polytetrafluoroethylene (PTFE) and has very low creep, long durability, high tensile strength and ultimate wrap and fill stresses of 785 pli (pounds per linear in.) and 560 pli, respectively. A safety factor of 4 was considered in the design of the membrane as were various loadings, including gravity, seismic, wind, thermal changes and pre-tensioning. Allowable drift and other component deflections were limited to *L*/250 (or 0.004 times the span being considered).

The spire mast is supported by five cantilevered horizontal beams from the building structure in five different elevations. Based on architectural design, the support beams were required to be small in size and depth. As a result, heavy W16×100 steel beams reinforced with 1½-in. plates on either side of the web, forming rectangular box sections, were designed to provide necessary stiffness and capacity. Following complex 3D analysis of the spire structure and various loadings, the structural designers had to come up with a special solution for interface connection between the mast and building beams that had the necessary capacity and stiffness, but at the same time provided sufficient tolerances for proper installation.

◄ ▼ ► The 125-ft-tall spire consists of three trusses attached to a vertical mast. The exterior is covered by a translucent fabric—Sheerfill II-HT membrane—which is made of fiberglass and PTFE and has very low creep, long durability and high tensile strength.


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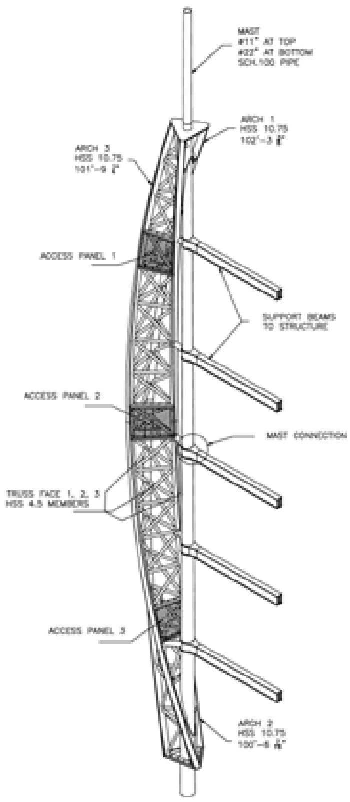
▼ The assembly features three access panels for servicing the interior lighting.



Sutter Health/TTG/Birdair


Sutter Health/DPR/Birdair/JPW

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➤ ⮟ Interface between the spire and the main building came in the form of double-end plate-type connections with 2½-in. end plates and high-strength bolts.

⮜ ⮟ The spire's shape and length required two cranes for erection in a very tight construction space, given that the building itself was already completed.

Photos this spread: Sutter Health/DPR/Birdair/JPW

Accordingly and to provide some flexibilities for the installation, the interface connections between mast and building beams were designed using double end-plate type connections with two 2½-in. end plates and 12 1⅜-in. high-strength slip-critical bolts.

Fabrication and Erection

To compose the truss, more than 120 members needed to be cut in perfect angles, arches and lengths. All were then connected to each other and to the mast using welds to preserve smooth surfaces per Devenney's design intent. Due to high stress levels and the project being under California's Office of Statewide Health Planning and Development (OSHPD) jurisdiction, continuous special inspections were performed for all welds. The spire was built in Syracuse, N.Y., by fabricator JPW Structural Contracting, Inc. It was fabricated in three large segments to allow ease of transportation for the 3,000-mile journey, and these were attached on-site to form one piece. Fabricating the interface connections between the mast and five building attachment beams required a high degree of accuracy to allow the spire to line up perfectly with the beams.

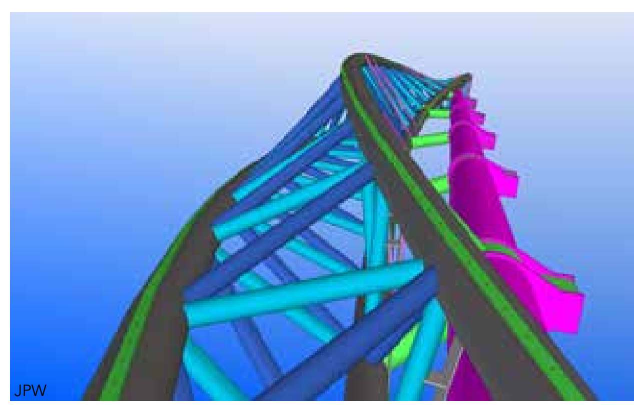
However, perfection wasn't achieved immediately. After the building support beams were constructed and underwent some deflection, it was discovered that they did not match up to the mast end plates' theoretical center within the acceptable tolerance of 1 in. that had been incorporated in the original design. Further, the steel beams presented some inconsistent settlements and distortions, which resulted in variations of the end condition for each beam.

As such, laser scanning was used to locate the exact position and orientation of each beam, after which the connection design was reevaluated and revised to accommodate the variations in the existing beams. The end plate connection was designed as slip-critical, requiring full contact between the two end plates. To achieve this, thin, precise shims ranging from 1/32 in. to ⅛ in. were fabricated using an on-site CNC machine. After the beams and connections were ready, two large cranes simultaneously lifted the spire and aligned it with the building support beams to com-

Workers prepare spire connections and templates to be attached to the building support beams.

Holding the spire in place to allow connection to the building.

A Tekla model of the spire structure.



JPW

plete the installation. Using two cranes was necessary to ensure proper alignment of the spire with building support beams as well as to eliminate any unexpected swings and potential damage to the building framing or the recently completed façade.

A special procedure was employed for the order and magnitude of fastening the bolts for each connection. First, the bolts in all 12 holes had to be installed and snug-tightened per a specific sequence until the connected plies were all in firm contact. Then the site-manufactured shims had to be inserted, as required. Once the shims were in place, the joints were pre-tensioned in the opposite sequence; both the compacting and pretensioning phases began at the most rigidly fixed or stiffest point. Special inspections were performed for all phases of the spire's installation.

With extensive and continuous collaboration under tight schedule pressure (as the spire was the last element to be completed on the building), the project team successfully designed and delivered the complex spire, which used 21 tons of steel in all. This complex and signatory element, which can be seen from great distances and multiple angles, provides Eden Medical Center with an eye-catching icon worthy of its high quality of healthcare. ■

See "Special Delivery" in the November 2013 issue (at www.modernsteel.com) for more on the Sutter Health Eden Medical Center building itself.

Owner
Sutter Health

Architect
Devenney Group, Ltd.

Structural Engineer
TTG (TMAD Taylor and Gaines)

Specialty Structural Engineer (Spire)
Birdair, Inc.

General Contractor
DPR Construction

Steel Team

Fabricators and Erectors

Spire
JPW Structural Contracting, Inc.

Main Building
The Herrick Corporation

Bender-Roller (Spire)
Chicago Metal Rolled Products

Detailers

Spire
JPW Structural Contracting, Inc.

Main Building
Candraft Detailing, Inc.