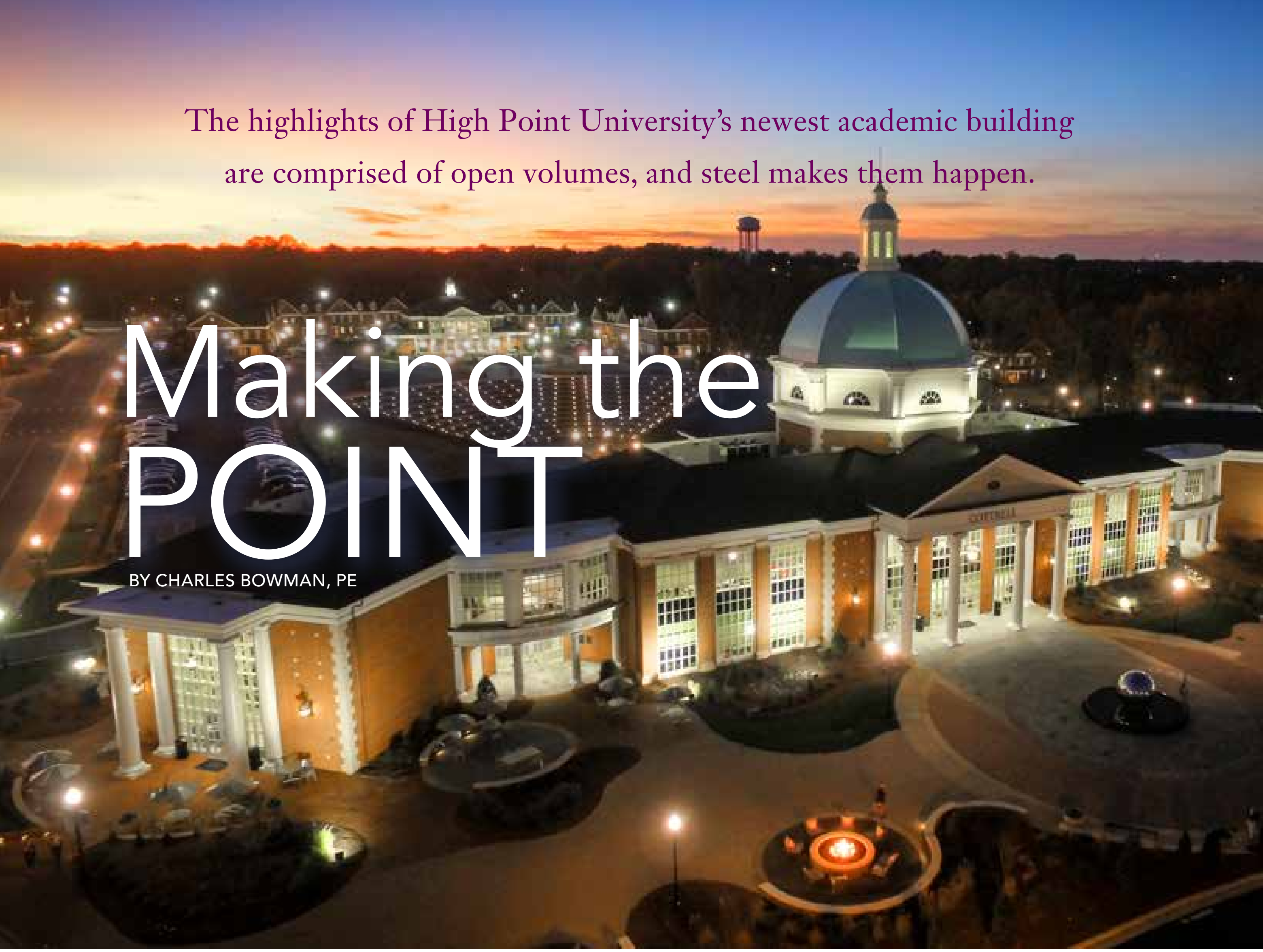

The highlights of High Point University's newest academic building are comprised of open volumes, and steel makes them happen.

Making the POINT

BY CHARLES BOWMAN, PE

THE NEW COTTRELL HALL, home of the Flanagan Center for Student Success, could be conceived structurally as a typical low-rise building with some large floor openings to work around.

Located on the campus of High Point University in High Point, N.C., the 46,000-sq.-ft, $13.4 million, two-story structure is long and slender, but features multiple openings between the first and second floors, as well as a large, open dome. Combining traditional Georgian architecture with an innovative structural steel framing system, it incorporates meeting, classroom and study spaces. The design intent was to have large open floor spaces and high open volumes in order to provide a sense of open community and excitement within the building, as well as a sense of entrepreneurial team building and creativity.

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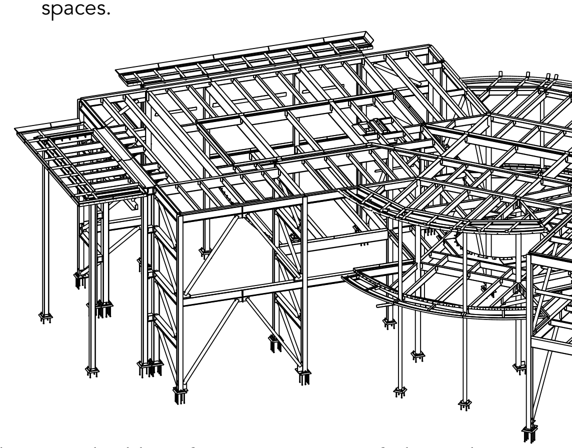
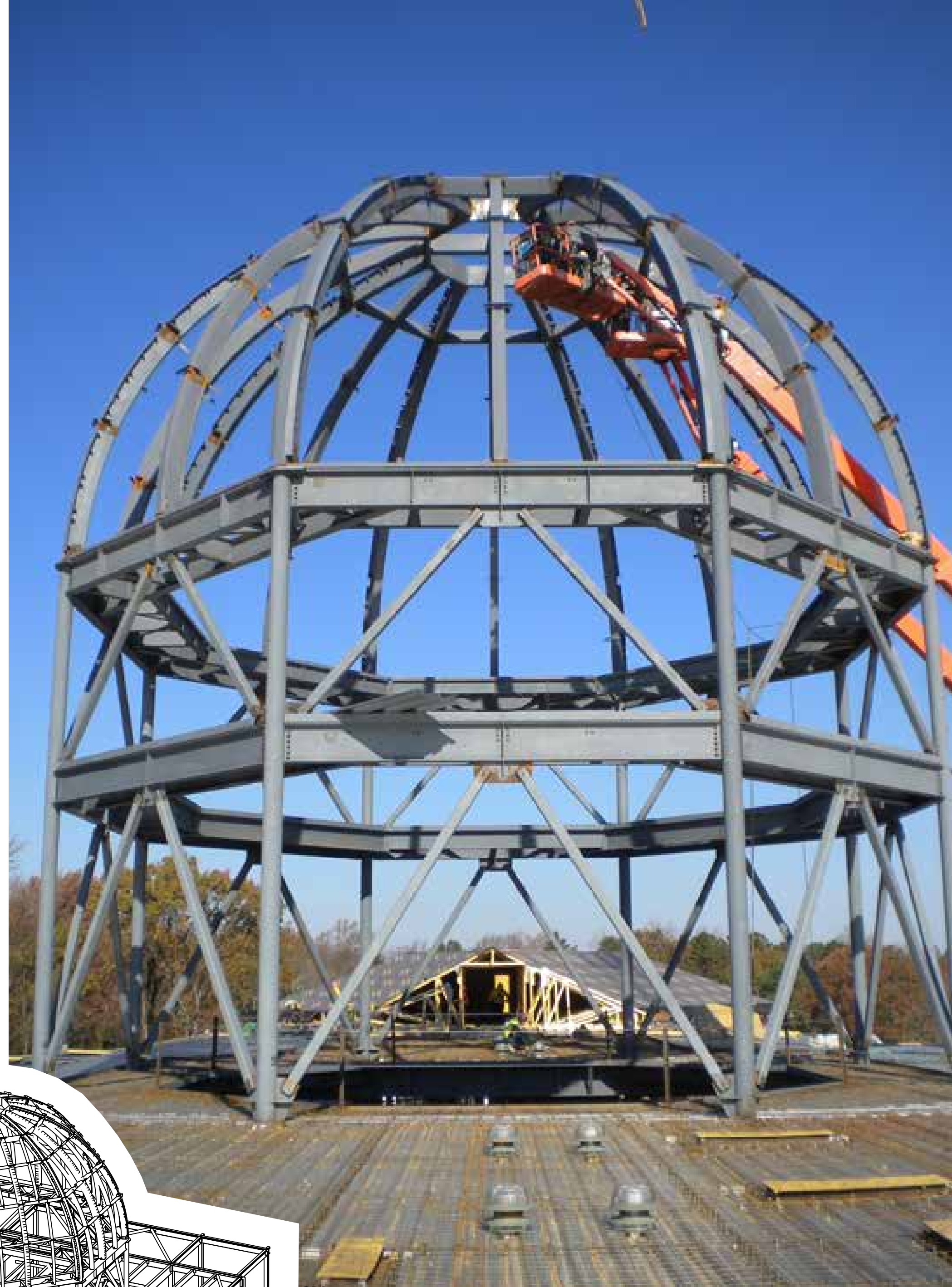
▲ The new two-story building incorporates 46,000 sq. ft of meeting and classroom spaces.



The main building framing consists of elevated decking of 3¼-in. lightweight concrete over 2-in. composite metal deck supported by steel beams that are in turn supported by wide-flange columns founded on shallow spread footings (these columns range in size from W8×31 up to W12×79). Lateral stability for the project is provided by concentrically braced steel frames, and the roof system is comprised of structural steel beams supporting a composite con-

Samet Corp.



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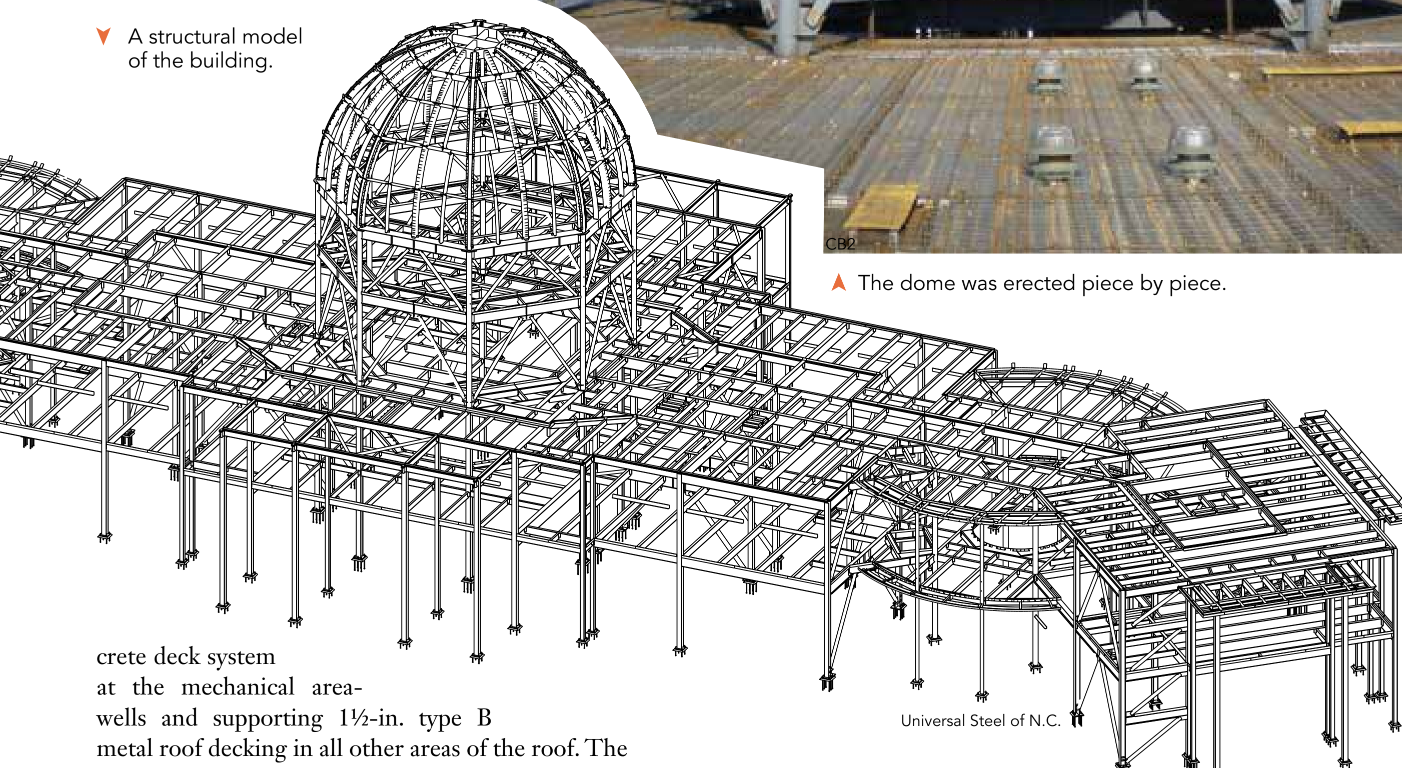
The dome was erected piece by piece.

A structural model of the building.



Universal Steel of N.C.

crete deck system
at the mechanical area-
wells and supporting 1½-in. type B
metal roof decking in all other areas of the roof. The
entire project incorporates 550 tons of structural steel.

The dome's architectural design called for the roof to be comprised of eight faceted curved surfaces joined together at intersecting ribs.

Dynamic Dome

The building is nearly 300 ft long and for the final 60 ft at each end, it undergoes a 45° shift in plan geometry, and also includes large vertical openings at four locations along its length. The largest of these, and the primary architectural focus of the building, is the steel-framed dome located near the entry vestibule at the center of the building. Glass-fiber-reinforced gypsum wall and ceiling panels are suspended from the interior of the dome, which also features a 35-ft-long modern art chandelier suspended from the center.

The dome's architectural fixtures, dead weight, live loads (as required by the local building code) and lateral seismic and wind forces all created load combinations resulting in significant member stress and deflection variations depending on lateral force direction. After studying the forces in several directions and using multiple load combinations (aided by RISA 3D software), the design team concluded that hollow structural sections (HSS), welded to one another as rigid frames, would provide the best solution for the resulting member stresses and calculated structure lateral and vertical movement—as well as keep with the architectural requirement of having an open, unobstructed interior dome volume.

The dome's architectural design called for the roof to be comprised of eight faceted curved surfaces joined together at intersecting ribs. The ribs were to be rolled to a constant radius while the faceted faces of the dome were to be rolled to ever-tightening curves as the roof surface approached the apex of the dome. However, current technology for rolling HSS members does not permit them to be rolled to ever-tightening, multi-centered arches. Structural engineer CB2 Structural, working with fabricator Universal Steel and bender-roller Chicago Metal Rolled Products, determined that the best course of action was to roll the HSS roof members to three separate circular arch lengths at different locations along each dome member length, holding multiple in-person meetings to work through the complexity of the various rolled shapes. By rolling the

The building is nearly 300 ft in length. The final 60 ft at each end of the building undergo a 45° shift in plan geometry.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➤ One of the floor openings.

HSS roof steel to three circular arch center points, the architecturally requested multi-centered arch face of each roof facet could be approximated in the shop.

Another rolling challenge involved the interaction between the supports for metal roof decking and the circular curved rib members. The theoretical metal deck intersection point at each facet rib member would be located directly above, but not in contact with, each circular rolled rib member. A bent plate could not be rolled to an arch shape atop the curved rib without the plate buckling. As a result, the steel team developed a solution involving a series of small plates, each of slightly different geometry and elevation, along the length of the rib members to allow support and anchorage of the metal deck to each side of the members.

Perfect Placement

When it came to getting the dome to its final position, the team recognized that erecting a rigid frame, while suspended some 88 ft above ground level, would be difficult, to say the least. As a result, CB2 Structural designed the dome framing such that it could either be fully erected on the ground and then lifted into place as a single, fully assembled unit, or erected in the air, piece by piece, through the use of multiple cranes. Once erection planning was under way, safety, necessary crane sizes, erection time and fit-up considerations were all weighed when comparing the two schemes, and the piece-by-piece plan was deemed the best option.

CB2 Structural had designed the central (middle) octagonal tube steel ring, located at the top of the dome, to be used as a suspended framing point for erecting the dome rib members. While the central ring was on the ground, two of the curved tube rings were welded to it. The central ring and two ribs were then hoisted into place via one of the site cranes. The ring and two ribs were then suspended by one crane while each of the additional rolled HSS ribs was held in place by a second crane and welded into place at both the lower supporting HSS columns and the upper supporting


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▲ Looking up...

▼ ...and looking down through the main floor opening beneath the dome.


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steel ring. Each rib was erected in a similar manner until the basic framework for the dome was fully erected. Once the central octagonal ring and primary rib members were erected, supplementary facet members (those rolled to multi-point arches along their lengths) were erected. The members were held in place by cranes while the erection crews worked from bucket lifts operating around the perimeter of the erected dome ribs.

▼ Curved steel for the dome framing.

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▲ The central (middle) octagonal tube steel ring, located at the top of the dome.

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▲ The building is framed with 550 tons of steel.

Lateral Challenges

The dome's lateral and vertical forces were transferred to the roof diaphragm and steel framing below via concentrically braced steel frames, and this load path was used to design the diaphragms as well as the building's concentrically braced frames. In addition, the openings in the second-floor diaphragm—which allowed occupants on this level to view the first level—complicated the distribution of lateral wind and seismic forces Where diaphragms with a limited number of openings may have made for fewer braced frames in a similar plan size, the larger and more frequent floor and roof diaphragm openings required that braced frames be located both frequently and uniformly throughout the floor plan. Frequent braced frame plan locations resulted in diaphragm load paths that were compatible with the architectural floor opening requirements. The braced frames consisted of wide-flange columns and beams diagonally braced by HSS6×6 and HSS8×8 members.

The owner's vision for an exciting building, the architect's work to bring about the owner's vision and the structural engineer's close coordination with the steel team all combined to

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A 35-ft-long chandelier is suspended from the dome's interior.

deliver an exciting project via the flexibility and workability of structural steel.

Owner
High Point University, High Point, N.C.

General Contractor
Samet Corporation, Greensboro, N.C.

Architect
Mercer Architecture, High Point, N.C.

Structural Engineer
CB2 Structural Engineers, PLLC, Kernersville, N.C.

Steel Team

Fabricator
Universal Steel of NC, LLC, Thomasville, N.C.

Detailer
Prodraft, Inc., Chesapeake, Va.

Bender-Roller
Chicago Metal Rolled Products