Fab Five

Kyle Zirkus

courtesy of Tishman Speyer

2025
IDEAS² AWARDS

2025 IDEAS^2 AWARDS

EXCELLENCE IN ARCHITECTURE

Pima Community College – Advanced Manufacturing Center
Tucson, Ariz.

EXCELLENCE IN ADAPTIVE REUSE

Top of the Rock Redevelopment
New York

A college building with a teaching tool as a design feature, a 1960s office building modernized with new steel elements, and the world's largest spherical structure are among the 2025 IDEAS^2 award recipients.

FIVE RECENT PROJECTS have earned one of the steel industry's most notable honors: an Innovative Design in Engineering and Architecture with Structural Steel (IDEAS^2) award.

AISC annually presents the IDEAS^2 awards to projects that illustrate the many possibilities of building and designing with structural steel. The awards display innovative steel use in:

- the accomplishment of the structure's program
- the expression of architectural intent
- the application of innovative design approaches to the structural system
- leveraging productivity-enhancing construction methods

All IDEAS^2 entries and winners must have met these criteria:

- New buildings, expansions, and renovation projects (major retrofits and rehabilitations) are eligible. There is also a category for sculptures, art installations, and non-building structures.
- Building projects submitted for 2025 IDEAS^2 awards must be in the U.S. and must be completed between Jan. 1, 2023, and Aug. 31, 2024.
- A significant portion of the framing system of a building must be wide-flange or hollow structural steel sections (HSS).
- Most of the steel used in the project must be domestically produced.
- Pedestrian bridges entered in the competition must be an intrinsic part of a building and not standalone structures. Members of project teams for standalone bridges are encouraged to enter their work in the 2026 National Steel Bridge Alliance's Prize Bridge Awards.


Jason O'Rear


Severud Associates


Severud Associates

EXCELLENCE IN CONSTRUCTABILITY

200 Park
San Jose, Calif.

EXCELLENCE IN ENGINEERING

PENN 2 Redevelopment
New York

PRESIDENTIAL AWARD FOR ENGINEERING DESIGN AND CONSTRUCTION

Sphere
Las Vegas

Like last year, the IDEAS^2 jury honored projects that took full advantage of specific benefits—sustainability, cost, speed, reliability, and resilience—that make structural steel the best choice for designers, rather than award projects by budget category like in previous years. Many IDEAS^2 winners are landmark structures, but the program also honors smaller, less visible projects. No matter the project size or fame, all IDEAS^2-winning structures share a commitment to innovation and imaginative design.

The five winners were in five different award categories: excellence in engineering, excellence in architecture, excellence in adaptive reuse, excellence in constructability, and a special honor: a presidential award for engineering design and construction.

Three IDEAS^2 recipients are new structures. One is an office building in San Jose, Calif., that became the second-ever project to use the composite SpeedCore system and is now the city's tallest building. Another—and perhaps the most recognizable—is the world's largest spherical structure that's already a prominent U.S. event venue. The third new building is a community college addition incorporating a hands-on learning tool as a design feature.

Elsewhere, two midtown Manhattan buildings added new steel elements. A 1960s office building gained a steel addition that provides valuable space, adds natural light, and connects the building with the neighborhood. One of Manhattan's more iconic buildings added two rides to its scenic rooftop, supported by new steel.

"Innovative breakthroughs happen at intersections, whether they're meetings of minds, changes in a structure's needs, or a challenge to build something that will make people stop and take notice," AISC Senior Vice President Scott Melnick said. "Each of these projects found themselves at the right intersection with the right team at the right time."

A five-person jury decided on this year's IDEAS^2 award recipients:

- Jill Lavine, AIA, LEED AP, founding principal, FIFTEEN Architecture + Design
- Jeremy Loebs, business development executive, Schuff Steel
- Rob Martinelli, senior vice president, operations, Pepper Construction
- Fraser Reid, PE, CEng, MICE, associate principal, Buro Happold
- Nima Balasubramanian, AIA, NOMA, director of architecture, AISC

Read on to learn more about this year's winners.

2025 IDEAS² AWARD

EXCELLENCE IN ARCHITECTURE

Pima Community College – Advanced Manufacturing Center

Tucson, Ariz.

"The Advanced Manufacturing Center is an excellent example of seamless integration between building design, building purpose, and defining structural elements. The elevated crane bay connecting the length of the building puts the structure on display and becomes this iconic and unifying feature that reinforces the idea of bringing partners together in education, industry and community. The attention to detail carries through each structural element and exemplifies the spirit of the project."

—Jill Lavine


Kyle Zirkus

AN ARIZONA COMMUNITY COLLEGE'S new campus centerpiece incorporates key learning tools into its design, an architectural and engineering innovation only possible with a structural steel system that helped complete the project under budget.

Pima Community College in Tucson, Ariz., invested in significant campus additions in hopes of helping solve the shortage of qualified workers in local industries. The main component is the Center of Excellence for Applied Technology, a collection of academic and technical buildings offering transportation/logistics, advanced manufacturing, and infrastructure studies. It will provide formal degree and certificate programs, plus short-term training opportunities.

The Center of Excellence has two main buildings: the 43,000-sq.-ft Transportation Center Building (TCB) focusing on automotive training and the 95,000-sq.-ft Advanced Manufacturing Building (AMB). The latter is a three-story industrial learning facility with space to teach welding, machine tools, mechatronics, and CAD, among other trades. It also has a workforce development incubator, a flexible industry training lab, administrative offices, and a rooftop patio for outdoor learning and events.

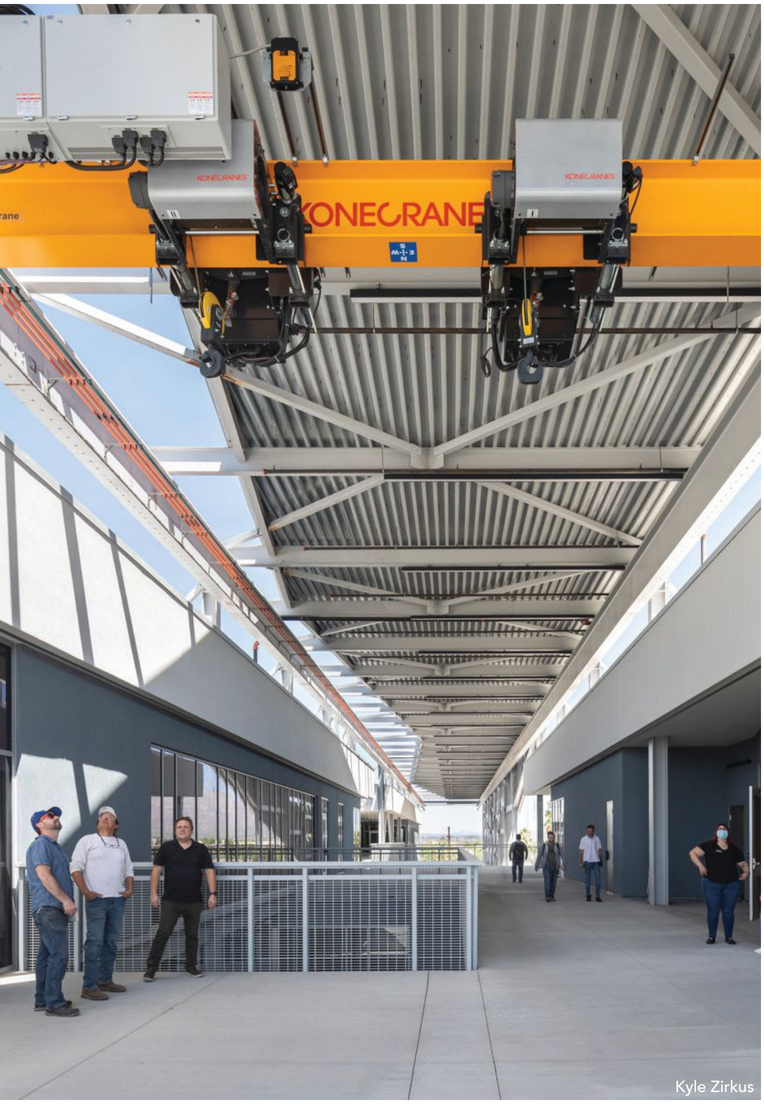
The AMB promotes flex learning by providing classrooms and labs that open and connect to outdoor areas to provide extended spaces for project-based learning. This centralized circulation spine is connected visually and functionally by a 10-ton underslung bridge crane, which transverses the entire building length above the exterior walkways and connection spaces. The crane, which can transport materials throughout the facility, provides a visual cue for students to see and understand the connections between the various learning pathways.

A Clear Choice

The main structural system is comprised of composite floor deck supported by wide-flange steel beams and columns, as well as metal roof deck. Hollow structural sections (HSS) braced frames comprise the lateral load system. The crane runway beam is supported by the main building columns instead of a separate supporting structure. The structural steel system was the only choice for this unique design because of its economy, aesthetics, and flexibility.

A building this large and complex can often go above the initial construction budget. The steel structure helped ensure that the superstructure was designed as efficiently as possible so other supplementary items, such as the metal screens and façade elements, were not value-engineered out of the project. The column grid system was studied intensely during the schematic design phase to find a bay size that was wide enough to maximize the floor framing capacity but not too wide to cause too much vibration.

After finding the right bay size for the loading and massing of the building, the structural engineers worked closely with the architects to limit changes during design development. The outcome was a project built for less than $400 per sq. ft and $3 million under budget.



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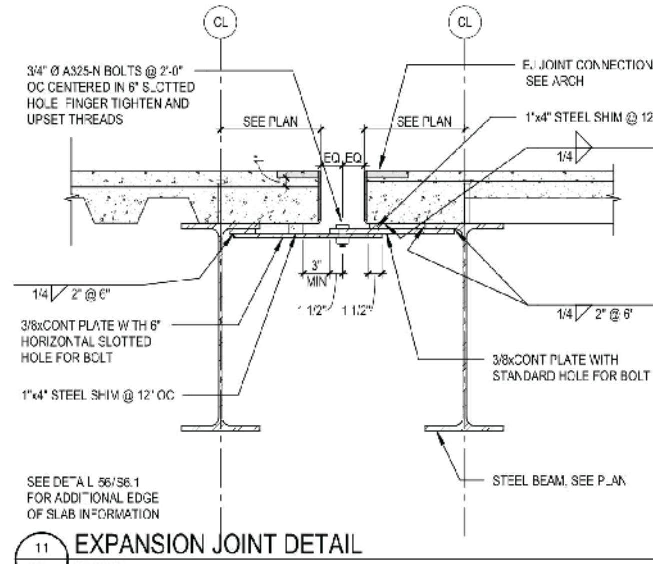
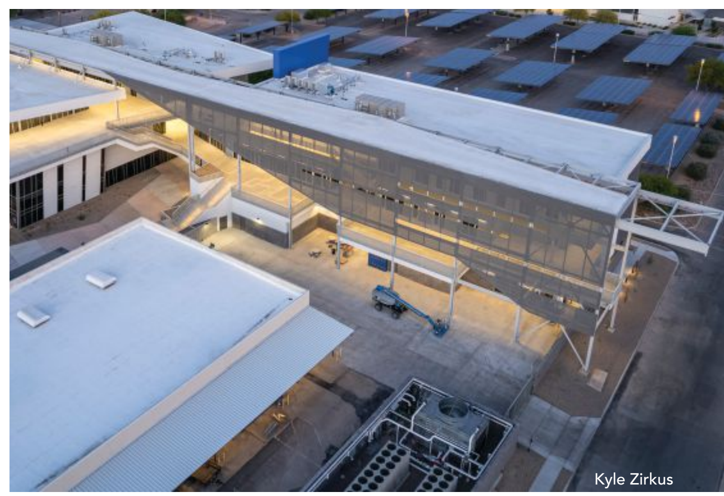


DLR Group


Kyle Zirkus

The learning spaces' manufacturing focus warranted a more industrial building aesthetic, resulting in lots of exposed structural steel. The exposed structure contributed to the design aesthetic of the interior spaces, such as classrooms and lab spaces, and significantly drove the exterior design. In addition, the metal screens along the building's south and east sides contribute to the façade design while also reducing the building's cooling loads and providing shaded outdoor learning environments. The screens were constructed of exposed wide-flange and HSS steel framing, with a perforated metal B-deck as the screen element.

Pima Community College wanted the AMB to adapt to changes brought on by evolving student needs and allow a wide range of industry partners to lease the space. These requirements meant selecting a structural system that could be easily modified to support new hanging loads of ducts, pipework, and equipment, and be easily reinforceable if future equipment loading exceeds the current structure capacity.

Crafting the Crane

To reduce the additional cost of the crane, the building superstructure resists the gravity and lateral loads of the crane. Having the building superstructure support the crane structure allowed the building's braced frames to support the lateral loads. However, this support plan proved to be challenging in the transverse direction. The crane structure was elevated approximately 8 ft above the surrounding roof diaphragms, and a braced frame could not be placed in the crane bay without obstructing the crane travel. The solution was to provide knee braces from the crane columns down to the roof beams below to transfer the lateral loads directly from the crane assembly to the roof diaphragm, which would then transfer the lateral forces to the superstructure's braced frames.

The knee-brace geometry was carefully considered with input from the architect so the crane roof could still appear to be floating above the roof and provide the required lateral support. The brace was kinked so that the portion that went through the roof assembly became vertical, ensuring an easier condition for the roof contractor to install around and properly waterproof.

Additionally, the crane needed to traverse the building's expansion joint. Introducing an expansion joint is not a typical detail in the design of a crane runway beam, so a custom connection was designed. A crane has severe limitations when sloped, so the engineering team collaborated with the crane manufacturer to handle an increased slope of ⅜ in. per ft. The resulting detail is a steel bent plate that covers the 5-in. gap that is fixed on one side and can slip on the other. The plate tapers from ⅜ in. down on either side so that the crane can move across the expansion joint while allowing the two structures on either side to move independently.


Matthew Winquist


Kyle Zirkus


Kyle Zirkus

The crane has a 28-ft cantilever on both ends of its runway, allowing it to pick up equipment directly from truck beds. The cantilever's stringent deflection requirements were difficult to achieve, especially with the required depth restrictions so that the crane could travel above the building's parapet. The design solution was to weld a 1-in. plate top and bottom to the crane runway beam and to provide in-plane HSS bracing, which stiffened the runway beams and delivered the lateral load back to the columns.

Pondering Key Placements

The building's length required an expansion joint to divide it into two, and the natural joint placement was at the bridge between the main volumes on either side. A double framing line at the expansion joint was implemented, providing a separation solution for the gravity system. However, the real challenge came when considering how to stabilize the floor diaphragm laterally at that same spot.

Due to the program layouts and limitations, the AMB offered few locations where braced frames could be added to support the east-west lateral loads. Furthermore, the crane runway occurred from the north to south ends of the structure, eliminating a whole bay to place a braced frame. A braced frame on the expansion joint's north side stabilized the edge of the northern massing of the structure, but one could not go on the south side to provide stability for the bridge's floor diaphragms.

During design, the structure was analyzed to determine if the floor structure could cantilever the 57 ft from the next brace frame located on the opposite side of the bridge. The overall movement at the north edge of the bridge structure created a need for lateral support along the expansion joint boundary. The solution was to provide a steel plate connecting the diaphragms across the expansion joint, allowing the required movement in the north-south direction but translating the lateral load from the bridge diaphragm across the joint into the braced frame line to the north. The carefully detailed custom connection provides the lateral support for the bridge floor diaphragms and the crane roof diaphragm above.

Indoor and outdoor spaces are intertwined throughout the AMB. There are multiple locations where an outdoor walkway or patio occurs over conditioned spaces below, which meant the outdoor walkway system had to act as a roof, thus requiring the continuous insulation mandated by the energy code and design lanes for proper drainage.

The drainage issues were solved by stepping the floor diaphragm 12 in. to allow for 3 in. to 6 in. of rigid insulation sloped to internal drains with 3 in. of wearable concrete slab on top. The steel structure easily allowed for the diaphragm steps to occur. The structural engineers worked closely with the architects to align the building steps at column grids for efficiency. When alignment was not possible, the steel detailing's inherent flexibility allowed the steps to be located where needed.

Steel as an Aesthetic Staple

While the exposed structural steel and perforated steel screens enhance the overall building aesthetics, steel contributed to the architectural expression of two other primary areas: the west façade and the connection from campus to the TCB.

The west façade is the new entrance to the campus block, and architects wanted a striking design. The architects created exterior installation and finish blocks dubbed "the French fries" that alternately project and recess from the plane of the façade, creating a dynamic effect above the lower level's concrete masonry unit exterior. Hidden behind the finish material, the French fries' massing is cold-formed metal framing attached to HSS frames.

Constructing the entire assembly of structural steel had several advantages. Notably, having one materiality in the assembly ensured the frame construction was one subcontractor's responsibility and facilitated quick and easy installation. Once the structural steel was erected, the metal stud fabricator provided the intermediate framing later when the exterior wall framing was installed and did not become a pinch point for the construction timeline.

The campus block to TCB connection was accomplished at the AMB by separating the building's massing so visitors could still see the TCB from the AMB's east side. The AMB's two masses were connected at the second- and third floor-bridge and with the crane overhead.

On the AMB's east side, an egress stair from the third-floor patio to the second-floor bridge became a challenge for the structural engineers. Avoiding support columns at the landing maintained the strong visual connection to the TCB under the bridge and stairs. Vibration was a major concern because the single run of stairs was long, and it was supported at the top by a cantilevered beam and at the bottom by a long-span beam. Without proper support, the assembly would have been noticeably bouncy. Two rods at the stair landing hung from the crane roof provided additional stability without visually blocking the view.

The $29 million project opened in time for the 2023–24 academic year. Pima Community College has been a staple in the Tucson area's skilled trade education since its founding in 1969, and the AMB has positioned it to remain that way for the next 50 years and beyond.

Owner
Pima Community College, Tucson, Ariz.

General Contractor
Chasse Building Team, Tucson, Ariz.

Architect and Structural Engineer
DLR Group, Phoenix

Kyle Zirkus

2025 IDEAS² AWARD

EXCELLENCE IN
ADAPTIVE REUSE

Top of the Rock Redevelopment
New York

courtesy of Tishman Speyer

AN ICONIC NEW YORK CITY BUILDING added attractions to its popular rooftop observation area, and the project's new steel elements facilitated disruption-free work and success on a tight rooftop jobsite.

The Top of The Rock on the 67th, 69th, and 70th floors of 30 Rockefeller Plaza in midtown Manhattan is a popular tourist destination, and the owners wanted to bring new interactive experiences to the observation deck portion. One is called The Beam and allows patrons to recreate the famous "Lunch Atop a Skyscraper" photograph from the 1930s. The other, the Skylift, is a telescoping platform that rises 30 ft above the 70th floor and rotates 360° to provide panoramic city views. The rides lift out of the roof deck and, when not operating, look like natural observation deck features.

The observation deck could not close during construction of both rides and the frame adjustments to accommodate them, and work could not interrupt the building's elevators despite a lack of freight elevator access to Top of The Rock. Luckily, choosing steel for the additions and modifications allowed structural engineer Gilsanz Murray Steficek (GMS) to work more efficiently with Rockefeller Center, which was constructed with a steel frame. The range of available steel shapes and sizes allowed for creative use of new sections and reinforcement, and any other material choice for a ride that pays tribute to a photo of ironworkers constructing Rockefeller Center would have felt wrong.

Not So Spacious

Space and access constraints were the building's biggest hurdle. The 67th and 69th floors are roughly 60 ft wide and the 70th floor is only about 20 ft wide, with elevator machine rooms and other base-building mechanical systems occupying nearly all the space along the core.

Keeping the observation deck open meant that most work occurred between midnight and 8:00 a.m. when it was closed. While portions of the deck could close during the day, jobsite space on the deck never exceeded 2,000 sq. ft.

Mike Pugliese

Mike Pugliese

Early design phases brought frequent coordination calls and design submissions to the ride manufacturer to understand its restrictions and requirements. Gantry cranes on the roof were used to install both rides, and nearly every cubic inch of space was accounted for and needed in the Skylift motor room and the suspended pits for The Beam.

GMS had the building's original 1932 erection drawings and an incomplete set of drawings from the 2004 renovation project that included substantial observation deck work. There were numerous instances where the conditions on site did not match any drawings, leading to probes of existing conditions to finalize the design. Steel's design flexibility was crucial for incorporating new information and the resulting design tweaks.

Building up The Beam

The backbone of The Beam's support system is a new W36×150 that spans approximately 28 ft between two existing girders, which needed extensive reinforcing. When the ceiling below the 69th floor was removed, the team discovered a 30 in. by 18 in. web opening had been cut into the west existing girder. The web opening was at a high-shear area and did not comply with proportioning and spacing recommendations in AISC Design Guide 2: *Steel and Composite Beams with Web Openings*.

The W36 would connect approximately 6 in. from the nearest edge of the opening, and it could not be moved without moving the location of The Beam, which was not an option. A surplus of utilities—including approximately 12 antenna cables owned and operated by NBC, the New York Police Department, and the FBI—were crammed within the web opening.

GMS created extensive finite element analysis models to explore all options to avoid moving the cables. None were viable, though, so the solution was to cut and reroute the antenna cables, partially reduce the web opening size, and add a doubler plate.

Skylift Substructure

The Skylift's substructure has four static guideposts connected to the 70th-floor framing at the 12, 3, 6, and 9 o'clock positions. The project phasing relied on GMS completing the base-building work at the motor room and roof opening and turning over a turn-key space that would accept the Skylift equipment. The location, elevation, and configuration of the base-building structure at these four connection points along the 70th floor were hyper-critical. The new beam at the 3 o'clock position was the last project hurdle.

The new Skylift motor room is a former gift shop that occupied half a column bay, and at first, the team had limited access to survey details concealed by finishes. To stay on schedule, Skylift fabrication began before the gift shop was gutted. Gutting revealed the space's east-west dimension was approximately 1 ft smaller than initially thought based on prior renovation drawings and initial surveys. Recovering the lost space by setting the existing structure 3 ft lower cost nearly all the extra pit floor space allotted for tolerances. It also meant the new beam along the 70th-floor east edge would be partially within the elevator machine room in the other half of the bay.

The two new girders that support the Skylift are each 28 ft long, weigh about 2 tons, run east-west between existing columns, and are set directly below the original 69th-floor framing. Originally, the girders would frame into the existing columns' centerline, but that would put the east half of the girders partially within the 900-ft-tall elevator shaft. Moving them outward from the shaft would encroach more within the elevator machine room, which didn't have space for rigging and installation

Four disconnect panels were along the demising wall's north end, and critical electrical cabinets were along the south end. In that condition, the new beam would pass directly behind the disconnect panels and inches above the electrical cabinets. Furthermore, existing east-west beams into the Skylift motor room would have to be shored, cut, and reconnected to the new beam after the roof slab above the motor room was demolished. In response, all steel work was scheduled in coordination with a separate elevator upgrade project because it included temporarily relocating the electrical cabinets.

GMS worked with the contractor to develop a shoring sequence and reconnection detail that would fit into the constantly changing conditions. The final detail is like an inverted beam hanger where the vertical straps are in compression, a design that allowed all work to occur on one side of the demising wall without impeding building operations.


Nick Zickgraf

"Top of the Rock embodies the adaptive reuse that's possible with steel. It's not easy to rig an amusement ride at the top of an existing 90-year-old building. The ride captures the spirit of steel and the ironworkers who have brought it to life through the ages to celebrate the connection between a community and the structures that define it."
—Jeremy Loebs


courtesy of Tishman Speyer

Nick Zickgraf

courtesy of Tishman Speyer

Brian Bansrupan

Piecing Things Together

Given the lack of freight elevator access, each 28-ft-long girder had to be delivered to the site as four pieces, each about 7 ft long. Each piece traveled to the 67th floor in a recently refinished passenger elevator and was rigged up to a temporary work platform, which was built above the elevator staging area via an access hatch purposefully set where the Skylift installation team could later rig up materials from 67 to 70.

Once on the work platform, a system of carts on channel tracks maneuvered each 1,000-lb girder piece to its staging area on the west side of the work platform, and then the girder pieces were fit up and CJP-welded on a workbench hung from the 69th-floor framing. After the splice was completed, inspected, and ultrasonically tested, the workbench doubled as a track for pulling the girder to the east to allow for the next piece to be fit up in an assembly line-like fashion.

After all segments were spliced, shelf angles were welded to the column faces so the girder could be jacked into final position. The connections at the girders' eastern ends were designed to require access only from one side and required partial installation and inspection before the girder was pulled into its final location.

Both rides opened to the public in December 2023 and are a testament to steel's adaptability, even in the face of inconvenient jobsite constraints, and also demonstrate that steel frames can be adjusted later in their lifespan to serve a purpose never even considered during their initial design decades earlier.

The Top of the Rock project would have been easier to execute if the observation deck could have closed for a few months to accommodate blowing out existing bays and bulkheads and replacing them with a purpose-built frame, but it wasn't an option. Deliberate coordination, creative engineering, and working with an adaptable material resulted in a project whose original structure, designed for one purpose, could be elegantly altered for a completely new one.

Owner
Tishman Speyer, New York

General Contractor
Gilbane Building Company, New York

Architect
Montroy DeMarco Architecture LLP, New York

Structural Engineer
Gilsanz Murray Steficek, New York

Attraction Consultant
THG Creative, Pasadena, Calif.

Steel Team

Fabricator and Detailer
North American Manufacturing Corp.
Maspeth, N.Y.

Erector
Maspeth Welding, Inc., Maspeth, N.Y.

2025 IDEAS² AWARD

EXCELLENCE IN CONSTRUCTABILITY

200 Park
San Jose, Calif.

Jason O'Rear

"The SpeedCore system really set 200 Park apart in constructability. SpeedCore offers schedule efficiency and reduction of fireproofing based on the system thickness. More importantly, it offers a reduced level of high-risk safety activities associated with traditional concrete cores, because the preassembled steel frames are prefabricated and sequentially installed versus a concrete core rising in advance of the steel sequences."

—Rob Martinelli

THE TALLEST BUILDING in San Jose, Calif., is also the state's first of its kind. The 19-story, 300-ft office tower known as 200 Park became the first California building—and second anywhere—to use the SpeedCore structural system when steel erection began in 2021.

Steel was the unquestioned choice to achieve the building's open layout, which includes outdoor terraces on about half the levels and natural light pathways at almost every turn. SpeedCore emerged from the project team's studies and early considerations as more cost-effective than a traditional braced frame or reinforced concrete core. SpeedCore could also be erected faster—three months faster than a traditional reinforced concrete core. Additionally, its substantial shear capacity reduced wall thickness by up to 18 in. (up to 30%) compared to a concrete core wall.

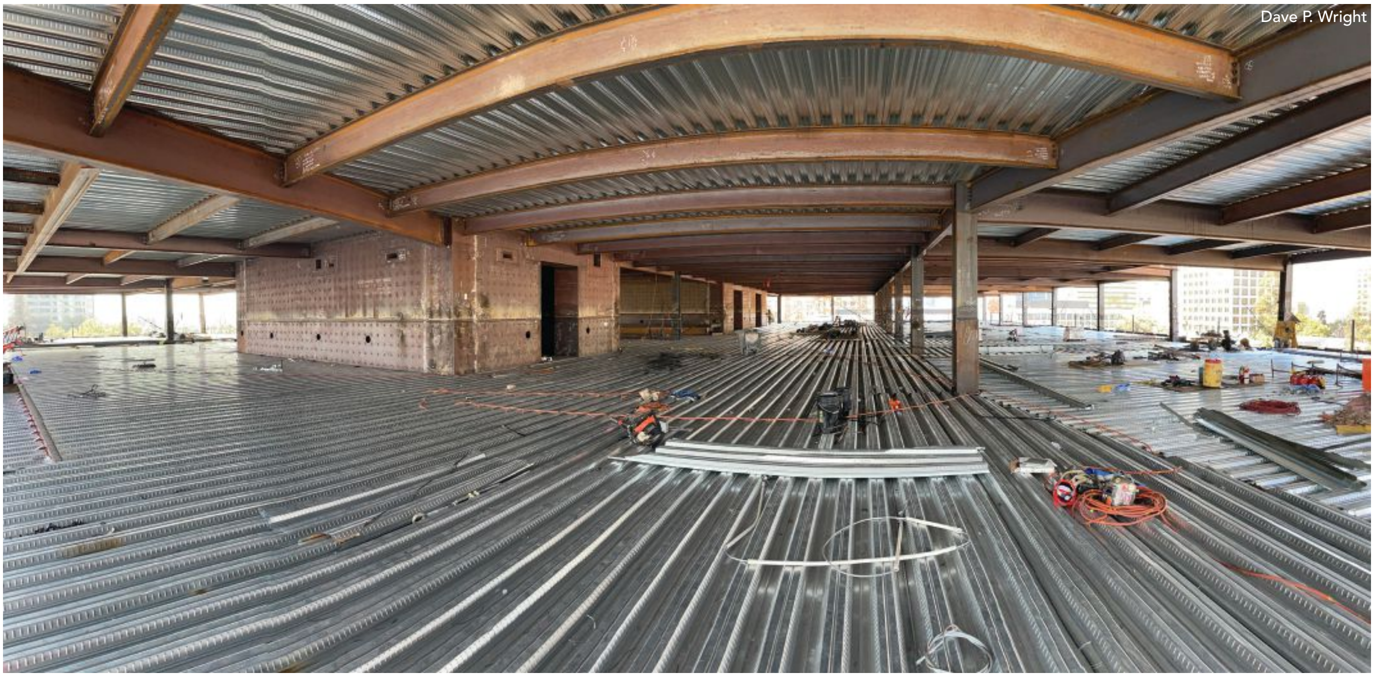
The $500 million building's framing system has 10,000 tons of structural steel. The tower's SpeedCore system—also known as composite steel plate shear wall/concrete-filled (C-PSW/CF)—accounts for roughly 4,000 tons of the total steel package. All told, it features nearly 1 million sq. ft of technology-driven Class A office space, four underground parking levels, ground-level retail, a 20,000-sq.-ft fitness center, and three above-ground stacker parking levels that can be converted into office space. Its oversized floor plates average more than 54,000 sq. ft—twice the size of typical San Jose office buildings.

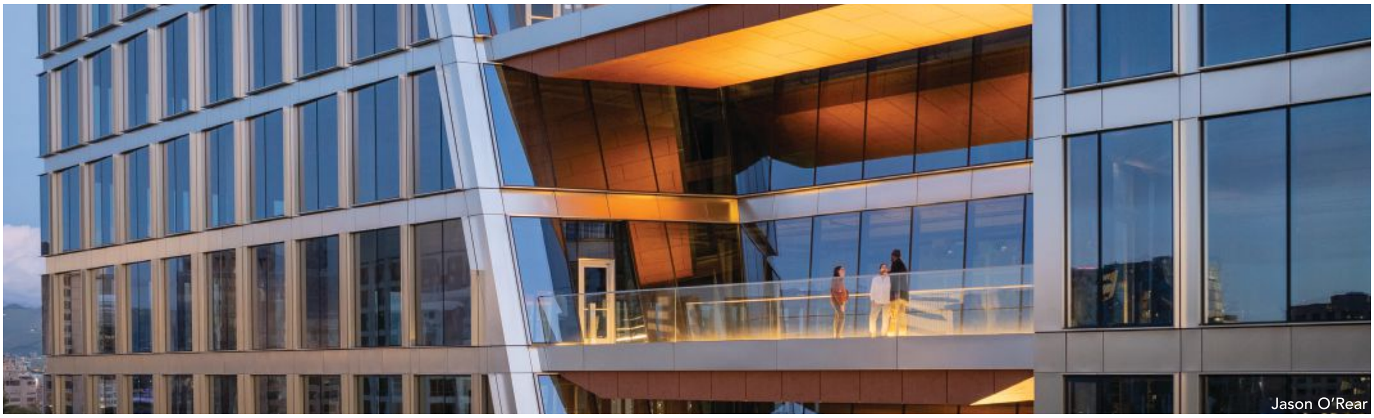
Two-story outdoor terraces create light canyons that allow natural light to travel deep into each floor while providing desirable outdoor access at each level. The total terrace area exceeds 26,000 sq. ft. The owner and architect wanted the terrace floor framing levels to be as slim as possible, requiring thin custom-tapered shaped beams and girders and sloping steel columns that frame out these openings. Without steel, these key architectural features would not have been economically viable, even though steel is not visible in the final condition.

The tower has two composite cores, ranging from 60 ft by 42 ft for the two-cell core and 40 ft by 32 ft for the single-cell core. Nominal wall thicknesses range from 24 in. to 42 in. and decrease in size as the building rises. The heaviest prefabricated core modules weighed more than 17 tons and were about 38 ft long, 14 ft wide, and 3½ ft thick. The cores contain more than 65,000 welded cross ties, and onsite core filling uses a special 10,000-psi grout.

Most of the SpeedCore elements are ASTM A572 Grade 55 plate with a specified limit to control yield strength, helping to ensure the as-fabricated materials closely matched the designers' performance expectations. The tie rods were designed using weldable 55 ksi round bars. Heavy gravity columns were designed using A913 Grade 65 to help reduce size where possible. The SpeedCore plate is ½ in. thick, and cross ties in the core have a 1-in. diameter.

Unique leaning gravity columns scattered throughout the structure required heavy diaphragm bracing at certain floor levels, which included back-to-back steel angle members configured in a horizontal truss fashion. In some cases, large L10×10×1⅜-in. angles were used.


Dave P. Wright


Jason O'Rear

Design Savings

While the project was still early in the design process, Purdue University's Applied Research Institute—which helped create SpeedCore alongside Magnusson Klemencic Associates (MKA) CEO Ron Klemencic—confirmed most fireproofing could be eliminated from the core. The testing showed that walls at least 24 in. thick easily exceeded the three-hour rating. The project team presented the discovery to local building officials and was permitted to eliminate most spray-on fireproofing from the SpeedCore faces, saving the owner additional time and money.

Another pre-fabrication cost-saver was a reduction in through-tie rods within the SpeedCore coupling beams. Additional research and testing at Purdue showed internal headed shear connectors could be used within specific zones on the coupling beam instead of through-tie rods that required connections to each face of core panel. The use of shear connectors simplified the fabrication and assembly of the coupled wall panels.

Research after the design of Seattle's Rainier Square Tower—the first-ever SpeedCore project—showed designers could reduce overall cross-tie quantities in the SpeedCore panels by increasing the spacing of cross-ties at certain regions of the cores (from 12 in. to 18 in.). This innovation helped lower overall fabrication costs and material quantities, as well as improved constructability.

The 200 Park project was the first time a SpeedCore-type system was used with a partial-height concrete core below grade. The first three basement levels used concrete shear walls before transitioning directly into SpeedCore. Interface with the concrete shear walls below and the significant quantity of reinforcing bars required extensive use of a building information modeling (BIM) approach by the design team and construction trades to ensure the two systems fit as planned.

At the ground level, where base shear is the most demanding, MKA devised a creative way to transfer the large diaphragm loads from the SpeedCore system into the heavy Level 1 concrete slab by using custom built-up plate girder drag elements integrated within the SpeedCore wall and column elements, along with threaded rebar couplers preinstalled to core modules.

About 15 column grids in the gravity-framed system incorporated slanted leaning columns to varying degrees and located at different elevations through the height of the building. Those helped define the light canyons and non-symmetrical building façade features. They introduced some large horizontal loading into the structure that was resolved by a horizontal bracing system located within the depth of the Level 5 framing that could transfer the loads back to the SpeedCore panels. This approach to transferring horizontal forces eliminated the complex interface of a steel-to-concrete or embed-plate construction and differing tolerances.

Constructability from Shop to Site

The prefabricated SpeedCore components are large and relatively thin, meaning tight tolerances must be maintained during fabrication to ensure field installation goes quickly and accurately. The fabrication process used specialized fixtures and jigs to help control distortion and ensure accuracy throughout manufacturing. It also required the fabricator to consider numerous operations for handling the oversized steel weldments during transportation to the job site, along with various erection activities before final welding and grouting.

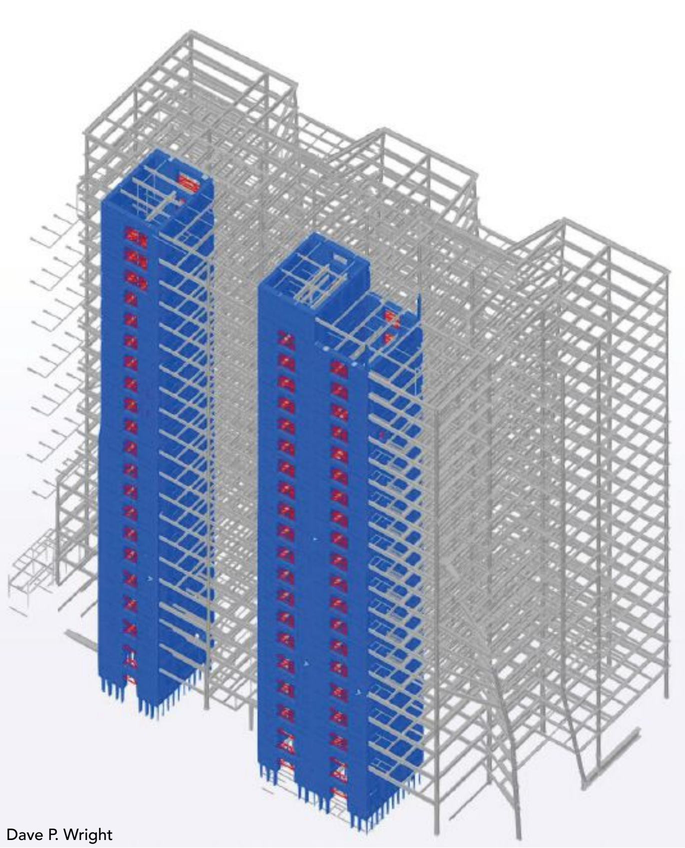
MEP penetrations through the SpeedCore system were critical considerations during the design planning. The location of reinforced sleeved penetrations through the core elements is important to the system's structural performance and efficient prefabrication before erection and core grouting. Several project stakeholders collaborated during the steel detailing and modeling phases to coordinate the layout and sizes and to ensure MEP designers had necessary passageways without jeopardizing structural performance. The collaborative efforts were rewarded with zero penetration modifications, additions, or location changes.

SpeedCore's swift erection timeline meant fabricator Schuff Steel needed to maintain a full pipeline of prefabricated core components and surrounding gravity framing to allow both crane hooks to erect steel without interruption. Schuff divided the work among five of its primary fabrication facilities—two produced the SpeedCore elements, while the other three focused on the non-lateral elements.

Schuff worked closely with MKA for all the lower-level specialized SpeedCore elements, which required heavy outrigger drag elements to interface with the core, and developed creative ways to configure them to optimize modularization. Thus, the difficult connections and weld joints could be fully completed in the fabrication shop, and field connections were simple. Schuff also worked with well-known welding expert and engineering consultant Bob Shaw to optimize welds, develop qualified weld procedures, and explore the best options for field welding to mitigate possible shrinkage or distortion in the core.

The building is about three miles from San Jose Mineta International Airport and under a primary flight path, which capped the structure and crane height. After discussion with airport officials, the FAA, general contractor Level 10 Construction, and crane suppliers Bigge Crane and Rigging Company and Bragg Companies, tower cranes were placed at the north and south ends.

An LR1300 crawler crane replaced the north tower crane for erecting the northmost steel on Level 18 through the penthouse. It could boom down in an emergency and be stowed after hours to suit U.S. Standards for Terminal Instrument Procedures (TERPS)



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Dave P. Wright

Jason O'Rear

requirements. The erection sequence for the north portion of the top two floors, roof, and penthouse left steel out of perimeter bays to allow for a shallower boom angle for erecting the balance of the structure without impacting the overall schedule.

The tower cranes were not freestanding and required lateral support via tie-ins to the primary structure. The structural general notes clearly defined requirements for the state of the structure at the time of tower crane jumps and tie-ins. Specifically, the cores had to be grouted to the level of the tower crane tie-in before any jumping operations. In general, the SpeedCore notes required that the grout within the core walls be placed so that the elevation of the grout is always greater than the elevation of the last poured floor.

To overcome the tie-in challenge and create flexibility, Level 10 Construction engaged erection engineer Simpson Gumpertz & Heger (SGH) to analyze an un-grouted core's behavior. The results of a detailed finite element analysis of the cores relaxed the constraints so deck pours could occur before the grouting operations for a maximum of one floor, in addition to allowing the tower cranes to be jumped and tied in at a steel framed and decked level, even if the core had not yet been grouted up to that level.

A tight job site meant prefabricated SpeedCore panels were often hoisted directly from the delivery trucks, staged on the working floors, and eventually re-erected into their final position. The extra step required detailed structural analysis from SGH to help ensure local stability and loading on the partially completed framed and decked floors.

All field splices between the SpeedCore elements had to be welded, and the project team developed a plan for welders to stay closely behind the core erection teams to keep the process moving and avoid delays to trades working below.

The building was completed in May 2023, and SpeedCore was the primary reason behind its three-month time savings compared to a traditional frame. It finished a month earlier than the initial SpeedCore schedule. It was speculatively designed, making it an attractive space for a wide tenant range now and in the future.

SpeedCore was also used in Seattle's Ranier Square office building, which opened in 2021 and shaved 10 months off design and construction time using SpeedCore. In 2023, AISC published Design Guide 38: *SpeedCore Systems for Steel Structures* (download or order at **aisc.org/dg**) to help engineers harness SpeedCore's benefits.

Owner
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Architect
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Structural Engineer
Magnusson Klemencic Associates (MKA), Seattle

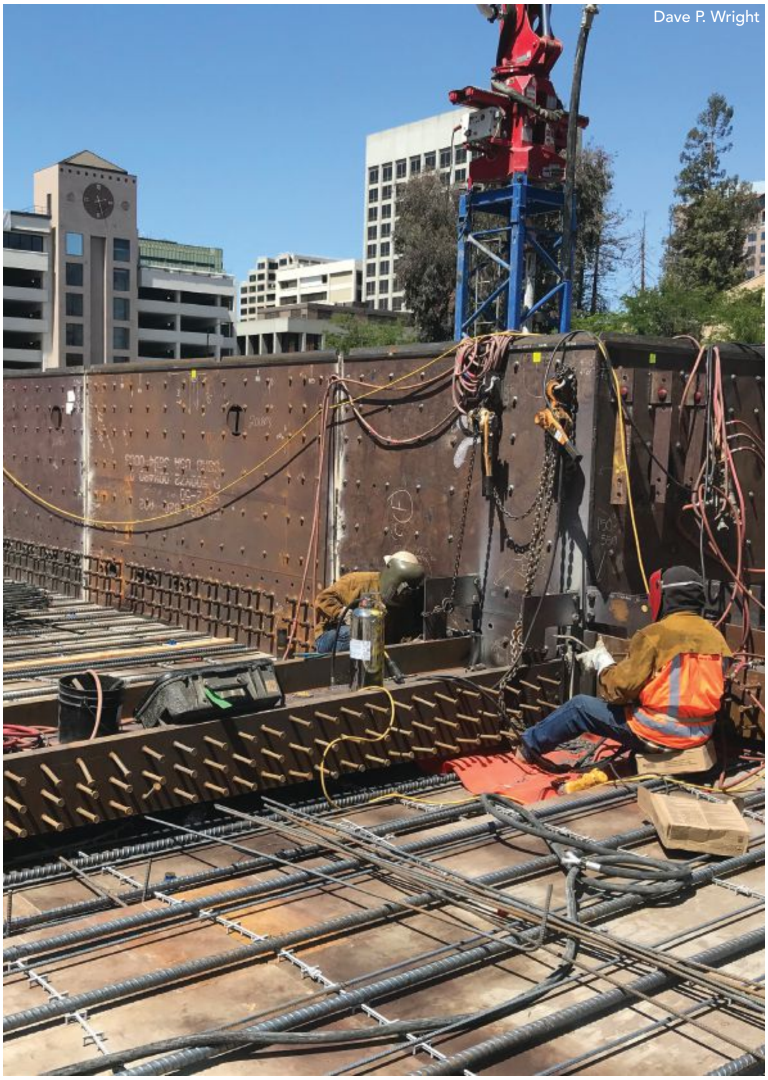
Steel Team

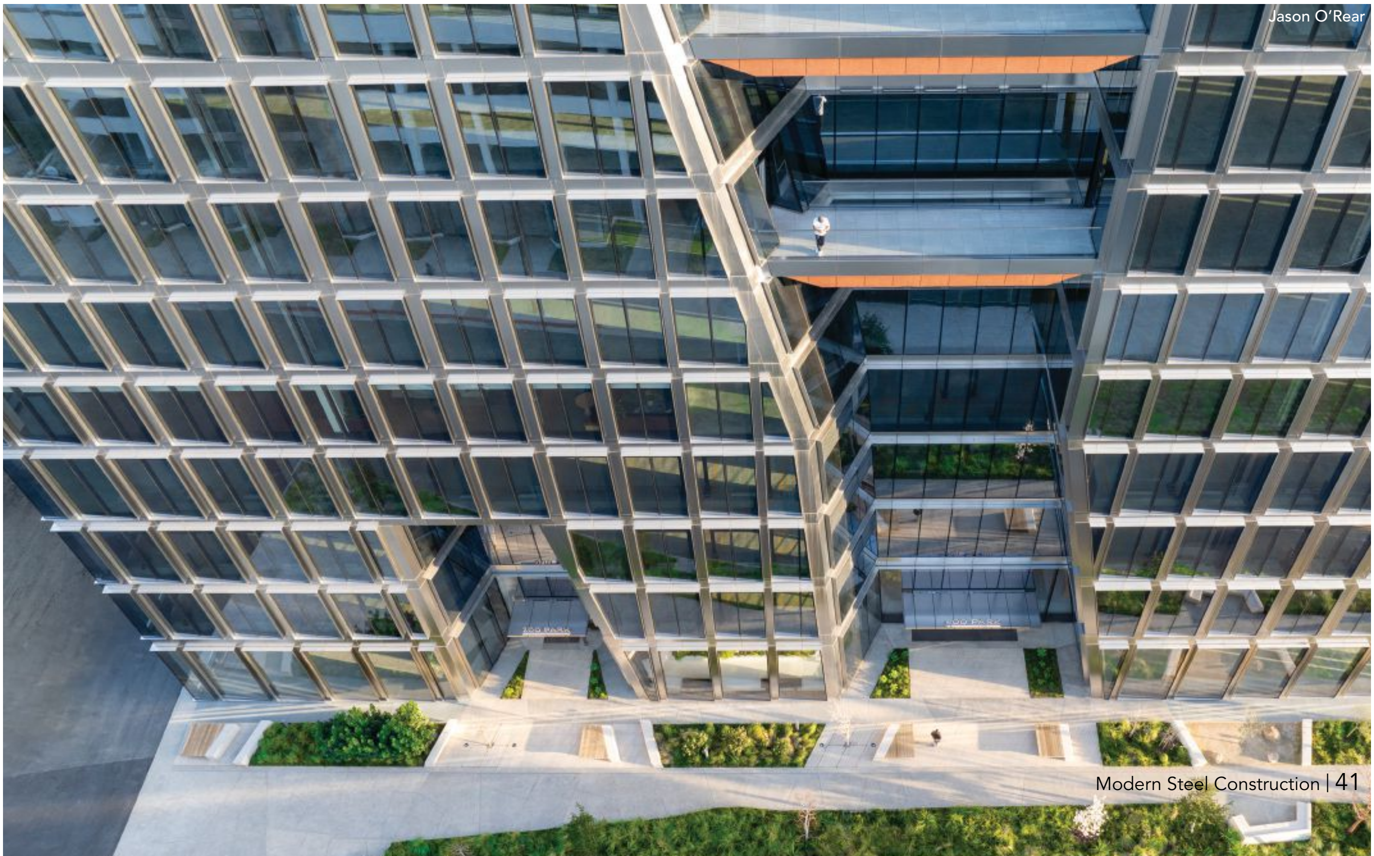
Fabricator and Erector
Schuff Steel Company (AISC Certified Fabricator), Phoenix

Detailer
DBM Vircon (AISC Detailer), Tempe, Ariz.

Erection and Construction Engineers
Hassett Engineering, Castro Valley, Calif.
Simpson Gumpertz and Heger (SGH), San Francisco

Connections Consultant
Steel Structures Technology Center, Inc., Howell, Mich.


Dave P. Wright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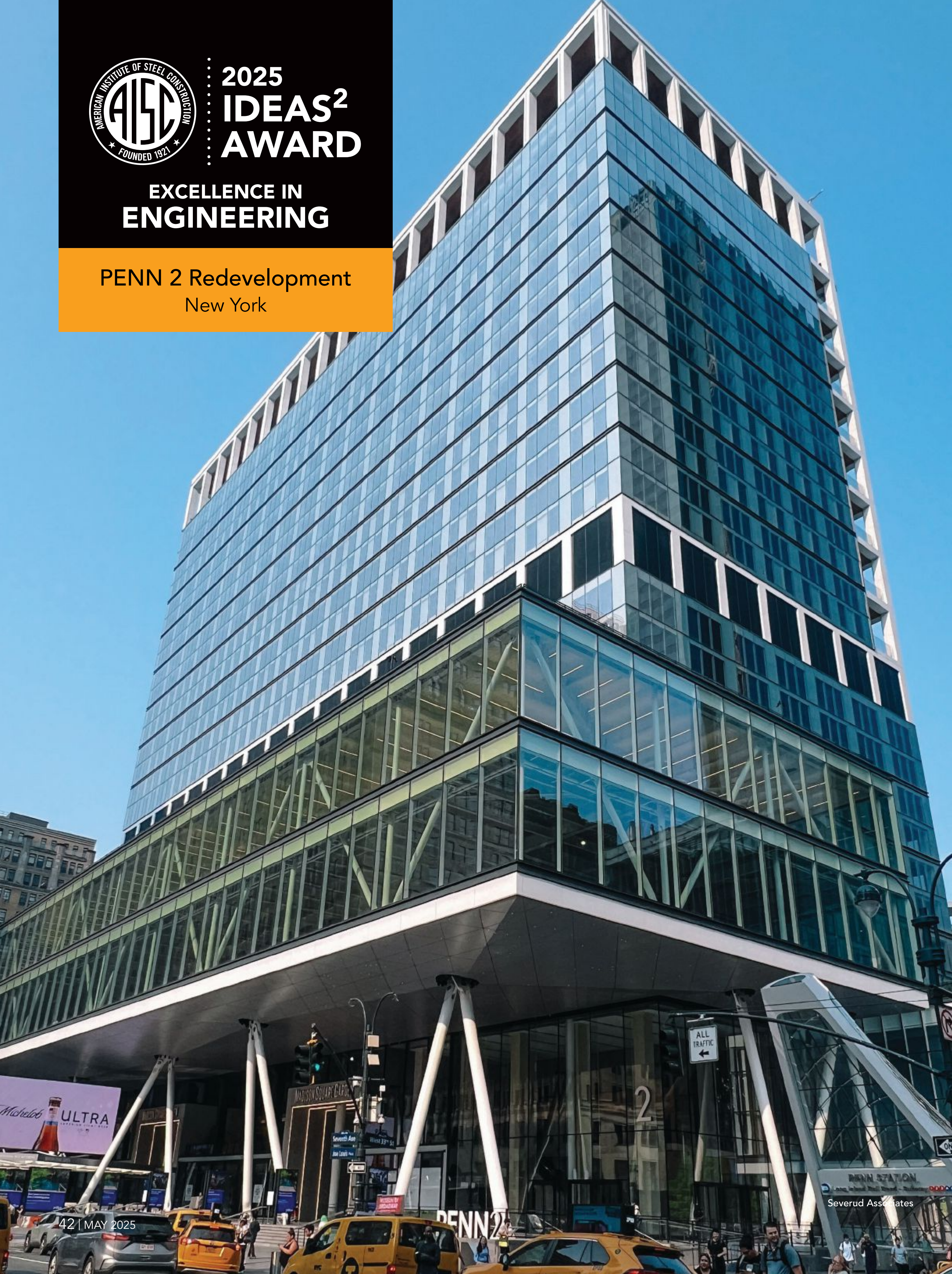
2025 IDEAS² AWARD

EXCELLENCE IN ENGINEERING

PENN 2 Redevelopment
New York



Severud Associates

Severud Associates

A MIDTOWN MANHATTAN OFFICE BUILDING needed a boost from its original 1960s form, and its steel frame lent itself to adaptation and longevity despite its age.

New steel elements incorporated at PENN 2 created a 75-ft by 450-ft addition called the Bustle that hovers 50 ft above the sidewalk on 14 dramatically sloped columns configured around an existing trainshed. Creative connections ensured the existing structure and addition do not transfer significant lateral load to each other.

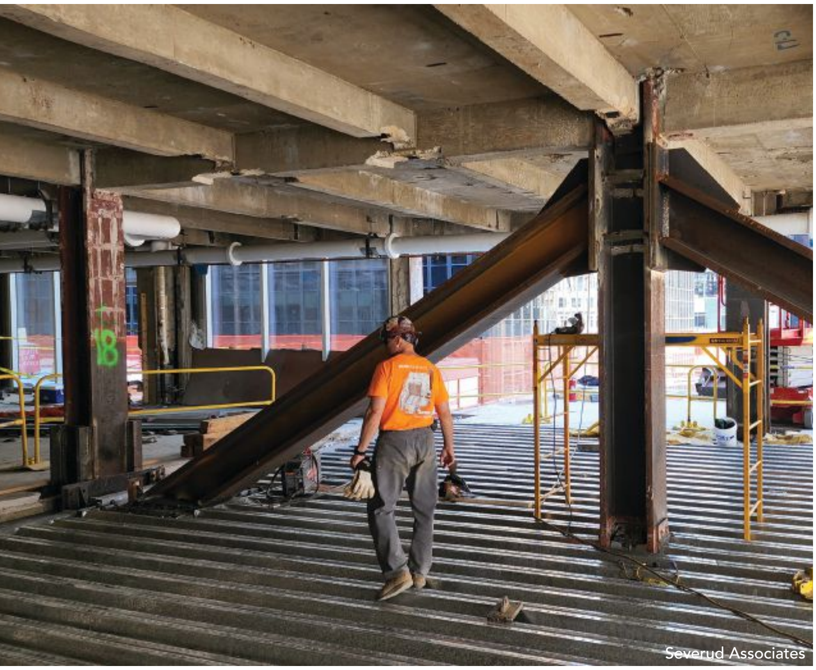
Redeveloping PENN 2, formerly Two Penn Plaza, added inviting public spaces, improved office facilities, modern worker amenities, and updated aesthetics to the Penn District neighborhood and reconnects the building with street life. The 32-story building was constructed in 1968 following the original Penn Station's demolition, replacing a monumental public space on a double-wide block on the west side of Seventh Avenue between West 31st and 33rd Streets.

The Bustle goes from the fourth to 10th floor and provides 100,000 sq. ft of double-height, column-free office space, 43,800 sq. ft of roof terraces, and an expansive, protected public plaza adjacent to Seventh Avenue. It takes advantage of the existing building's setback from Seventh Avenue by using space not embraced in the 1960s design.

The addition stretches the width of the double block, extending almost 40 ft beyond the north and south ends of the tower, which are also set back from the sidewalk. The massing honors the former Penn Station but adds slender, widely spaced columns that replace the former station's dense and regimented colonnade.

Smaller additions at the north and south ends are supported both by existing columns and new columns bearing over the existing trainshed framing. The north addition includes the column-free, double-height Town Hall between the second and fourth floors that accommodates up to 280 people and supports a future pedestrian bridge spanning over PLAZA 33 to PENN 1. Other features include a triple-height entrance lobby, double-height corner loggias, a rooftop pavilion, and terraces.

Several years of conceptual studies and design development resulted in minimal disruption to the existing transit facilities and the hundreds of thousands of travelers who use them daily. Documentation of existing structures, including field surveys and material testing, combined with sophisticated analysis and advanced materials, allowed a modern addition to be built atop a century-old trainshed structure.



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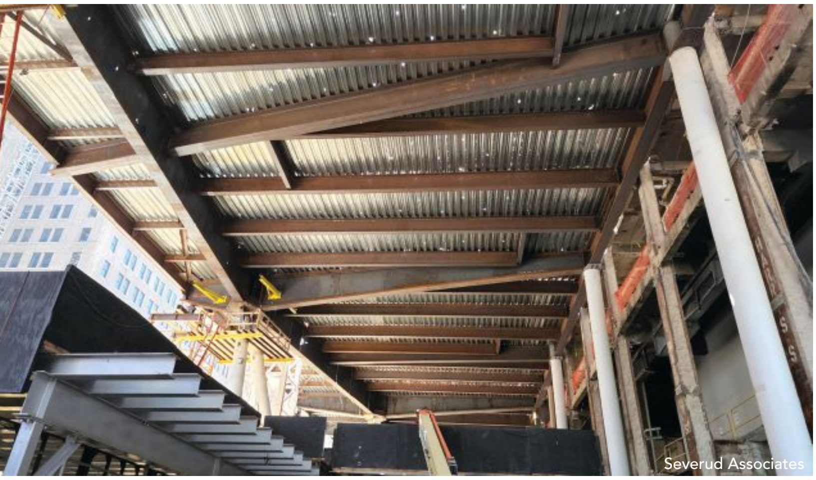

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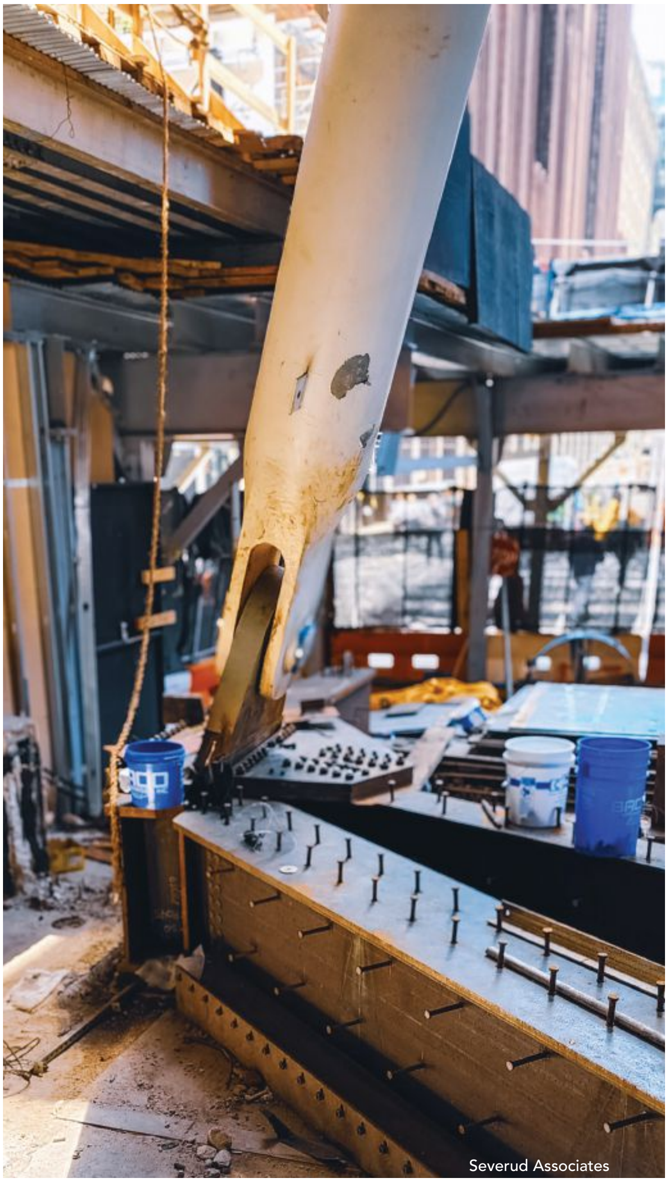


Severud Associates

Adding Steel

Structural steel was the natural choice for the project. The original building is framed entirely in steel, with cinder concrete slabs and beam encasement to increase allowable stresses. That system is a precursor of today's composite steel and concrete-filled metal deck and was easy to design and construct.

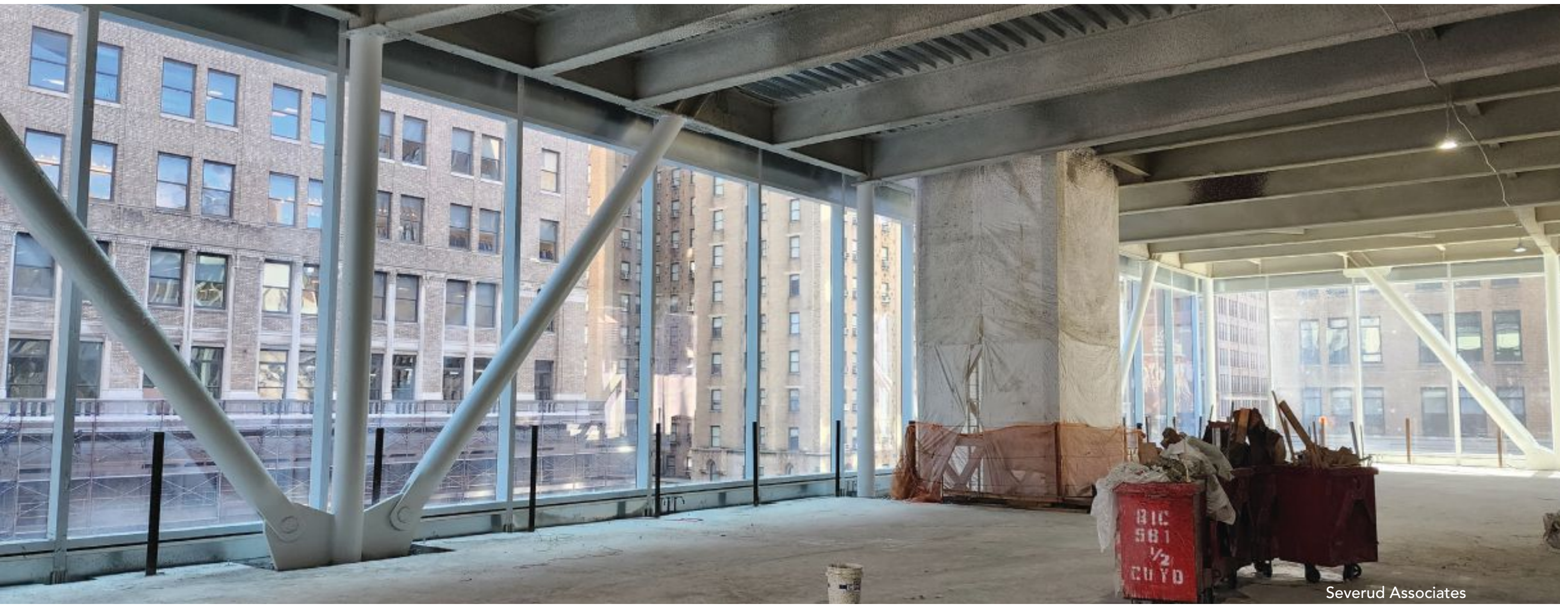
The triple-height entrance lobby, double-height corner loggias, and roof terrace and pavilion were created by selectively demolishing entire framing bays—except for members bracing existing columns—and reinforcing the columns for the increase in unbraced length. New infill framing was erected and the temporary bracing beams were removed.

Structural steel, even if more than a century old, can have remarkable reserve capacity. Engineers determined older steel locations where coupons could be cut and tested for tensile properties, chemical composition, and base metal notch toughness, per Appendix 5 of the AISC *Specification for Structural Steel Buildings* (AISC 360-22). Rivets were also tested.

The primary types of steel on the original structure were Penn Station's 1906 ASTM A7/A9 60-ksi tensile strength (average) with a 30-ksi yield point and Two Penn Plaza's ASTM A36 58-ksi tensile strength (minimum) with a 36-ksi yield point. Tests on both showed they met or exceeded current standards for ASTM A36. Some steel contained high concentrations of sulfur or silicon and was coated with lead-based paint, which was abated wherever necessary. Nevertheless, additions and reinforcement with steel were practical, efficient, and economical.

Steel's aesthetic advantages were also important. MdeAS Architects desired an expansive protected public plaza beneath the Bustle and slender, widely spaced columns to support it. The sloped columns' arrangement and their cast steel end connections' simplicity perfectly matched the architect's and owner's visions. The sloped columns, other round columns, truss diagonals, pin connections, and supporting gussets were all considered showcase elements and were fabricated, shipped, and erected to architecturally exposed structural steel (AESS) Category 4 (showcase elements).

Aesthetics were crucial in the Bustle framing as well. Tapered plate girders at the Bustle's lowest level create an LED-lit faceted soffit, adding captivating visuals. The widely spaced perimeter columns and compact floor framing maximize the open feeling of the office space from inside and outside. The perimeter truss diagonals provide the necessary load transfer and stiffness while minimizing obstructed views through the two-story curtainwall.



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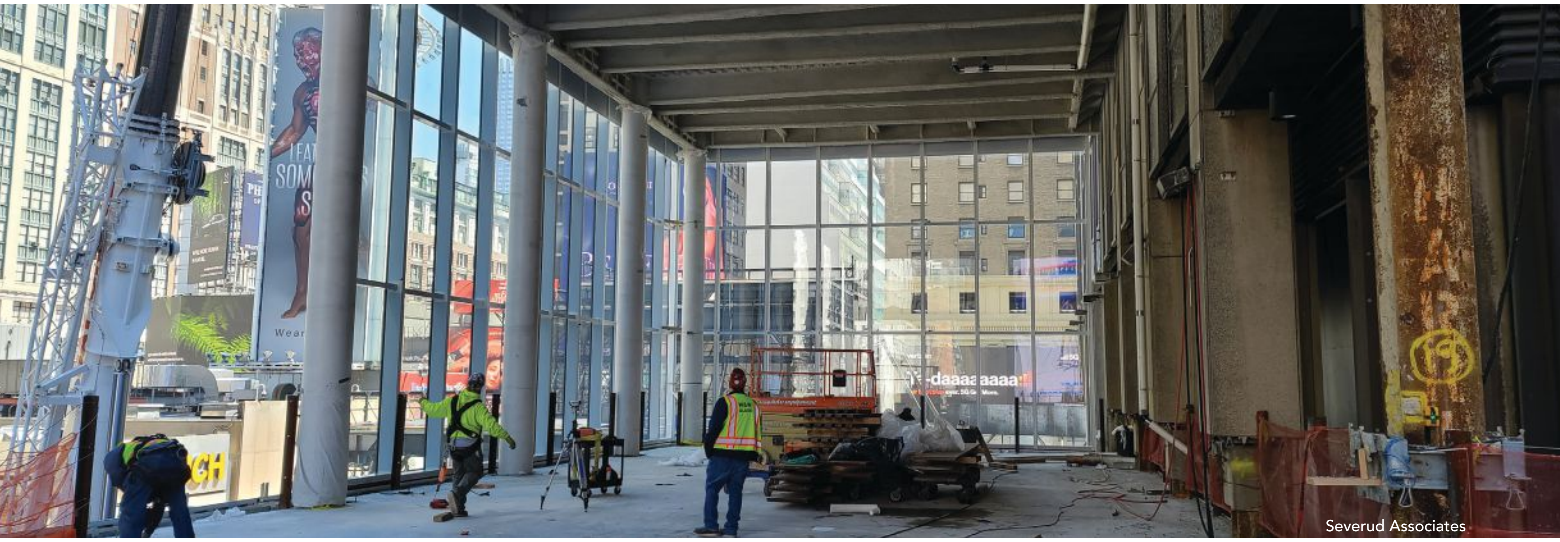


Severud Associates

Trainshed Tactics

The north, south, and east building expansions are supported on the original Penn Station trainshed. The station's above-ground portions were demolished in the 1960s to make way for Madison Square Garden and Two Penn Plaza and the below-grade structure remained mostly intact, with excess structural capacity due to the removal of the above-ground structures.

The original columns and foundations were used to their fullest extent to limit existing structure reinforcement within the trainshed and corresponding train service disruptions. Consequently, the sloped column locations were meticulously calibrated to land in specific locations on the sidewalk-level transfer structures to distribute the loads to the existing columns without exceeding their capacity. A new column to carry the load to bedrock was needed at only one location.

The transfer structures consist of plate girders and heavy wide-flange sections divided into seven individual platforms that bear directly on the trainshed roof, which simplified installation and precluded disturbing the tracks below. The framing is integrated into the elevated plaza—constraining its depth and arrangement—and encased in concrete for stability and weather protection.

Working above and within Penn Station and the trainshed required coordinating with multiple agencies, primarily Amtrak. With the trainshed's tight clearances and an order to minimize service disruptions and track outages, the structural design had to be as compact as possible, with work performed from above wherever practical.

The only existing structural drawings available for Penn Station and the trainshed were not original; they had been redrawn in the 1940s. Field investigations and condition surveys were performed as needed to verify critical existing structures affected by the work.

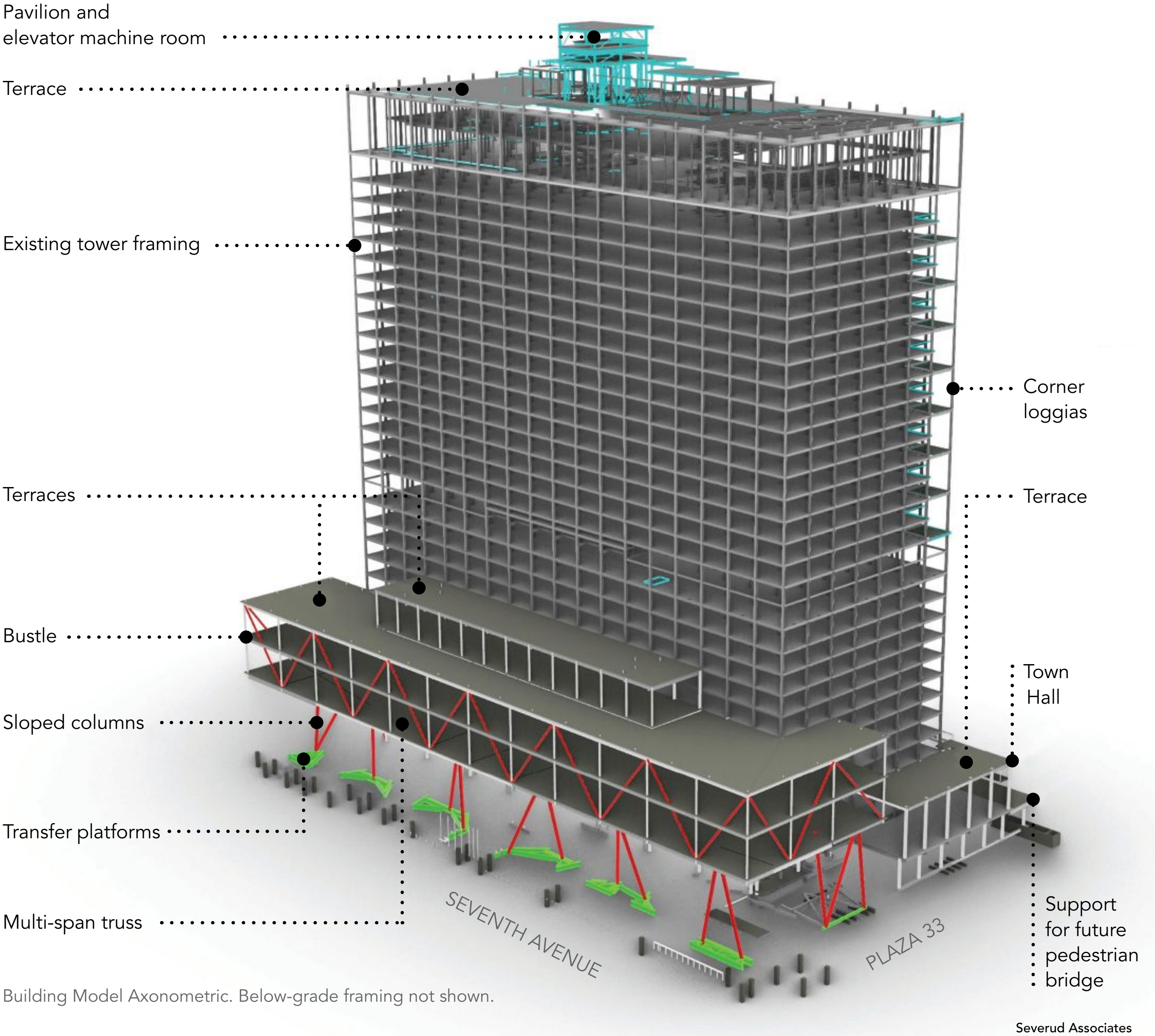
Load Management

The sloped columns support the east and north sides of the Bustle; one sloped and six vertical columns support its west edge, adjacent to the tower. Brackets field-welded to existing steel columns support the Bustle at the building center, and field-welded steel plates increased their load capacity.

All sloped columns are 24-in.-diameter HSS with a cast steel pin connector at both ends. The complete end connections, including clevis, pin, and gusset, were fabricated in the shop and the gussets field-welded to accommodate their tight tolerances better. A high-performance coating system protects the columns from weather.

"The engineering team overcame so many intricate and complex design challenges while working within the constraints of the existing structure. The multi-story sloped columns configured around an existing trainshed were also used to laterally brace the new structure. The strategically placed connections between the addition and the existing structure ensured a balanced lateral system without transferring significant load between either system."

—Fraser Reid



Building Model Axonometric. Below-grade framing not shown.

The Bustle's lowest level is framed as a cantilevered tabletop. Steel plate girders span east to west from the face of the tower and over the top of the sloped columns to the exterior. In the north-south direction, a line of plate girders snakes across the tops of the sloped columns, cantilevering at their ends. The Bustle exterior is diagonalized between the fourth and eighth floors to form a multi-span truss to collect vertical loads tributary to the plate girders and their supporting columns. The diagonals are 14-in.-diameter hollow structural sections (HSS) with cast steel pin connectors.

Laterally, the Bustle and other additions are self-supporting to avoid triggering an upgrade to the lateral force resisting system of the existing tower—which was designed well before modern wind and seismic design codes were developed. All loads required are per the current building code, and loads on the existing building were not increased beyond the level that would trigger an upgrade to the building's lateral force-resisting system.

All column-to-beam joints incorporate moment connections, and the sloped columns act as diagonal braces. Connections at the sixth, eighth, and 10th floors ensure stability without transferring significant lateral load. At the fourth floor, an isolation joint uncouples the existing building from the addition and prevents lateral load from flowing to the sloped columns. The brackets that vertically support the Bustle allow horizontal slip for the expected deflections.

The additional lateral loads are resisted by existing north-south concrete retaining walls in the trainshed and existing east-west moment-resisting frames in PENN 2. The plaza concrete slab and girder encasement are reinforced for the additional shear. At sidewalk level, steel plates were anchored to the trainshed roof and spliced together to form a load path from the plaza framing to the resisting elements. A reinforced concrete slab to transfer the loads at sidewalk level would have been too thick.

Removing an existing column between the ground and fourth floors further opened the lobby. New columns added one bay to either side and bear on new girders below the ground floor. Existing fourth-floor framing was replaced with beams spanning between the new columns on both sides. Diagonal members between the fourth and fifth floors create a truss to transfer load to the new columns. The 6-ft-deep ground floor plate girders transfer load back to the original location. This double-cantilever girder acts like a well-balanced seesaw; the tips are braced laterally but free to deflect vertically.

After the truss connections were locked in, jacks relieved load from the existing column. The new columns were shimmed tight and the existing column removed. When the jacks were released, the load transferred to the new columns and back to the existing column, leaving the distribution of vertical load essentially unchanged.

Columns and Conversions

Columns spring from the tabletop's perimeter to create a column-free interior. Along the tower's face, wide-flange columns align with the existing columns at about 20 ft on center. On the exterior, the 14-in.-diameter HSS columns are spaced at about 36 ft. They support beams spanning east-west at the sixth and eighth floors, creating the double-height volumes.

The triple-height lobby was created by removing second- and third-floor bays. Eliminating beam-to-column joints redistributed lateral load and required reinforcement of existing moment connections around the lobby. Removing the existing framing of the north- and southwest corner bays between the 14th and 29th floors created the double-height loggias. On even-numbered floors, new framing supports the increased dead and live loads of the terraces. On odd-numbered floors, the corner columns were reinforced for the resulting increase in unbraced length, prior to removal of the spandrel beams.

Converting the tower's roof to terrace space and adding a multi-purpose pavilion required reinforcing the existing framing. New beams were added between existing beams, and existing girders were augmented with tee sections field-welded to their bottom flanges. Extending the high-rise and freight elevators was also required. The existing machine room was demolished, the shafts extended, and a new machine room was constructed. Existing columns were reinforced as needed.

Construction Considerations

Studying existing structures helped plan the Bustle's steel erection sequence. The long spans, cantilevers, double cantilevers, and multiple levels of supporting steel could deflect, shift, or vibrate during erection. That meant tolerance issues for fitting up the steel framing, curtain wall, and finishes were considered.

Temporary supports were installed for the tabletop using the permanent transfer platforms, other existing trainshed columns, and the existing concrete retaining wall. Temporary girders were installed where needed for two tower cranes.

The tabletop framing was erected using tower cranes, with supports at the cambered tips of the cantilevers. Next, the concrete fill on metal deck was placed. Concurrently, the sidewalk steel plates were installed and the plaza concrete completed. Once the tabletop steel had been checked and adjusted and the concrete had cured for 28 days, the temporary supports were removed. The tower cranes then erected the remainder of the Bustle using the tabletop as a stable platform.

Throughout the design process, the construction manager brought together the structural engineers and contractors to evaluate the work and suggest modifications to streamline fabrication, delivery, site logistics, erection, and connections to best use the shop's methodologies and personnel. Engaging the steel casting supplier resulted in simpler connections to fabricate and erect and satisfied the aesthetic vision.

PENN 2 steel work was completed in December 2023. The $650 million building opened in 2024, satisfying its stakeholders' stringent requirements and meeting budget. The redevelopment is a sustainability win by reusing an existing facility. A complete demolition and rebuild would have been easier but would have increased waste, new material creation, and train station impact. Instead, the project team adapted a 20th-century building to attain 21st-century environmental performance.

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Steel Team

Fabricator and Detailer
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Erector
Skanska USA Civil Northeast, Inc., East Elmhurst, N.Y.

Casting Supplier
CAST CONNEX AISC ASSOCIATE, Toronto

2025 IDEAS² AWARD

PRESIDENTIAL AWARD FOR ENGINEERING DESIGN AND CONSTRUCTION

Sphere

Las Vegas

Severud Associates

THE LARGEST SPHERICAL STRUCTURE IN THE WORLD is a display of groundbreaking steel innovation that has helped redefine the immersive entertainment experience. Sphere, the next-generation music and performing arts venue just east of the Strip in Las Vegas, is a 516-ft-diameter semi-spherical building rising 366 ft above ground. It encloses a bowl-shaped theater for 17,600 guests seated beneath a domed roof and a suspended media plane.

Sphere visitors first encounter the exosphere, the venue's outer latticed grid shell composed of steel pipe sections and cast steel connecting nodes and covered with 580,000 sq. ft of programmable LED lighting. Starting from a traditional geodesic arrangement—a "Bucky dome," as envisioned by architect Buckminster Fuller—Severud Associates structural engineers employed parametric design and optimization to determine the sphere's lightest tessellation. The engineers also found significant benefits with cast steel nodes, a crucial project component.

Inside the venue, the lower seating bowl framing, stage and proscenium, and back-of-house components are concrete bearing on piles and mats. The upper seating framing and perimeter concourses are structural steel in a barrel-shaped arrangement. All seats are supported on precast concrete stadia, and 10,000 of them are immersive and include haptic systems. An optimized steel-framed dome tops off the theater.

The project also includes a separate collar structure with the loading dock and other back-of-house facilities, plus a 1,200-ft serpentine pedestrian bridge framed with steel box trusses that connects the venue to a convention center. A bridge building provides a transition to the venue. The bridge and collar buildings are isolated from the exosphere.

"It's an engineering and architectural marvel that redefines immersive entertainment. It combines a stunning LED-clad exosphere with groundbreaking steel innovations to create the largest spherical structure in the world. Detailing in two dimensions is already complicated, but bringing to life this three-dimensional geometry was even more commendable. This project exemplifies the kind of creativity and collaboration that will set the standard for future wonders like this one."
—Nima Balasubramanian

Sphere Entertainment Company

Steel Solutions—and Conversions

The exosphere shape is critical to Sphere's aesthetics and its exterior LED displays. A sphere is one of nature's most stable shapes, but wind load, thermal expansion, and acoustics made it a completely isolated structure. Constructing a free-standing sphere in any other material would have been essentially impossible.

Sphere's multi-sensory theater experience requires a huge column-free space, clear sightlines to the stage, and an expansive media plane. Maintaining the proper focus for 17,600 guests made the shape of the venue—a sphere within a sphere—a natural choice. As with the exosphere, structural steel was the best material to carry the roof and rigging loads efficiently without adding significant dead load.

Formwork for a concrete roof dome would have been extensive, costly, and time-consuming and would have interfered with other trades. The roof dome framing was prefabricated in sectors—including intermediate framing—that were easily erected and required only one center temporary support tower. A 10-in.-thick concrete slab on metal deck provides permanent stability and acoustic damping.

The venue's exterior walls (immediately behind the exosphere) are barrel-shaped to maximize internal space, and the resulting double-curvature was easily framed with curved hollow structural section mullions and girts. The mullions are supported laterally by the cantilevered slabs at each concourse level and vertically only at the third level. Slip connections allow the other floors to deflect independently without inducing loads in the wall framing.

Steel fabrication's flexibility and its ability to coexist with other materials were critical to Sphere's construction. The ground through fifth floors are framed with concrete slabs, beams, and columns, while the rest of the floors are steel.

Early in the pre-construction phase, Severud flipped the sixth floor and above from concrete to steel. The switch allowed the steel contractor to start detailing and fabricating at about the same time as the superstructure concrete contractor. When the concrete contractor approached the fifth floor, the steel contractor was prepared to start erection as soon as the concrete was placed. That quick transition saved about six months on the overall schedule and facilitated all following work by eliminating several levels of shoring.

The seating is supported by raker beams carrying the precast concrete stadia. Four concrete shear wall cores combine with concrete walls that wrap around the stage to provide lateral support for the entire venue.

Diurnal temperature ranges are as high as 100° in the summer and vary from one side of the structure to the other. The exosphere is self-supporting and isolated from the rest of the building; it rests on its own ring of pile caps and grade beams. The separation allows the exosphere to expand and contract in or out up to 2 in. without restraint from the venue within, which is insulated and less thermally variable.

Castings Bring Savings

The project team's solution for the lightest constructable and transportable tessellation was 14 horizontal latitudes of continuous ring members and crisscrossing diagonal geodesic elements, continuous between the pile-supported grade beam at its base and a latitudinal ring near the crown. The topmost framing, known as the Oculus, is framed radially. This configuration resulted in a slightly higher tonnage, but at a lower cost because it could be erected with minimal shoring.

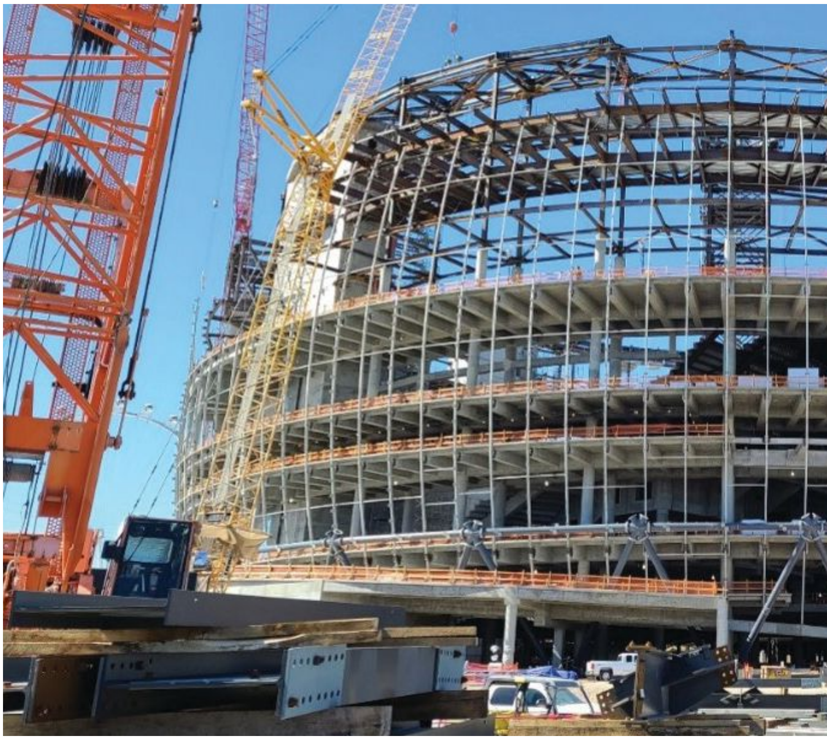
The team next studied node connection details, bringing in CAST CONNEX to advise on cast steel nodes. Two designs based on welded plates were compared to castings with flanges, with a focus on cost and schedule. Extensive analysis revealed that built-up plate nodes presented daunting constructability issues.

Cast steel nodes, though, offered significant advantages in material optimization, improved tolerances, and reduced construction risk. They resulted in a 40% reduction in weight compared to built-up nodes because they did not need stiffener plates and other appurtenances. Further, they occupy a quarter of the surface area, which afforded significant savings in the exosphere's three-part, high-performance weatherproof coating.

All the castings are essentially identical, eliminating concerns about fabrication tolerances. Grid shell structures are sensitive to angular variations at the nodes and length variations of the members. Cast nodes with CNC machining of the flanges increased precision, while bolted end-plate connections allowed shim packs to accommodate variations in the length of the members, which were fabricated slightly short. The cast nodes' geometry was an order of magnitude smaller than that of built-up nodes.

The system provided greater overall geometry control during erection, which reduced construction risk by simplifying erection and minimizing the potential for out-of-tolerance errors, resulting in further cost savings.


Severud Associates

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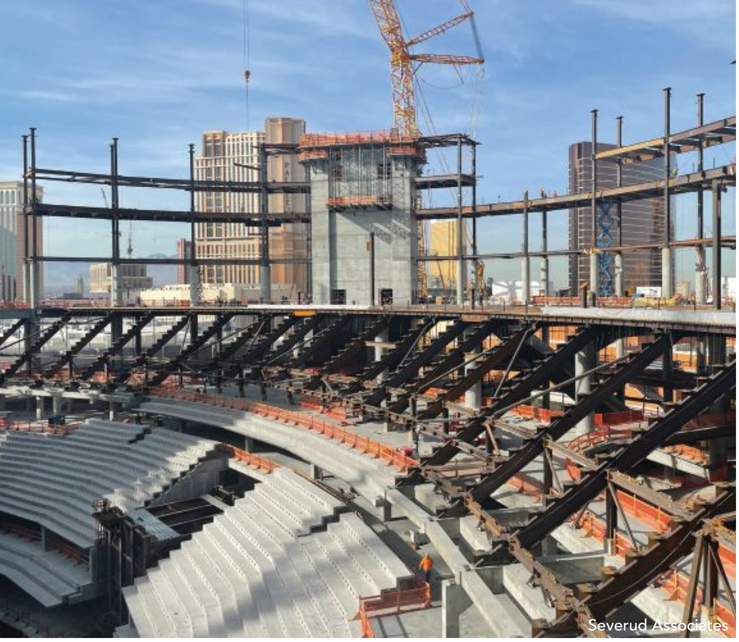
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Dome and Concourses

The steel-framed top dome is 400 ft in diameter, and it's designed to optimize depth, radial arches, and compression rings. Pairs of adjacent half-arches, intermediate framing, and a temporary tie rod were prefabricated into units and lifted into place between the perimeter columns and a temporary center shoring tower.

The flat roof of the concourses is incorporated into the dome framing and acts as a tension ring to resist the dome's thrust; only vertical forces are delivered to the supporting columns under gravity load. The connections to the columns allow the dome roof to move radially without restraint under most conditions. The dome's shape and location within the exosphere minimize wind load; therefore, it is only under seismic load that the columns are engaged laterally.

The double ring of perimeter columns supports the concourse levels. A combination of slabs, metal deck, and diagonal braces provide the strength and rigidity necessary to collect lateral loads from the entire venue (except the self-supporting exosphere) and deliver them to the cores and stage walls.

Two composite steel and concrete girders span across the stage to transfer roof columns and support the fly tower. The increased stiffness—roughly three times what it would be with concrete-only or steel-only designs—keeps deflections small and mitigates concerns about possible adverse impacts from the augured pile foundation's differential settlement.

All dome field connections were bolted—there was no field welding. Fabrication and erection tolerances were expected to be on the order of 3 in., but fabricator W&W|AFCO delivered the dome to about 1 in. of ideal geometry. The 160,000-sq.-ft media plane required tolerances down to ⅛ in.

A steel roof dome and grillage system allowed for adjustments at several stages needed to create a nearly spherical surface. The grillage, which supports rigging and catwalks, hangs only from the dome to avoid bridging systems that behave differently. It transitions from the dome geometry to the media plane configuration while maintaining the 1-in. tolerance. Erecting the primary framing that hangs from the grillage involved jacks to adjust elevation and reduce tolerance to ½ in. The secondary framing included attachment clips that allowed ¼-in. precision. LED tile connections to the secondary framing created a spherical surface within ⅛ in. of theoretical.

Construction Considerations

A staged construction analysis showed the exosphere could be cambered by adjusting member lengths. As erection progressed, the framing settled into proper alignment. The first ring cantilevered from the foundation. Once fully bolted, a ring could support the next ring's framing up to the Oculus, which was erected in a single unit. Finite element modeling also achieved a higher level of confidence in the roof dome's structural behavior.

Additionally, multiple daily surveys aimed to predict structural displacements and assess conformance to tolerances at regular intervals. Consequently, large framing sections were pre-deformed to fit the structure's surveyed shape. Large racking frames introduce forces into the structural members and balance the additional deflections to meet the LED systems' stringent tolerances.

Structural systems were chosen with contractor availability and expedited construction in mind. Some systems were changed pre-pandemic and early in the pandemic to keep the project moving. Sphere's successful and timely completion relied heavily on its structural steel components and their integration with other trades.

courtesy AISC

A Venue for the Future

Sphere's commitment to sustainability began with its design and construction. Parametric structural optimization, a cutting-edge algorithm-based design approach that seeks reduction in materials and costs as a goal by iterating structural properties such as the number, arrangement, type, and depth of structural members, led to significant tonnage reductions for the exosphere and the venue's roof dome.

All concrete substituted supplementary cementitious materials for up to 20% of standard cement and used reinforcement made from nearly 100% recycled steel. The structural steel framing contains over 90% recycled material.

Sphere is also committed to sustainability in its operation and hopes to set a new standard for environmentally responsible energy use by entertainment venues. The venue intends to source approximately 70% of its electricity from solar power facilities and is pursuing a long-term agreement with its local electric utility.

Sphere's exterior and interior lighting is composed entirely of LED systems that are among the most energy-efficient lighting available today. Its advanced heating and cooling systems avoid wasteful reheating. The central plant is comprised of high-efficiency chillers and condensing boilers and is also used to cool distributed kitchen equipment loads. The facility's data center conforms to state-of-the-art efficiency standards, using hot-aisle containment and directing cooling where needed.

Although Sphere is composed of distinct structural systems, they are all interconnected to form a cohesive, balanced, efficient, and elegant superstructure. Sphere aimed to create a fully immersive experience and elevate in-person entertainment to new levels. The $2.2 billion facility took five years to construct and opened in September 2023.

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Detailer
Pro Draft, Inc. (AISC Detailer), Surrey, B.C.

Bender/Rollers
Chicago Metal Rolled Products (AISC Associate), Chicago
Max Weiss Company (AISC Associate), Milwaukee

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