Modern steel design and construction help Texas A&M University's new 21st Century Classroom Building live up to its name.

Well-Rounded Education

BY CARLO TADDEI, PE

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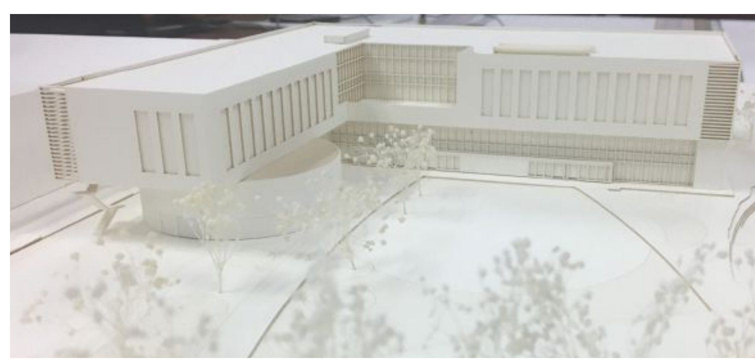
IN THE NEVER-ENDING COMPETITION amongst colleges to attract the best and brightest, Texas A&M University (TAMU) has built a world-class facility to bring top talent to its flagship campus in College Station, Texas.

The primary goal of this new addition to the TAMU campus, the 21st Century Classroom Building (21CCB), is to build a culture of excellence in teaching and learning by creating dynamic learning environments that foster student engagement. According to TAMU president, Michael K. Young, "Building a modern classroom facility advances our goal of increasing student success through transformational learning. This facility in both layout and technology will be built to optimize how students today learn and will meet the needs of our innovative faculty."

Scheduled to open this fall, the 120,000-sq.-ft building contains 2,200 general purpose seats across 10 classrooms at a total project cost of $85 million ($53 million in construction cost). Classrooms range in size from a 600-seat auditorium to 72-seat learning studios, and are complemented by informal study spaces. The top floor has offices for three instructional support groups: Center for Teaching Excellence, Office of Academic Innovations

above, left, and below: Two lecture halls in TAMU's new 21st Century Classroom Building can seat hundreds of students apiece while still feeling intimate and engaging.

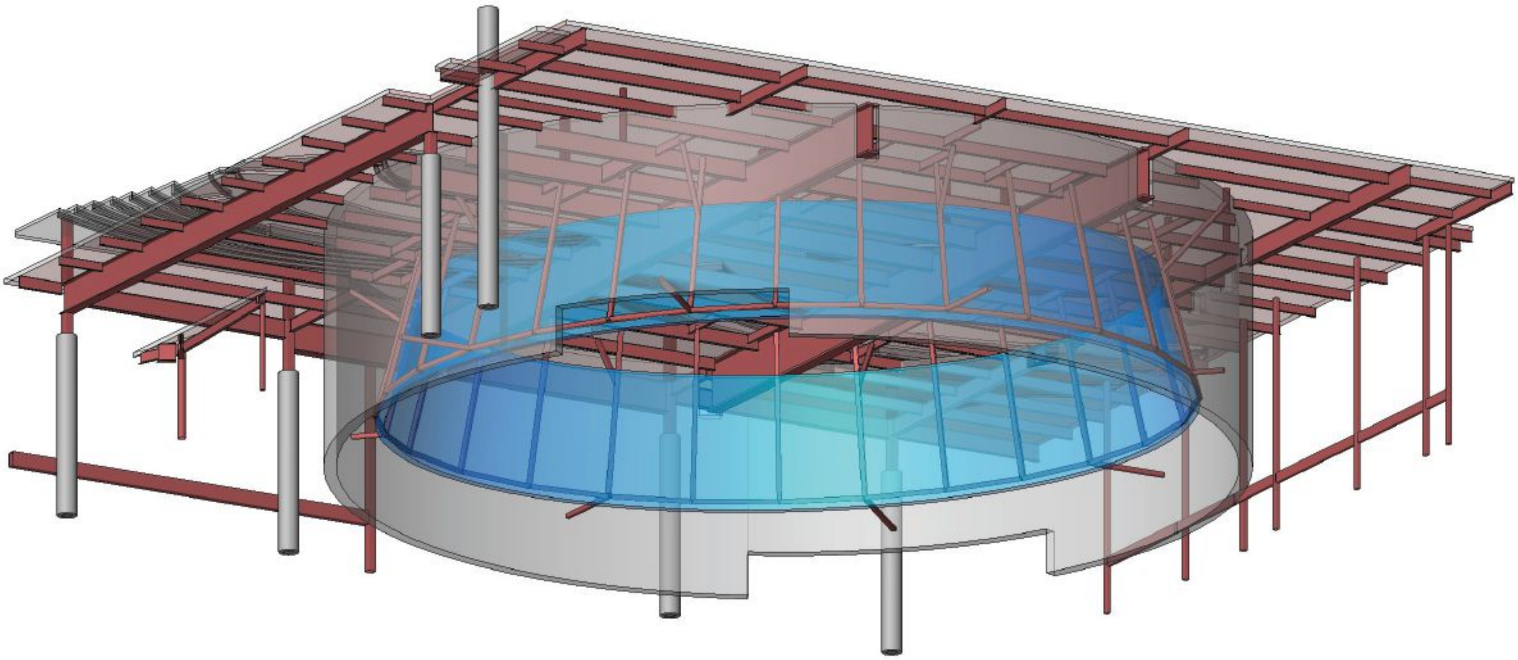


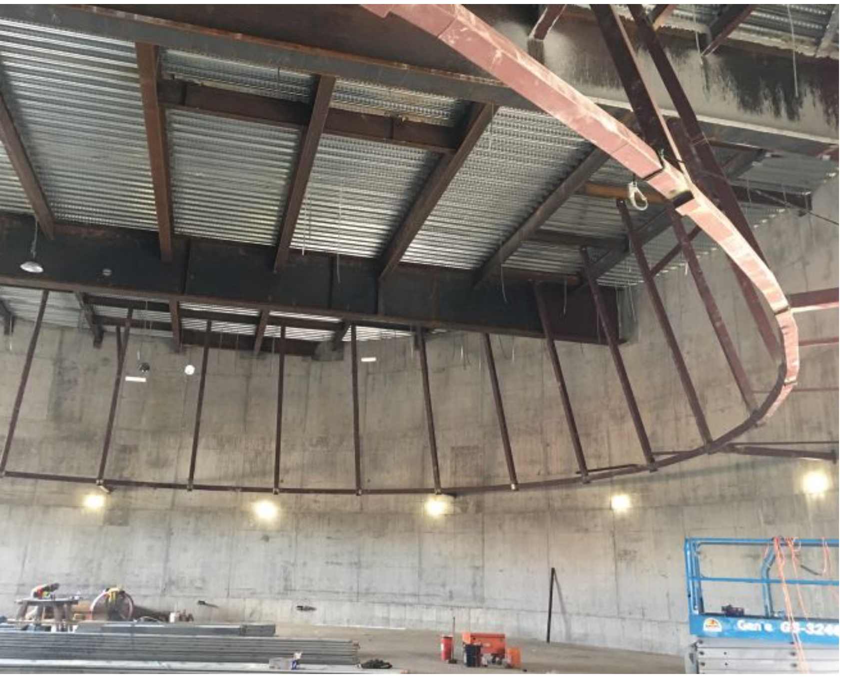
and Instructional Media Services. These departments are collocated in the building to enhance and better promote active learning pedagogies at TAMU. Except for the cast-in-place concrete walls of two large auditoriums, the entire building is steel-framed via approximately 1,085 tons of structural steel.

Theaters in the Round

The two "theater in the round" auditoriums—one seating 600 and the other 400—are located on the ground floor and place the instructor in the middle of the arena, surrounded by tiered seating, to give every student the same vantage point no matter where they sit; both auditoriums also include 360° video screens. The building is L-shaped, with one auditorium in each leg, and the walls of the two auditoriums act as bearing walls for the structure above and as shear walls for lateral load resistance, providing lateral resistance in all directions.

To bridge the 104-ft-diameter span of the 600-seat area, a variety of framing layouts were evaluated as the floor structure not only had to clear span the large arena, but also needed to support transfer columns for the third floor and roof above. The final framing configuration consisted of two steel plate girders located at the one-third points of the circular auditorium, which reduced the span of the girders and as well as the tributary loading. This also helped keep the secondary floor beams to a reasonable depth to allow for routing of the MEP services to the auditorium. The plate girders were 6 ft deep with a web thickness of 1¼ in. and use 3-in. by 18½-in. flange plates (ASTM A572-GR 50) with a length of 100 ft and an approximate weight of 34 tons apiece. The flanges were welded to the web plate with continuous 5⁄16-in. fillet welds on each side of the web, and the girders were cambered 1 in. and designed to act compositely with the concrete-filled steel deck,





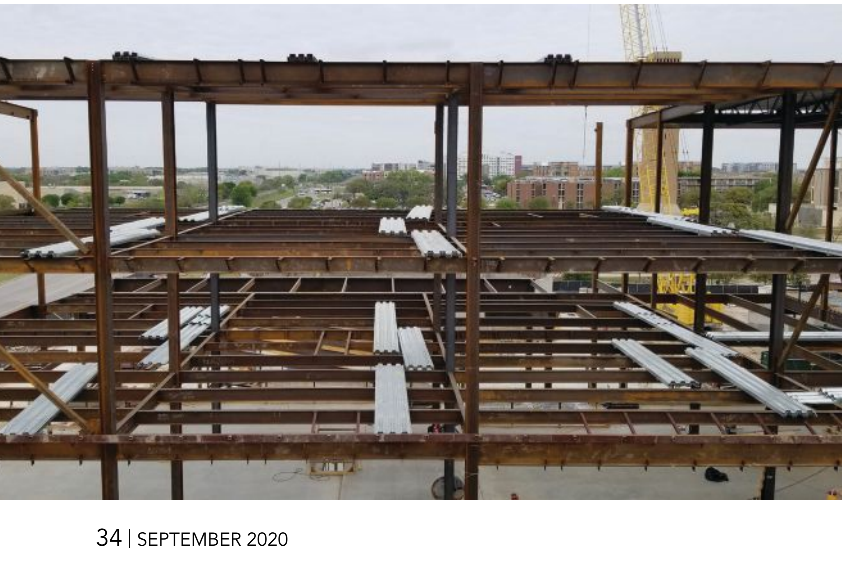
above and left: Both round auditoriums implement a theater-in-the-round layout and 360° video screens (supported by hanging steel frames) allowing every student to have the same vantage point from any location in the room.

which required 255 ¾-in.-diameter by 5-in.-long headed stud anchors.

The construction was sequenced such that the concrete on the second-floor decking was placed and cured prior to erecting the third floor and roof to allow for the plate girders to be fully composite before the transfer loads were applied. This yielded a more economical design and reduced the size of the girders. The top of the concrete wall was formed with a 3-ft-wide block-out to receive the plate girders, which were set on 1½-in.-thick bearing plates anchored to the top of the concrete wall with 1-in.-diameter anchor rods. The block-outs were then filled with non-shrink grout after the framing was installed.

While the 400-seat auditorium had a smaller diameter (90 ft) it came with its own unique set of challenges. The auditorium was placed such that the north edge extended 25 ft beyond the face of the building, and the east edge was inset 15 ft from the face of the building above. As the auditorium was placed within an open breezeway, the architect wanted to give the appearance that the upper portion of the building was floating above the auditorium. Thus, the building columns had to be transferred at level 2 along the north and east faces, and the floor structure had to cantilever up to 20 ft past the face of the auditorium to transfer the roof support columns along the east face.

The plate girder along the north face of the building is 6 ft, 2-in. deep plate with a web thickness of 1 in. and 3-in. by 1-ft, 8-in. flange plates (ASTM A572-GR 50) with a cantilever of 20 ft and back span of 83 ft. This plate girder not only supports the transfer columns for the roof but also



The building incorporates nearly 1,100 tons of structural steel.

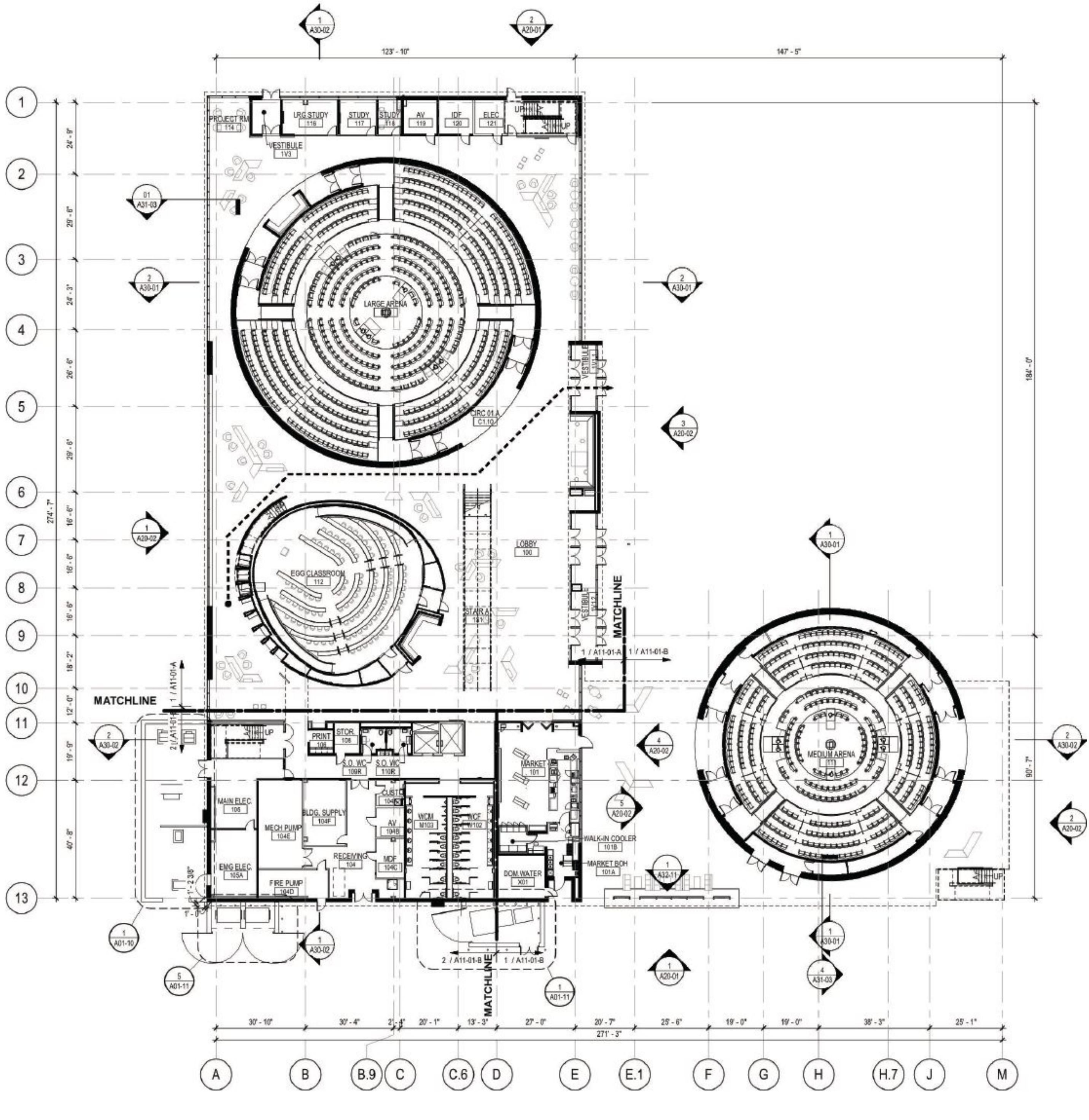
The "PG3" plate girder, weighing approximately 20 tons, being lifted into place. The project's heaviest plate girder weighs 34 tons.

the low roof structure over the portion of the arena that projects beyond the building face—which includes a landscaped roof—and 32 ft of brick veneer. The center girder was located 12 ft, 6 in. south of the center of the auditorium and consists of a 5-ft, 4-in.-deep plate girder with a web thickness of 1 in. and 2-in. by 1-ft flange plates (ASTM A572-GR 50) with a cantilever of 16 ft and back span of 90 ft. The southern girder was located close to the edge of the arena, which shortened the loading and clear span of 64 ft and a cantilever of 27 ft, thus permitting the use of a W44×290 in lieu of a plate girder.

Plate girders were also used for the level 2 floor structure south of the 600-seat auditorium, where spans up to 84 ft were required to bridge over the "egg" classroom at level 1 (called this for its egg-shaped design). These long-span girders were also required to support transfer columns for level 3 and the roof. As this area was in the direct path from the mechanical room at the south end of the building and the 600-seat auditorium, and a high ceiling was desired for the lobby below, the deep plate girders created conflicts with mechanical ducts and pipe runs. As such, web penetrations—as many as five per girder—were made in the members to allow for the MEP runs to be uninterrupted. These web openings were analyzed using the procedures presented in Omer W. Blodgett's book *Design of Welded Structures* and AISC's Design Guide 2: *Design of Composite Beams with Large Web Openings* (**aisc.org/dg**).

right: Web penetrations—as many as five per girder—were made to allow for MEP runs to be uninterrupted.

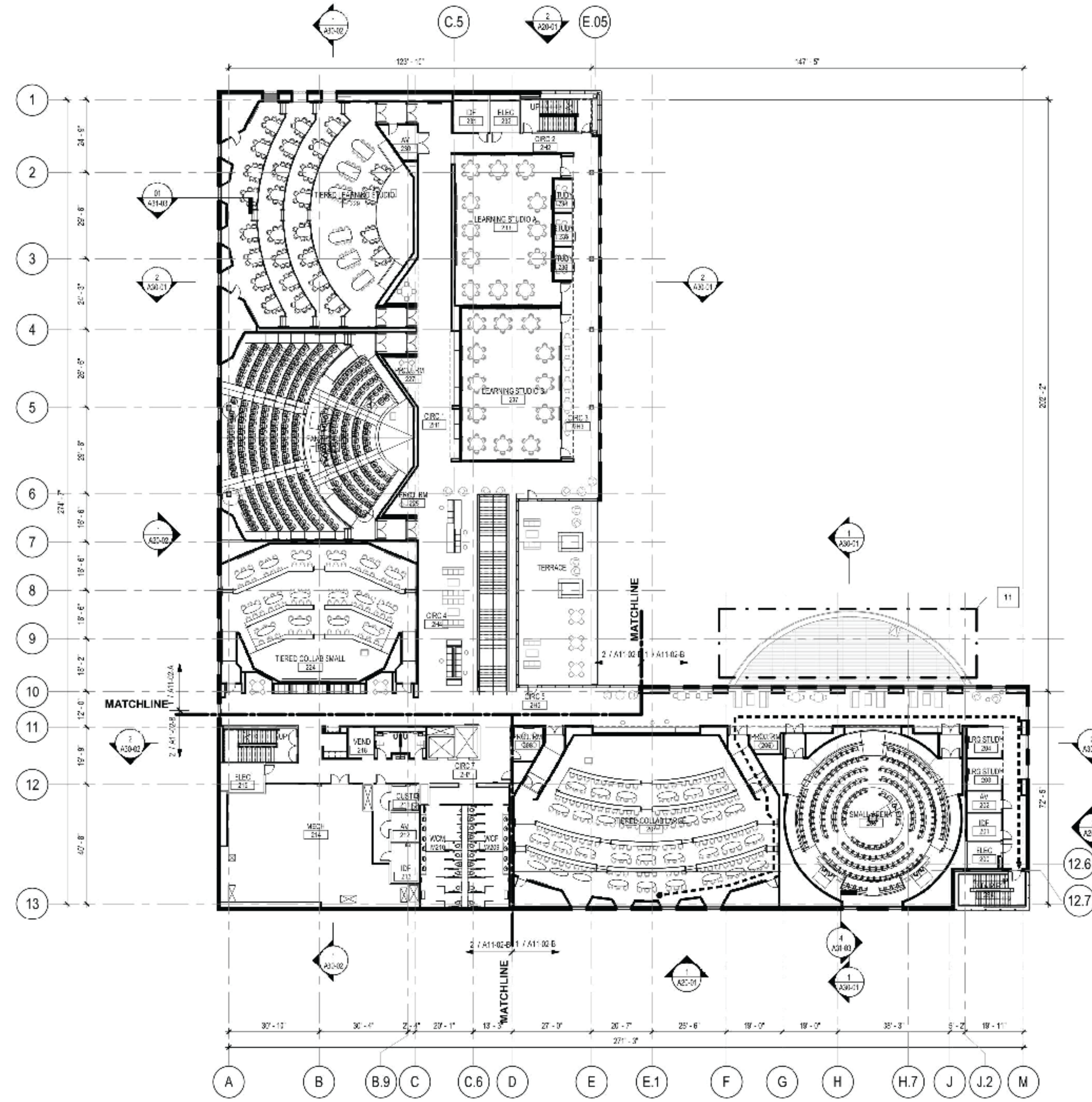
below: The 120,000-sq.-ft building contains 2,200 general purpose classroom seats across 10 classrooms.



Connecting the plate girders to the steel columns presented some challenges, as the maximum service load was 585 kips, which could not be achieved with a typical beam-to-column shear connection due to the bending introduced into the column from the connection eccentricity. Thus, the engineering team at JQ designed the HSS14×14×⅝ columns to be spliced to create a bearing connection for the plate girders. In total, six plate girders of four different types were used on the project, each one transported fully assembled from fabricator MSD Building's facility in Pasadena, roughly 100 miles from the project site. Welding the plate girder splices was a continuous operation to maintain a constant temperature, which required around-the-clock heating, welding, and two forms of non-destructive testing (NDT) for the welds: magnetic particle testing and ultrasonic testing.

Exterior and Roof

The tall floor height between levels 1 and 2 allowed mid-height location of an 11,500-sq.-ft mezzanine framed with steel beams and girders supporting a composite steel deck. While the mezzanine was largely dedicated to mechanical and building support functions, it also extended over the egg classroom on the first floor to provide a prominent study space. The tall floor height also posed challenges for bracing the façade as several areas contained long strip windows up to 80 ft in length, with 16 ft of masonry veneer overhead. This required large wind girts at the window heads to brace the wall out-of-plane and to serve as lintels for the masonry veneer. Wind girts up to HSS24×12×⅝ were required to span between the building columns, which were up to 32 ft, 8 in. apart. As the girts were required to be within the wall system and



opposite page: The first floor is highlighted by the two round auditoriums as well as the "egg" classroom.

above: The second floor of the L-shaped building includes several more traditionally shaped classroom spaces.

the center lines of the columns were inset up to 3 ft from the building face, steel haunches off the face of the columns were required to support the girts.

Roof framing above the large classrooms at level 2 consisted of 40-in.-deep, double-pitched top chord LH-series joists spanning up to 63 ft, and deep-rib steel roof deck (3 in.) was used to maximize the spacing of the long-span structure. The building façade at level 2 projected approximately 1 ft beyond the façade at level 1 and extended 7 ft below level 2 (the top of the parapet is 32 ft, 9 in. above level 2). As the façade consisted of brick masonry and had a series of closely spaced tall narrow windows that begin at level 2 and stop approximately 5 ft below the 25-ft-tall roof, the design team decided to relieve the brick at the window head around the entire building perimeter. To achieve this brick relief, top chord extensions for the steel joists and HSS6×4×¼ outriggers at 5 ft on center were used to support the channel frames and brick relief angles. The roof beams were designed to limit deflections to $L/600$ (⅜ in. maximum) which required stiffer roof structure around the perimeter. Aside from the large number of windows and expanses of curtain wall, four 6-ft-wide, 22-ft, 6-in.-long roof monitors were introduced over the third-floor structure in the north wing to bring in additional daylighting.

Steel columns consisted of a mix of wide-flange and hollow structural sections (HSS), and 50-ksi steel was used for the HSS (ASTM A500, Grade C) to provide higher axial strength for the tall building height and transfer structure loading, with wide-flange columns (65 ksi) used only in the back-of-house mechanical room spaces. In these areas, there was a desire to have the columns bear

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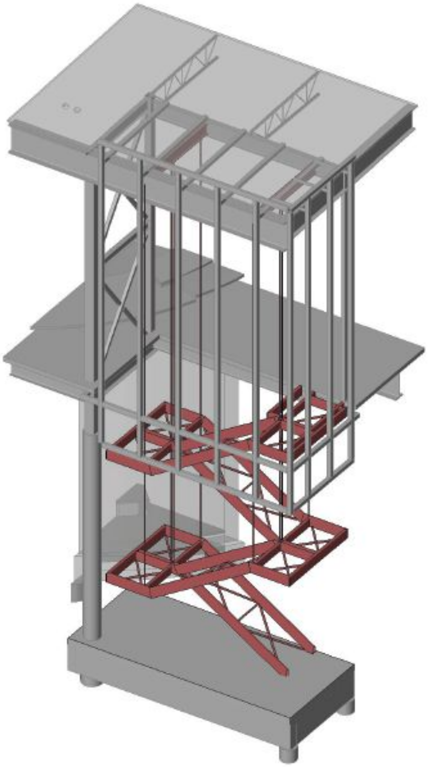
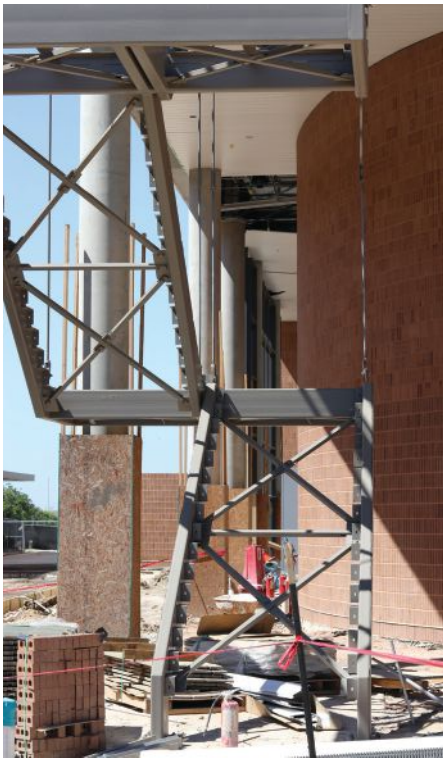
above: A monumental stair stretches 65 ft horizontally and 33 ft vertically through the interior lobby.





above: The exterior "spring" stair at the southeast corner of the building contains three intermediate landings that give the appearance of a coiled spring.

below: The building's 21st century learning goals are defined by the "four Cs": critical thinking, communication, collaboration, and creativity.

on top of the foundation slab instead of recessing these base plates, and using wide-flange columns allowed for the anchor rods to be located within the webs of the columns and not create a tripping hazard. Lateral bracing around the back-of-house area and throughout the building from the podium at level 2 up to the roof consisted of concentrically braced frames in X-brace and Chevron configurations.

Exposed Steel Stairs

Two other focal points of the building were the interior monumental stair that stretches 65 ft horizontally and 33 ft vertically through the interior lobby, and the exterior stair. The monumental stair stringers consist of 20-in.-deep architecturally exposed structural steel (AESS), specified as AESS 1 (Basic Elements), and HSS members supported at two intermediate points by HSS8×8 beams (for more on the various AESS categories, see "Maximum Exposure" in the November 2017 issue, available at **www.modernsteel.com**). In order to achieve the one-hour fire rating for the steel columns, architect Perkins+Will wanted them to be encased in concrete. This created a

construction sequence issue with the connections of the HSS8×8 beams to the stair support columns. The intent at this joint was for the HSS beam to be directly connected to the column, but the contractor wanted to pour the concrete before installing the stair. This required a revision to the connection shown in the construction documents to include a HSS stub with an end plate that could be installed before the concrete was cast. After the concrete pour, the contractor was able to connect the HSS beam to the end plate.

The exterior "spring" stair was located at the southeast corner of the building at the cantilevered second floor and contains three intermediate landings that give the appearance of a coiled spring. The stair consists of 14-in.-deep HSS beams and is suspended from the roof structure above with eight 1-in.-diameter high-strength rods. Aside from the hangers, the stair is connected to the structure at the second floor and the foundation. Since there are no columns at this corner, the roof girder along the south edge of the building cantilevers 25 ft to catch the intersecting north-south beam and to support the stair hangers, and a W44×335 girder was required to provide stiffness for the stair and terra cotta louver system. As the stair is exposed (also adhering to AESS 1 requirements) and subject to wind loading and racking, horizontal bracing was provided between stringers to provide lateral stability to the stair.

The use of structural steel helped bring the project vision to life by providing a lighter solution to achieve the long spans, column-free auditoriums and lobby space, lower foundation costs, and faster construction time—culminating in a 21st century solution for a 21st century building. ■

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Texas A&M University System

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Perkins+Will, Dallas (Architect of Record)
Bora Architects, Portland, Ore.

Structural Engineer
JQ Engineering, Dallas

Steel Team

Fabricator
MSD Building Corp., Pasadena, Texas

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Chicago Metal Rolled Products, Chicago