PERFECT TEN

A concert venue that raises the roof, a 1950s Mies van der Rohe design built seven decades after its creation, an art museum whose structural form is itself a work of art, and more comprise the winners of this year's AISC IDEAS^2 Awards.

IT'S A PERFECT TEN!

That's the number of projects that have been named winners of the 2023 Innovative Design in Engineering and Architecture with Structural Steel (IDEAS^2) Awards!

Presented annually by AISC, these awards recognize projects that illustrate the exciting possibilities of building with structural steel and highlight the many ways steel can help express architectural intent while harnessing its unique advantages for both simple and complex structural systems.

The awards showcase the innovative use of structural steel 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 entries must meet the following criteria:

- New buildings, expansions, and renovation projects (major retrofits and rehabilitations) are eligible. There is also a category for sculptures, art installations, and nonbuilding structures.
- Building projects in the 2023 competition must be located in the U.S. and must be completed between Jan. 1, 2020, and Sept. 30, 2022.
- A significant portion of the framing system of a building must be wide-flange or hollow structural steel sections (HSS).
- The majority of the steel used in the project must be domestically produced.
- The project must have been fabricated by a company eligible for AISC full membership. Projects with a unique or distinctive feature fabricated by a company eligible for AISC full membership will also be considered.
- Pedestrian bridges entered in the competition must be an intrinsic part of a building and not standalone structures. We encourage members of project teams for standalone bridges to enter the 2024 National Steel Bridge Alliance's Prize Bridge Awards.

National and merit winners were awarded in four categories according to constructed value in U.S. dollars:

- Less than $15 million
- $15 million to $75 million
- $75 million to $200 million
- More than $200 million

In addition, one Sculpture/Art Installation/Nonbuilding Structure Winner was named.

This year's winners are an intriguing mix of adaptive reuse and brand-new structures. Two of the winners—Seattle's Federal Reserve Building and a brick industrial space in San Francisco—needed substantial work to bring their seismic systems up to code. On the opposite coast, steel turned a 20th-century post office into a 21st-century transportation icon in New York.

Also in Seattle, steel allowed for a near-total demolition of the interior of Climate Pledge Arena—while keeping the roof and façade in place—and in Milwaukee, steel kept the music playing at an aging but beloved lakeside concert venue by literally raising the roof.

Bridging the gap between old and new, another winner brought a 1952 Ludwig Mies van der Rohe design to life in a brand-new building on the Indiana University campus, seamlessly bringing the striking design into compliance with modern building requirements. In Inglewood, Calif., steel allowed a massive new stadium to feel light while also allowing movement in the event of seismic activity.

Down the coast in Orange County, steel served as an inspiring canvas for an art museum—and it gave visitors to St. Louis' zoo a lemur's-eye view of the world. Finally, steel landed at a new terminal at Dallas-Ft. Worth International Airport in large, modular sections, creating a modern new space and enhancing the airport experience for passengers.

This year's jury consisted of:

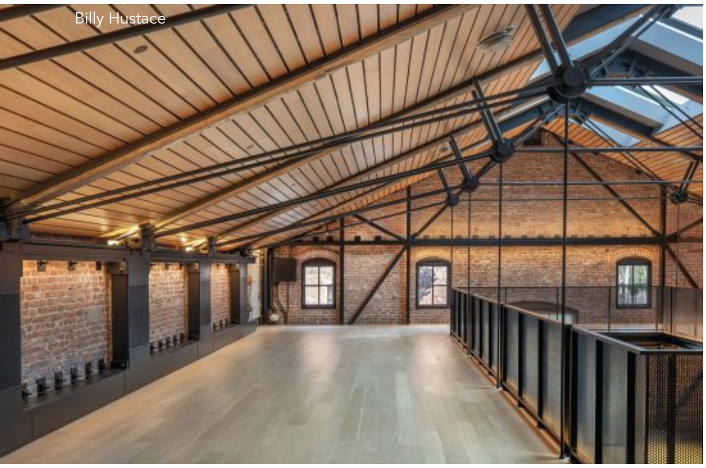
- David Horowitz, executive vice president with Tishman Construction
- Jim Foreman, SE, PE, senior project engineer with Martin/Martin Consulting Engineers
- Mark Trimble, PE, senior vice president with AISC
- Anders Lasater, AIA, CEO, principal architect with Anders Lasater Architects
- Helen Torres, SE, PE, president and founder of Helen Torres and Associates Structural Engineers

Trimble, Lasater, and Torres have all been subjects of *Modern Steel*'s monthly Field Notes interview column and podcast. (You can listen to their interviews at **modernsteel.com/podcasts**.) In addition, this month's Field Notes column (on page 22) highlights Mark Waggoner, a structural engineer with Walter P Moore that helped design SoFi Stadium, one of this year's winners.

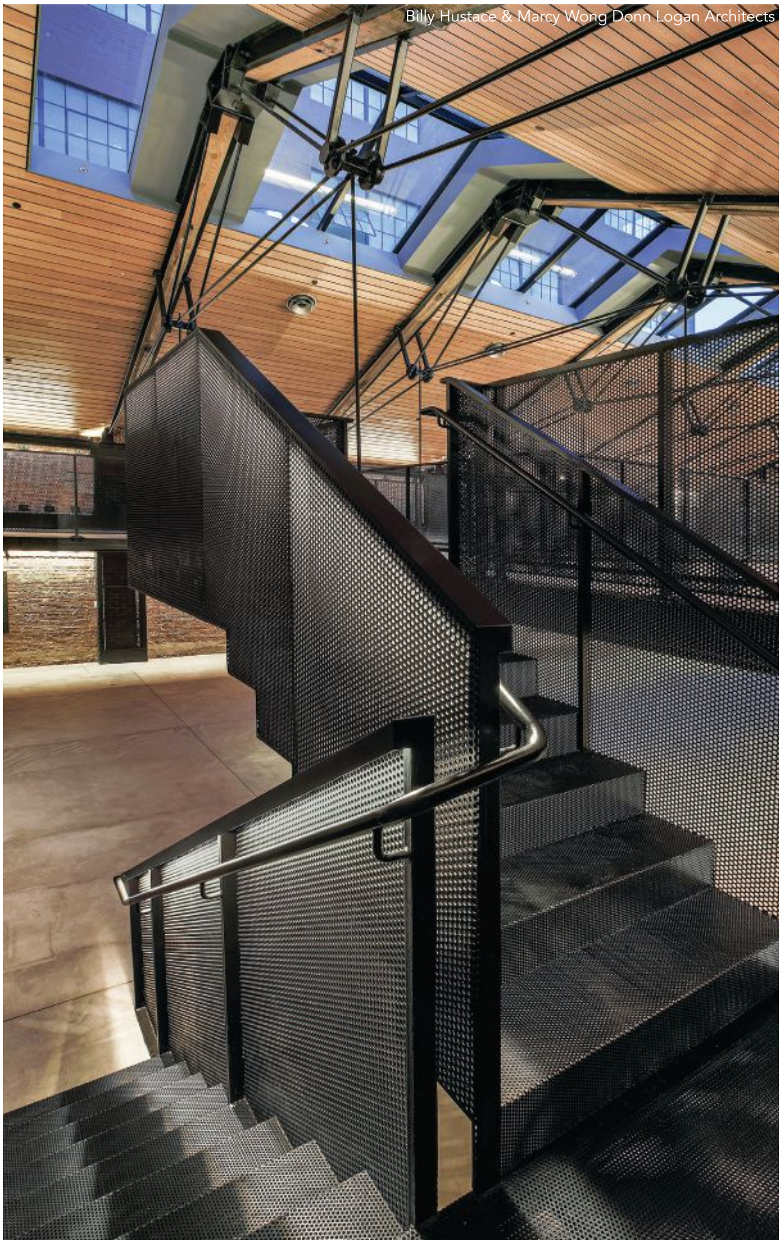
Read on to learn more about and see fantastic images of all this year's winners!

2023 IDEAS^2 AWARDS

Billy Hustace



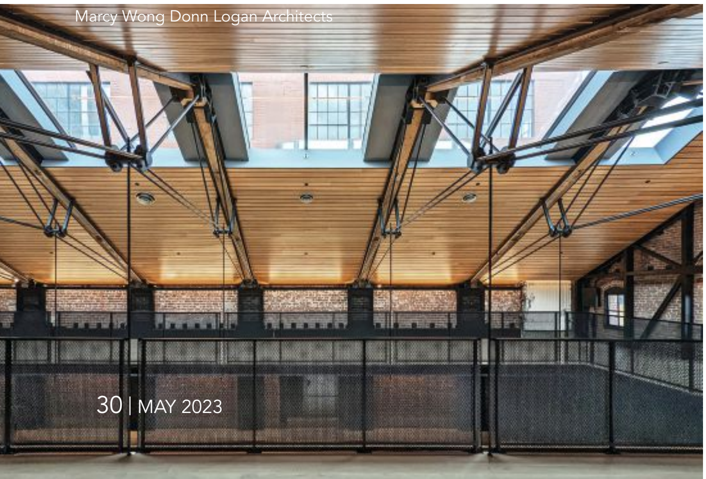
Billy Hustace



Billy Hustace & Marcy Wong Donn Logan Architects

"A thin, sleek design—something you could only have done in steel that completely lets your eye pass to the historic pieces of the building that remain."

—Jim Foreman



Marcy Wong Donn Logan Architects


RHC Construction


RHC Construction

LESS THAN $15 MILLION National Award

MacLac Building D (Rebirth of a Historic Paint Factory), San Francisco

AIRY STEEL TRUSSES and a new mid-height structural mezzanine add state-of-the-art seismic resistance to an unreinforced brick factory from 1906—preparing it for another century of service.

This rebirth of this historical building—with its newly unveiled, lofty interior volume made possible by the use of structural steel in the retrofit—is now ideal for functions that are in accordance with the City's PDR ("Production Distribution and Repair") zoning, which includes a showroom, restaurant, office, retail, light manufacturing, arts-related and design-related establishments.

The classically gabled, industrial brick edifice initially functioned as part of a lacquer and paint manufacturing complex and was known as Building D. The MacLac moniker reflects the previous owner's name (R. J. McGlennon) combined with the word lacquer.

At the outset of the project, the building's condition was akin to a rat maze, resulting from a century-plus accretion of ad hoc partitions, random levels, obsolete industrial equipment installations, and a surfeit of detritus. The solution was to raze the maze, exposing the previously hidden, magnificent volume of the historic building and the original construction materials of brick, wood, and steel. The architectural and structural design team's plan was to highlight these historical elements with 21st-century steel architectural and structural upgrades. The rejuvenation introduces crucial new steel seismic elements, accentuates the symmetry of the original building with an open second level whose footprint provides geometric reinforcement, introduces abundant daylight through ridge skylights extending the length of the structure, and provides architectural lighting that highlights the new structural steel architecture and elements. In addition, the original brick walls are reinforced by new steel braces and structural diaphragm elements that reduce the unsupported height of the brick walls.

Structural steel was the ideal material for this project, thanks to its high strength and ductility, providing seismic resistance crucial to the survival of the very building in a high-seismic area. Moreover, it provided the perfect solution for an industrial heritage adaptive reuse project, as it harkens to the roots of the building's history and is a visually outstanding complement to the old brick walls and new floors.

An innovative steel king post truss system and structurally suspended cross-laminated timber (CLT) mezzanine floor structural design visually highlight the building's geometry, original wood, and masonry while providing seismic safety and additional column-free ground floor leasable floor area. The team repurposed the top chords of the original heavy timber trusses as spacers between the steel channel top chords of the symmetrical king post trusses on each side of the existing trusses, allowing the new steel channel to encapsulate these top chords while leaving the bottom surface exposed. The system was prefabricated in two identical pairs of trusses, a center node, and two rods, which helped ease transportation and erection in the exiting building and resulted in no field welding. Once the rods joining the two sides were installed, they could be tightened to adjust the height of the ridge and assisted with aligning and leveling the old roof, and then existing web members and bottom chords of the trusses could be removed, leaving the light and elegant new trusses. The CLT floor mezzanine is suspended by hanger rods dropped down from the king post nodes on the roof trusses, leaving a column-free lower level with an open center area that allows light from a new skylight to reach the entire lower level. The "bonus" floor area of the mezzanine adds 2,555 sq. ft to the ground level area of 3,784 sq. ft, for a total interior area of 6,339 sq. ft.

The seismic-resisting system for the rejuvenated building is an ultra-stiff moment frame system consisting of deep steel columns and beams formed with hollow structural sections (HSS) acting as flanges and perforated steel plate acting as webs. This design accommodates the punched windows on the long sides of the buildings and works in tandem with stiff concentric braced frames on the gabled ends of the building. Thanks to the strength and workability of steel, a cantilevered steel landing at the mezzanine level supports a scissors stair whose only structure is the folded perforated steel plate forming the treads and risers, the perforated steel plate guard rails, and the perforated steel plate sandwich landing, all of which forms a torsionally stiff stressed-skin structure.

Owner
Comstock Realty Partners, Los Angeles

General Contractor
RHC Construction, Oakland, Calif.

Consultant
Mark Hulbert Preservation Architecture, Oakland, Calif.

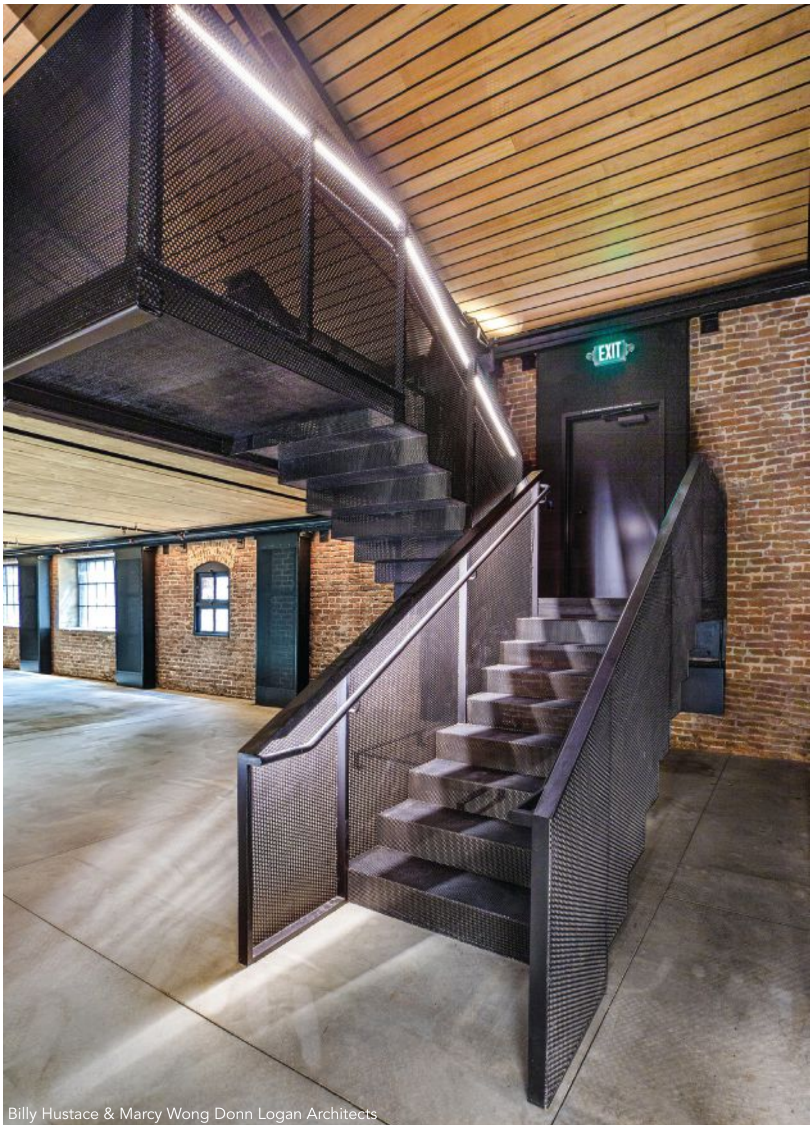
Architects
Marcy Wong Donn Logan Architects, Berkeley, Calif.
Peter Logan Architecture + Design/PLAD, New York

Structural Engineer
Gregory P. Luth and Associates, Inc., Santa Clara, Calif.

Let There Be Daylight

Meeting LEED v.4 C+S Gold Certification requirements was a goal for the design team, and the lighting system—including abundant daylighting—was a major contributor. The electrical lighting is grouped into different zones that correspond to primary and secondary daylight harvesting zones. The light fixtures have full-range dimming drivers and are connected to dimming controls, and daylight sensors located throughout the various spaces trigger the drivers to adjust the lighting to compensate for the amount of daylight penetrating the zone. As the daylight conditions change, the system responds to adjust the overall balance of light to appropriate ratios, allowing maximum energy efficiency to be attained at any given time.

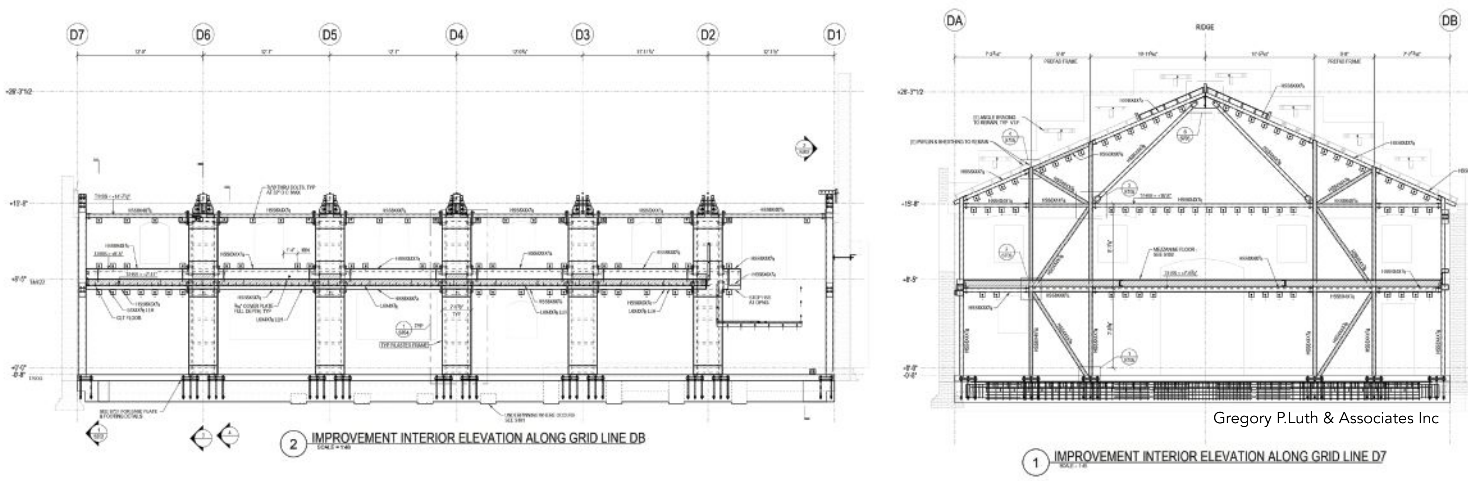

Marcy Wong Donn Logan Architects



Billy Hustace & Marcy Wong Donn Logan Architects


RHC Construction

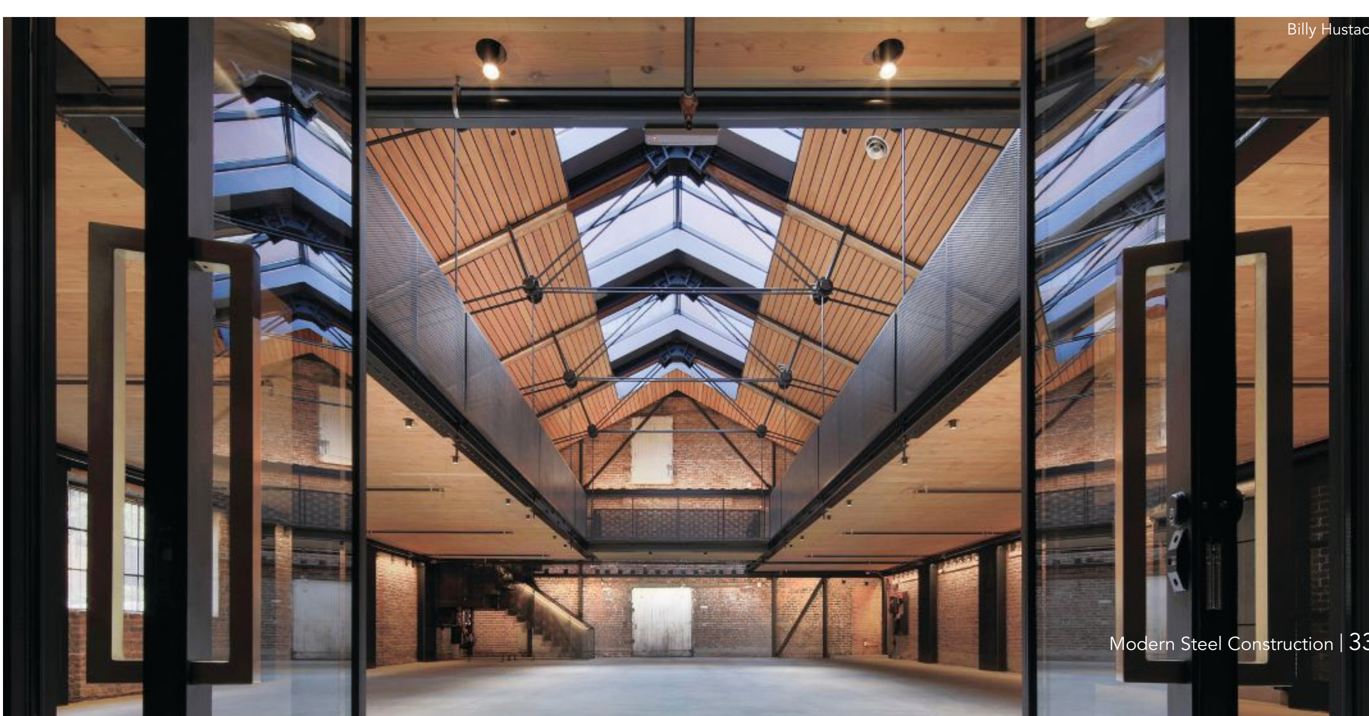
RHC Construction



2 IMPROVEMENT INTERIOR ELEVATION ALONG GRID LINE DB

1 IMPROVEMENT INTERIOR ELEVATION ALONG GRID LINE D7

Gregory P.Luth & Associates Inc



Billy Hustace

LESS THAN $15 MILLION Merit Award

The Eskenazi School of Art, Architecture + Design, Bloomington, Ind.

IN 1952, Ludwig Mies van der Rohe designed a house for the Pi Lambda Phi fraternity on the main campus of Indiana University in Bloomington, but funding cuts relegated the plans to the MoMA archives. Exactly 70 years later, students now get to enjoy that space—not as a fraternity house but rather as a design school.

The newly completed Eskenazi School of Art, Architecture + Design is a modern revival of van der Rohe's design. The new/old building was brought back to life through a recent collaboration between architect Thomas Pfifer and Partners and structural engineering firm Skidmore, Owings and Merrill (SOM). The team studied the original plans, drawings, construction details, and calculations while comparing them to similar van der Rohe buildings of the time. The team also gathered all available notes from the famed "less is more architect," including the original structural calculations for a similar building by Myron Goldsmith, formerly of SOM and van der Rohe's offices. A key challenge was to stay true to the original design intent while simultaneously aligning the project with current building codes and environmental considerations.

The two-story, 930-sq.-ft building, which officially opened in April 2022, features a lecture hall, offices, and meeting rooms for faculty and staff. The ground floor is mostly open, while a central square atrium carves the upper level. The design brings abundant light to the interiors with a white-painted steel frame and floor-to-ceiling windows. The original design was followed with only minimal alterations to the visible architecture. Changes to the ground level included the reconfiguration of the stairs to comply with current safety codes, in addition to an expanded mechanical room, and other modifications included the addition of a hydraulic elevator and changing the glazing from a single pane to high-performance insulating glass. The second floor of the original design remained largely intact, repurposed from bedrooms to offices.

Since the structure was a recreation of an original design in steel, steel was the only viable option. Then as now, it provided a crisp aesthetic to the defined edges of the columns and mullions and also allowed for a thinner floor slab, providing more space for the MEP services in the 15-in. ceiling sandwich.

Hadley Fruits

Hadley Fruits

"You can't separate the idea of steel and the idea of that building; steel is the only thing that could make that building work."
—Anders Lasater

Anna Powell Denton

Hadley Fruits

The primary structural challenges included engineering the steel mullions to accommodate insulating glass, wind loads, and building movements with minimal changes to the mullion profile of a typical van der Rohe design; coordinating MEP services through the 10-in. beams—in particular, locating and engineering the relatively large openings in the beams for air-conditioning ductwork, which the original design did not have; and creating structural details with no visible welds or bolts while simultaneously having all site connections bolted to facilitate erection provided some adjustability to maintain the very tight tolerances.

The solution for the mullion challenge was to use steel bars for the structural core of the mullions with glazing stops screwed to the steel bar core. The steel bar had the center machined to a ⅜-in. web to create a 1-in. glazing pocket, which was the dimension required to accommodate tolerances and frame wind load racking and vertical floor deflections. For mullion deflection calculations, the glazing stops were included in the mullion stiffness properties. The machining and careful selection of mullion stop screw size and spacing resulted in the absolute minimum mullion size.

There was a total of 15 in. available for the slab, steel framing, insulation, services, and ceiling for the MEP services, a depth that was dictated by the perimeter spandrel channel size, which was the same as the original design. The team specified a 2-in. slab over one ½-in. metal deck to achieve this extremely thin sandwich. The slab also had embedded radiant heat pipes, which required careful engineering and coordination of the slab system. For the building services, the second-floor beams had 220 openings in the steel girders varying in size from 3-in. round to 20-in. by 6-in. rectangular, with the latter openings requiring in-depth calculations to validate their strength.

All beams and girders on column lines were designed considering the connections as partially restrained for lateral load resistance and minimized deflections. Flush bolted end plates were used at the beam-to-column connections, and the built-up girders ran over the columns with end plate splices near the cantilever back-span inflection point. The channel spandrels also had bolted end plate connections near the inflection points (two on each façade) with corners shop welded. The end plate connections were subsequently seal welded and ground flush to provide the appearance of a continuous member. Beam-to-perimeter columns were bolted to studs welded to columns to eliminate the requirement for any welding on the exterior with the connection configured so the channel could be erected and bolted first, followed by the end plate connected beam.

Hadley Fruits

Hadley Fruits


Hadley Fruits

In addition to resisting wind loads on the glazing system, the vertical steel mullions also provide part of the second-floor gravity system. This is required since the second-floor channel spandrel at 15 in. was not adequate to span 30 ft, nor was it adequate for deflections of the 10-ft cantilevers. The vertical steel mullions are, therefore, rigidly bolted between the roof and second-floor spandrels, allowing part of the second-floor load to be shared by the roof spandrels, which have less load than floor spandrels. Also, rigidly connecting the spandrels together eliminates differential vertical deflection between the roof and floor, allowing a smaller glazing pocket than required.

The individual mullion elements are bolted to the structural frame with countersunk bolts in the glazing pockets. Horizontal mullions are attached to the vertical mullions with screws. The end plate connection of the vertical mullions is contained within the glazing pocket, so it is not visible from the exterior. By containing all fasteners within the glazing pocket, no fasteners were visible, and no welds were required, which allowed for crisp corners and edges for all the mullion elements without the need for grinding welds. Although integrating mullions in the structural system is not necessarily a new idea (as a matter of fact, the original design used this concept), connecting the glazing system with only screws and bolts, with the only visible fasteners being those attaching the glazing stops, was developed in a very innovative way.

Owner
Indiana University, Bloomington, Ind.

General Contractor
CDI Inc., Terre Haute, Ind.

Architect
Thomas Phifer & Partners, New York

Structural Engineer
Skidmore, Owings and Merrill (SOM), Chicago

Steel Fabricator and Detailer
MAK Steel Services, LLC, Seymour, Ind.

$15 MILLION TO $75 MILLION National Award

Orange County Museum of Art, Costa Mesa, Calif.

Jasmine Park

THE ORANGE COUNTY MUSEUM OF ART (OCMA) is a central component of the OC art scene. With a focus on 20th- and 21st-century art by artists with ties to California, the institution's focus has always been to educate and inspire the community.

In the mid-2000s, as OCMA was contemplating an expansion beyond its space within a high-end commercial mall, it identified a suitable new home: a portion of the Segerstrom Center for the Arts in nearby Costa Mesa, a massive campus of performance venues and public spaces.

The museum's new form is that of a flowing, irregular structure housing intimate small galleries, a reconfigurable main exhibition space, and a rooftop terrace for large-scale sculptural works. Located adjacent to the 3,000-seat Segerstrom Hall, it also serves as the final component of what was envisioned as a multi-disciplinary arts campus. With nearly 25,000 sq. ft of exhibition galleries—approximately 50% more than in the previous location—the new 52,000-sq.-ft space allows OCMA to organize major special exhibitions alongside spacious installations from its collection. The design complements and responds to the undulating façade of the neighboring concert hall and supports an outside-in and inside-out experience, and also features an additional 10,000 sq. ft for education programs, performances, and public gatherings, as well as administrative offices, a gift shop, and a café.

Visitors approach the new structure via an at-grade plaza punctuated by the 66-ft Connector sculpture by Richard Serra, and at the far end of the terrace is a sweeping staircase that looks over the entryway and central campus walkway, intended as a lounging and meeting place. The three primary gallery spaces within the flowing, irregular mass all required uninterrupted site lines, and the long-span spaces are arranged in complex configurations. The nonorthogonal architectural element—that, in places, cantilever more than 30 ft off the primary structure—and highly visible public spaces below a cantilever-trussed classroom wing required a structural material that could meet the aesthetic and functional needs of the design, endure the seismic forces of Southern California, and offer a sustainable, economically fabricated option. A high-bearing-strength material was also required for the necessary reduced column section below the massive girders that span the ground floor gallery. As such, structural steel was envisioned from the outset by the design team as the material of choice since it met all of these primary needs. The structure does employ concrete shear for the shear walls, but using it for floor framing would have been prohibitively heavy—and due to the sheer size of the members required, it would not have supported the architectural proportions desired for the galleries and public space elements.

The museum's design provides flexible and functional spaces over four levels, including a mezzanine and mechanical level. The main floor is dedicated to 60-ft-long open, reconfigurable internal and street-front galleries that can accommodate temporary and permanent exhibits. Maintaining the architectural clarity while supporting

Mike Kelley

Jasmine Park

"The architect and the structural engineers really understand the unique qualities and material capabilities of structural steel and found ways to use it to their design advantage."
—Anders Lasater

Mike Kelley

these long-span spaces was a significant challenge, made more difficult by the requirement that the soffit maintain a consistent elevation throughout, which limited the depth of steel beams and girders. This was solved in the ground floor gallery by adding a 700-lb-per-ft plate girder that spans roughly 68 ft at the terrace, with ten beams framing into it, and has a self-weight of roughly 24 tons.

A spacious roof terrace, equivalent in size to 70% of the building's footprint, serves as an extension of the galleries, with a sculpture garden and reconfigurable open-air spaces. In order to maintain column-free spaces at the indoor-outdoor threshold of the terrace, a full-story steel truss was cantilevered off of a concrete elevator core.

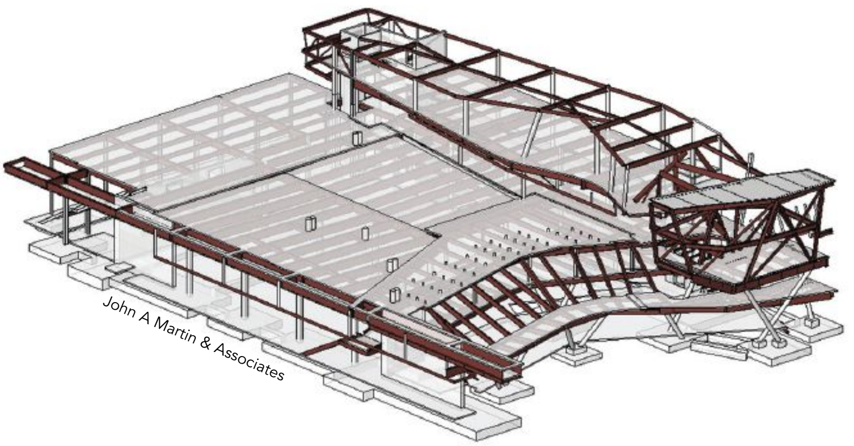
Further supporting the irregular geometries are two 5-ft-deep built-up plate girders that support the cantilevered planter, known as the "plantilever," on the northeast side of the terrace. These girders have a cantilever of roughly 40 ft, and one of them is supported by another cantilevered beam underneath it. The tip of one of these girders was cambered upward 3.5 in. to meet the project deflection criteria.

Finally, the unusual geometry of the museum's classroom component presented highly specialized superstructure and secondary structural design challenges. This public element is supported via a 36-in.-deep cantilevered truss with roughly a 68-ft span that simultaneously cantilevers and slopes up past the columns all the way to the front of the classroom. The truss is supported on 20-in.-diameter sloping columns that work in pairs to resist competing forces that develop as a result of their sloped geometry. Collectively, the element had a unique shape, sloping walls, special concentric braced frames, full-story-seep trusses, and a cantilever east end, which created multiple nodes where some or all of these elements intersected. Aligning these elements with architectural, MEP, and other systems required near-constant 3D model integration with the team, and drafting details created in collaboration with the steel detailer and erector also facilitated constructability and efficient fabrication.

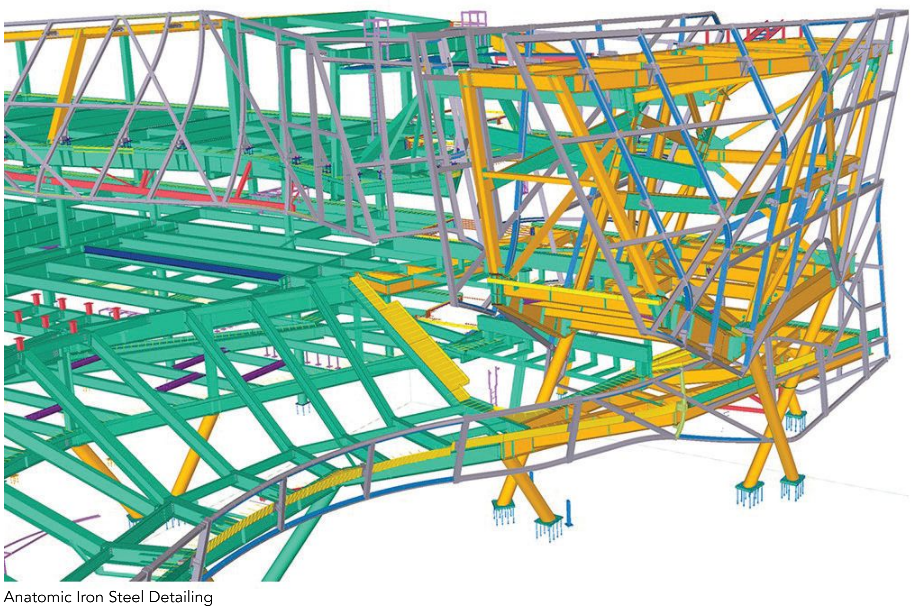
The structural system used special concentric braced frames with bolted connections designed to buckle in the plane of the frame, allowing for quick erection and reducing the size of the SCBF gusset plates. Because these elements were bolted and not welded, the gusset plates were smaller, allowing more architectural freedom.

While primary systems were designed at the same time, secondary systems were not determined or designed until much later in the production process. One such instance was with the façade, a series of differentially angled planes with radially curved surfaces connecting the various planes, all of which are clad with a terra-cotta rain screen system. Structurally, this required a geometrically complex secondary steel system that would support the façade and the long-span glazing system. That secondary system also required full structural integration that would be compatible in terms of loads and movements between the systems and eliminate independent support structures for each. The primary structure anticipated large, eccentric loading from the façade's secondary steel frame long before any specific load magnitudes or locations were available. The structural


John A Martin & Associates


John A Martin & Associates

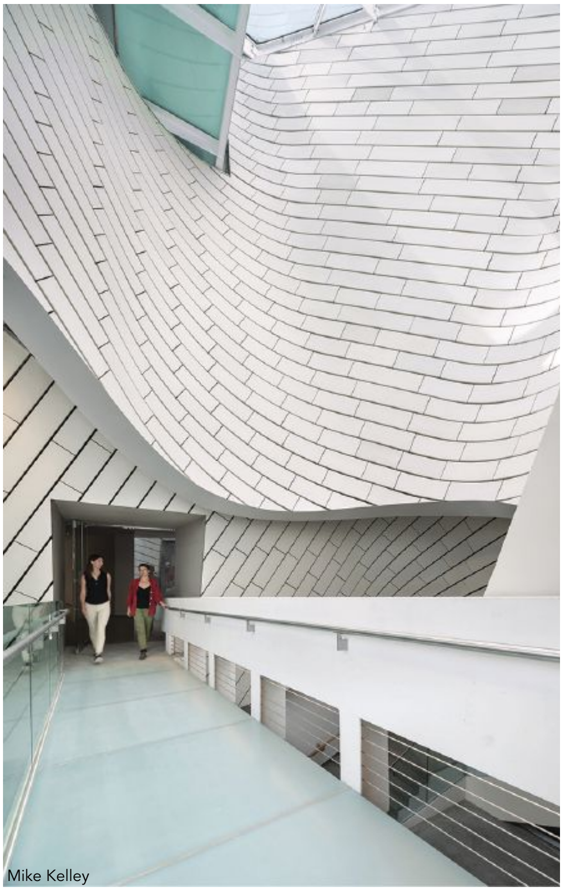

John A Martin & Associates


Anatomic Iron Steel Detailing

team used historical experience with these systems to design secondary steel frames that could inform loading assumptions for the primary structure.

At the outset of the design process, the team developed a BIM execution plan to lock in geometries and collaboratively establish guidelines that allowed the steel design to remain efficient and reduce complexity in detailing. These structural "rules" offered designers the freedom to massage geometries to meet conceptual or aesthetic goals, but they also established reasonable load paths in the structural system to support those elements.

As questions arose, the guidelines also allowed the engineering team to consistently distill issues into fundamental parts while maintaining an understanding of the overall load paths—a necessity to meet the rigorous seismic requirements in an area known for high seismic activity. This was highlighted as the project moved from design to construction and design models were combined in a BIM environment with fabrication models. For the review of shop drawings, the structural team would review 3D drawings in Tekla in tandem with 2D drawings to verify conditions. Work points were pulled from the architect's Rhino model by the engineering team and translated into the fabricator's Tekla model, ensuring a level of accuracy that nearly eliminated cost overruns due to coordination.

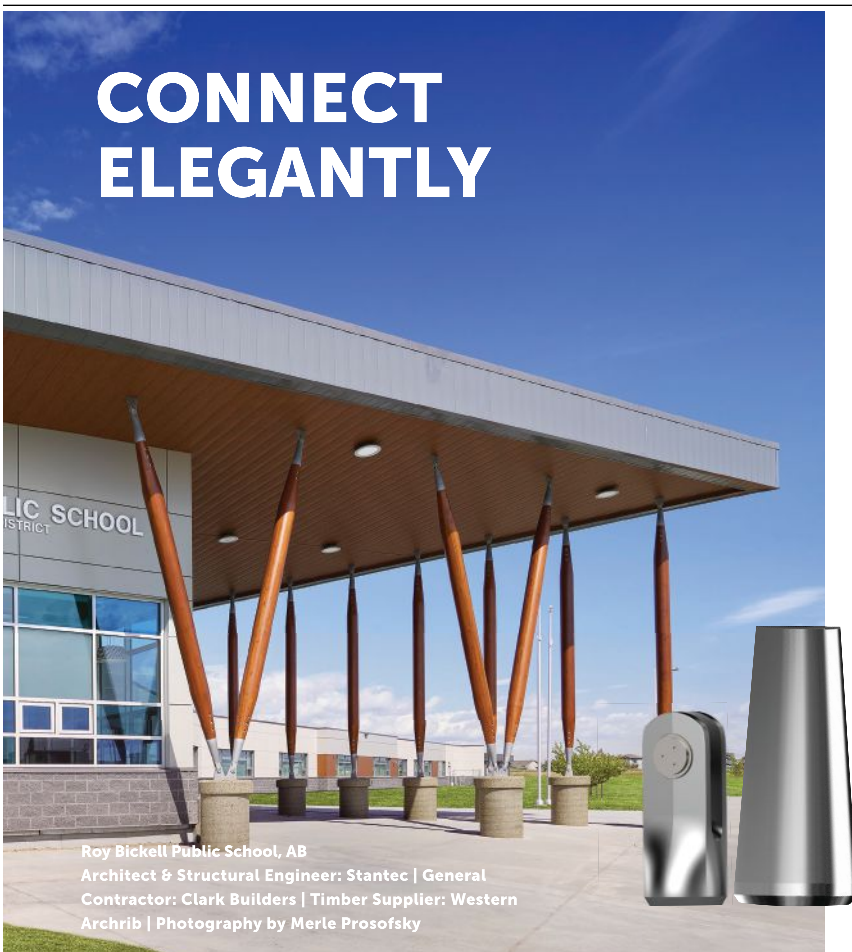

Mike Kelley

Owner
Orange County Museum of Art, Costa Mesa, Calif.

General Contractor
Clark Construction Group, Irvine, Calif.

Architect
Morphosis Architects, Culver City, Calif.

Structural Engineer
John A. Martin and Associates, Inc., Los Angeles



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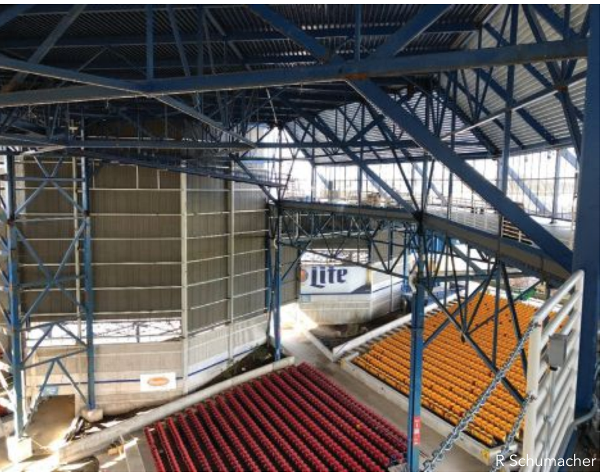


R Schumacher

Eppstein Uhen Architects

$15 MILLION TO $75 MILLION Merit Award

American Family Insurance Amphitheater, Milwaukee

MUSIC LOVERS have raised the roof at Summerfest's permanent venue in Milwaukee for decades. With modern stage acts requiring more vertical space, the project team had to raise the roof, too—to the tune of 26 ft higher.

Summerfest is an annual music festival that has been held in downtown Milwaukee along the shore of Lake Michigan since 1968. This destination event drove the need for a permanent concert venue, and after much planning and fundraising, the original 23,000-seat amphitheater (now called American Family Insurance Amphitheater) was completed in 1987. Over the years, performers grew accustomed to modern facilities that were able to accommodate elaborate stage shows that well exceeded the 39-ft clear height limit of the aging existing roof structure. To keep attracting the best talent to Summerfest, the steel-framed amphitheater needed to raise the roof from 39 ft to 65 ft to accommodate more modern stage shows.

And it did just that. The renovation was staged in two phases so that the premier concert venue could be available for performances in the prime summer festival season while construction work could take place in the colder months. Under a tight schedule and trying weather conditions, the lift was successfully completed safely without a single injury, and the upgraded venue hosted concerts a few short months later.

The existing roof structure and new framing were modeled and analyzed using RISA 3D, and the nearly identical 15° wedges allowed for modeling one wedge and replicating it with minor adjustments to complete the full model. This resulted in a model that used over 3,000 members and 3,000 nodes based on the 1987 shop drawings. The model included the new stage building with an extension of the braced bays at either side of the stage extended to three braced bays to resist the significant added wind loads and higher overturning forces. In addition, the existing columns in the seating area had knee braces added below to provide moment resistance and additional lateral stiffness.

The exposed steel followed the existing form of the amphitheater, and the lift frames were mounted to the top of the extended columns so that no significant other temporary structures were needed to support the lifted roof during the lift. The lift frame beams cantilever a couple of feet over the lifted roof with back spans to the adjacent columns or panel points, and the associated framing and added loads from lifting were modeled and analyzed, revealing that no additional reinforcing was required. Lifting lug plates were designed and welded to the frame with provisions to be removed after the lift.

Construction began with the demolition of the stage building and the removal of all siding and girts. Stage building foundation construction took place at the same time that crews were reinforcing the roof truss and connections. In order to lift the roof, the purlins connected to truss T-5 needed to be cut, so temporary


R Schumacher


R Schumacher


R Schumacher

steel beams were required to support the purlins and span between radial trusses. The whole and cut trusses were modeled, as were the new extended steel columns, and rotation and displacement values were calculated and compared. When cutting the truss member for the lift, a larger gap needed to be provided for clearance during the lift and to align with the final lifted position.

The lift contractor used 200-ton-capacity hydraulic strand jacks mounted to lifting beams to pull up the roof. The jacks were interconnected at the control room, where the progress of the lift was monitored to ensure uniform lifting. The weight of the roof portions at each jack needed to be calculated carefully to ensure uniform lifting. By the time the lift beams and equipment arrived on site, the support steel was erected and the temporary steel and lifting lugs were installed. Simultaneously, the stage, which had been demolished, was being reconstructed. A 300-ft-boom crane was used to install the lift beams and jacks.

Once the lift beams and jacks were installed and interconnected at the control room, the strand jacks were loaded to 90% of the anticipated load so the lugs could seat and any lift issues addressed. The lift took place the next day when the morning temperature reached a low of -10° F. The jacks were loaded to the anticipated weight, and the roof trusses and purlins were cut loose. The member cuts were widened to the anticipated rotation of the trusses following a loss of continuity from the cuts, and then the lift proceeded. The stroke of the hydraulic jacks was 18 in., allowing for length adjustments between strokes to ensure a uniform lift. The lift stopped at points where the lower chord of the lifted trusses needed to clear the top chord of the remaining trusses to grind portions of the cut ends for clearance, and the operation proceeded for about six hours to reach the 26-ft level when the jacks were secured for the night.

Reattachment of the trusses to the new upper frame began the next morning. The main trusses and lift jacks were set at eight locations to reattach the roof as quickly as possible, and the lifted roof was fully re-supported within two days, with most main connections completed in about a week.

For more on the American Family Insurance Amphitheater project, see “Upward Bound” in the January 2021 issue, available at ***www.modernsteel.com***.

Owner
Milwaukee World Festival, Inc. (Summerfest), Milwaukee

General Contractor
Hunzinger Construction, Brookfield, Wis.

Architect
Eppstein Uhen Architects, Milwaukee

Structural Engineer
Larson Engineering, Inc., Wauwatosa, Wis.

Consultant
Mammoet (formerly ALE Heavy Lift), Rosharon, Texas

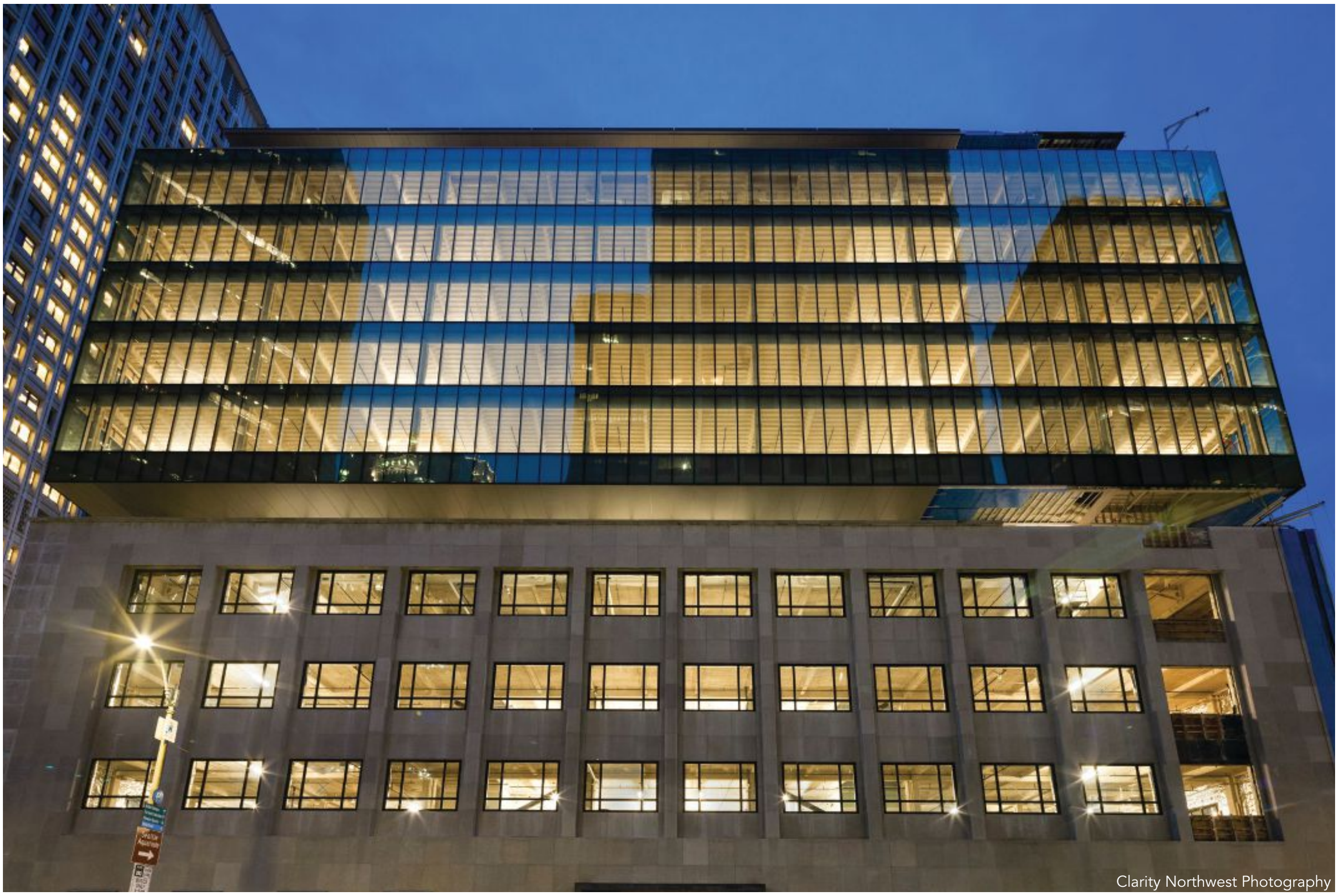
Steel Team

Fabricator
Ace Iron and Steel, Inc., Milwaukee

Erector
SPE, Inc. AISC ASSOCIATE, AISC CERTIFIED ERECTOR, Little Chute, Wis.

$75 MILLION TO $200 MILLION National Award

Federal Reserve Building, Seattle



Clarity Northwest Photography

BUILT IN 1949 and retired in 2014 due to its outdated security features and minor damage sustained during the 2001 Nisqually earthquake, the Federal Reserve Building in Seattle now reaches for the sky with a vertical expansion, a new seismic system, and new steel.

The landmark building has been converted into a 204,000-sq.-ft Class A office space thanks to an updated design featuring seven beautifully restored existing floors along with seven brand-new floors, with the latter encased in a glass jewel box structure providing stunning views of Seattle's new waterfront. In addition to the seven added stories on top of the original structure, the entire building was strengthened to comply with modern lateral building codes that have significantly changed since the original construction. Many unique challenges required innovative solutions, including providing a new seismic system while preserving the existing system, fabricating new steel framing, and incorporating a near-indestructible five-million-pound vault in the basement into the new building structure.

The framing for the original historic building was provided by Bethlehem Steel in Pennsylvania, and steel was identified as the clear solution for the new framing from the earliest design phases of the expansion and renovation project. In addition to making connections to the existing structure easy, the light weight of a steel framing system reduced the forces on the existing building, as well as the amount of strengthening required throughout.

In order to support the seven-story addition, new steel columns are woven through the existing structure to new foundations below. While the new and existing portions of the building have largely separate gravity systems, they share a lateral force-resisting system because the existing concrete wall system was found to be stiff but weak. Buckling restrained steel braces were installed at each level up the height of the building to provide lateral stability and are visible from the exterior of the building. The existing concrete walls at the lower level were cut away from the building so that they supported their own weight for in-plane forces, but they are supported by the new lateral system for out-of-plane movements. Because the new steel was woven through the existing steel that was placed on an orthogonal grid pattern, the new steel needed to be placed off the original gridlines, which resulted in new framing that did not often meet at right angles. The 3D fabrication model was instrumental in creating accurate shop drawings and identifying conflicts between the new and existing framing for this complicated structure.

To create design separation between the new and existing building, a one-story column-free "hyphen" was created at the perimeter above the roof of the existing structure. In order to accomplish this, a cantilevered plate girder was used above the setback that supports the entire weight of the perimeter columns from the added seven stories above. The design team created a full 3D model of the gravity framing to analyze the vertical deflections and vibrations of the building to make sure that the performance of the plate girders is within acceptable limits.

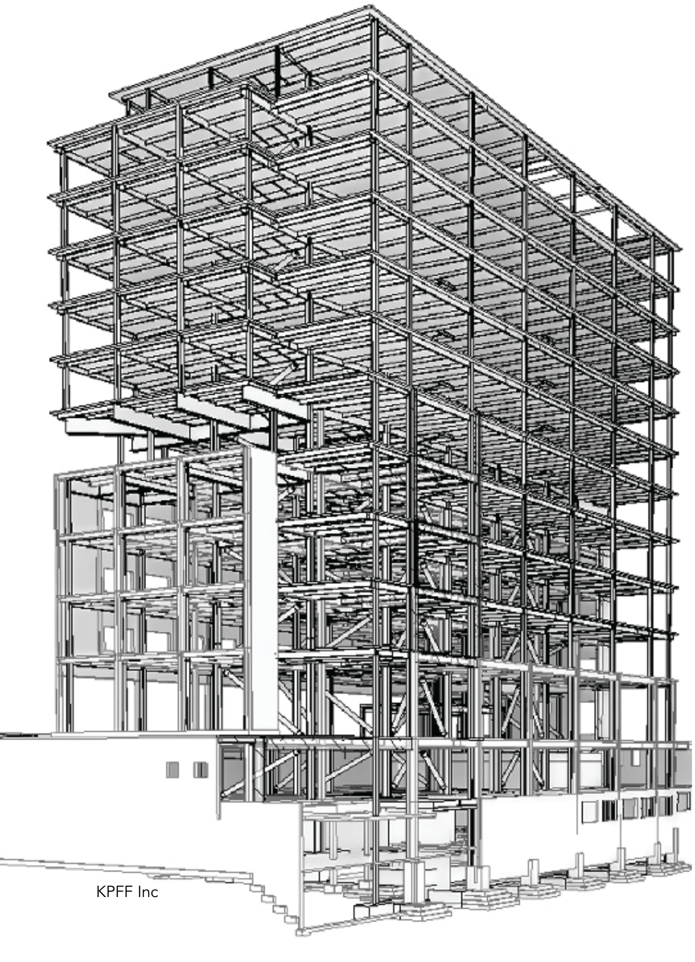
Clarity Northwest Photography

KPFF Inc

Clarity Northwest Photography

"The project showcases where steel has a truly unique ability to be connected and modified into an adaptive reuse of a building that otherwise could not be brought up to current codes."
—David Horowitz

Clarity Northwest Photography



KPFF Inc

Down in the basement, the original 55-ft by 54-ft by 27-ft vault occupies a significant plan area of the building and prevents the addition of foundations in this space. Original construction photos show that the steel security mesh in the vault was so thick that it wasn't possible to see through. The base of the vault was found to be adequate for gravity and downward seismic loads but not seismic uplift loads due to attachment restrictions. To provide uplift resistance, a bearing plate attachment in the middle of the clear span vault lifts up on the underside of the vault lid, and the vault has enough capacity to support its full weight from this one point of support. Eliminating the need to demolish the vault to construct new foundations saved significant time and material for the project.

The historical status of the building resulted in many design challenges, one of which occurs at the corners of the building where a seismic joint is needed, but the limestone panel cladding of the building can't be modified. In order to create a joint while also leaving the exterior of the building intact, a joint was cut vertically through the perimeter-backing concrete walls at the corners but not through the historical panels. The panels were anchored to stainless steel frames that are supported from one side of the joint and reach across the joint to support the entire panel. Fiber-reinforced polymer (FRP) was adhered to the backs of the limestone panels and anchored into the panel thickness to keep the panels from breaking into pieces if there is significant movement at the joint. In the final condition, the corners of the building look unmodified from their original condition.

Because of the original construction tolerances, and the movement of the 70-year-old building with time, the existing steel is close but not exactly in the locations shown in the original construction documents. In order to fabricate the steel correctly, a full 3D scan was taken of the interior of the existing building, and the resulting point cloud was compared to the fabrication model. Where the new steel framing attaches to the existing structure, the dimensions and detailing of the new framing were altered during fabrication to perfectly connect with the existing structure. Additionally, after the framing was installed, 3D scans were taken again and compared against the fabrication model to provide quality control and to verify that the framing was installed in the correct location.

Clarity Northwest Photography

In order to make efficient use of construction materials while also respecting the structure's history, the existing slab-on-deck floor plates were reused wherever possible. Demolition of portions of the existing floor plates only occurred at bays with new stairs and where required for the movement of materials during construction. The archaic concrete-slab-on-metal-deck system was not positively attached to the structural framing, and where beams and girders required strengthening for vertical loads, attachment to the deck was used to reduce the unbraced length of the framing and to increase the capacity instead of adding to the structural section. Performing strengthening via this method saved material and reduced the need for installation labor, including abatement.

Owner
Martin Selig Real Estate, Seattle

General Contractor
Lease Crutcher Lewis, Seattle

Architect
Perkins&Will, Seattle

Structural Engineer
KPFF Consulting Engineers, Seattle

Steel Fabricator and Detailer
Metals Fabrication Co. (AISC Certified Fabricator)
Airway Heights, Wash.

$75 MILLION TO $200 MILLION Merit Award

DFW High C Gates Demolition and Replacement – Core and Shell, Dallas

MODULARIZATION BROUGHT a new 80,000-sq.-ft concourse in for a speedy landing on a challenging site at Dallas-Ft. Worth International Airport (DFW).

The project involved the demolition and replacement of four gates, known as the High C Gates, at DFW's Terminal C. The new 80,000-sq.-ft concourse consists of six individual modules, roughly 84 ft by 84 ft, constructed roughly one mile away using conventional steel framing that were then moved to the terminal site using SPMTs (self-propelled modular transporters) and set on concrete columns. Once the modules were set in place, additional steel framing was erected to fill in the gaps between a few of the modules. This method allowed for the modules to be constructed while the existing buildings were demolished and foundations and supporting columns were installed, reducing the schedule by 22%.

Each module was designed to be structurally sufficient when freestanding at the fabrication yard, during transport on the SPMTs, and as part of the overall concourse at the terminal site. For this design concept to work, the system for lateral forces and the system for gravity forces required creative solutions. Laterally, each module was stabilized using a combination of braced frames and moment frames to create freestanding modules. The modules were then stitched together at the terminal site so the individual lateral systems could work in conjunction. At both the fabrication yard and the terminal site, a traditional gravity load path was followed, with all loads ultimately being transferred from the deck to beams, then to the columns that transfer the loads to the foundations.

Some columns at the terminal site could not be installed until after a module had been moved into place because they were in the direct path of the SPMTs, which could only support a module at the terminal site for a set amount of time before they had to be returned to the fabrication yard to transport the next module. Because of the time constraint, the team created a composite column concept, with the steel portion of the column designed to support the module when it was on the SPMT. Once the steel column was placed and the transporter released the module, concrete was poured around the steel column to create a composite column that could support full lateral and building service loads.

In addition to designing concourse girders that could support the weight of the module during transport, the team also analyzed possible overturning moments due to wind and the acceleration or deceleration of the SPMTs. Friction at the surface where the concourse girders were in contact with the SPMTs helped prevent the modules from sliding off during transport.

To further expedite the project schedule, the roof, exterior walls, metal panel system, and curtain walls, along with some mechanical shafts and pipes, were installed on the modules at the fabrication yard. This required additional coordination with the manufacturing of those systems and further analysis of the structure to ensure that any unintended deflections that might occur when the modules were being transported or transitioned would not damage the metal panel system or the glass in the curtain walls.

Owner
DFW Airport, Dallas

General Contractor
The Walsh Group, Chicago

Architect
PGAL, Addison, Texas

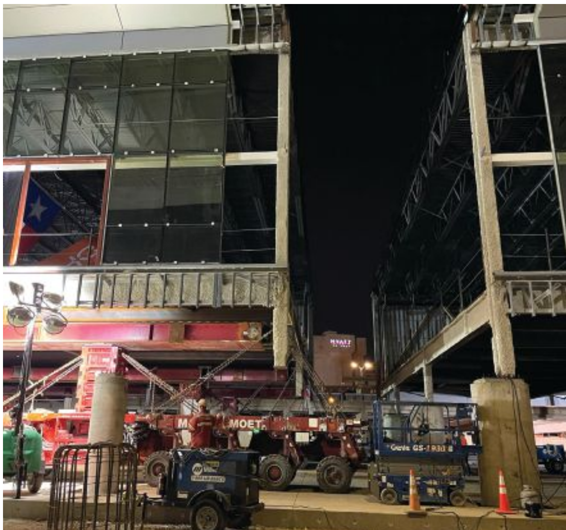
Structural Engineer
Henderson Rogers Structural Engineers, LLC, Houston

Consultant
Mammoet, Rosharon, Texas

Steel Team

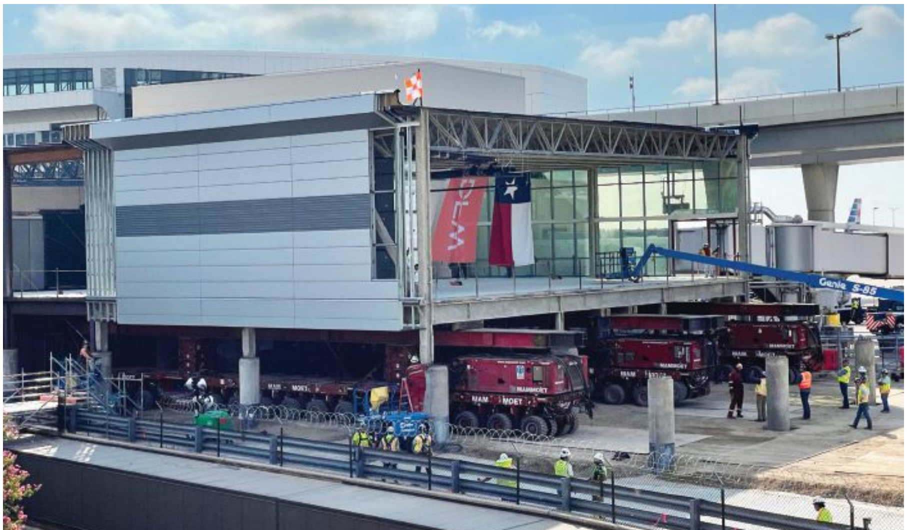
Fabricator and Detailer
Miscellaneous Steel Industries (AISC Certified Fabricator), Kyle, Texas

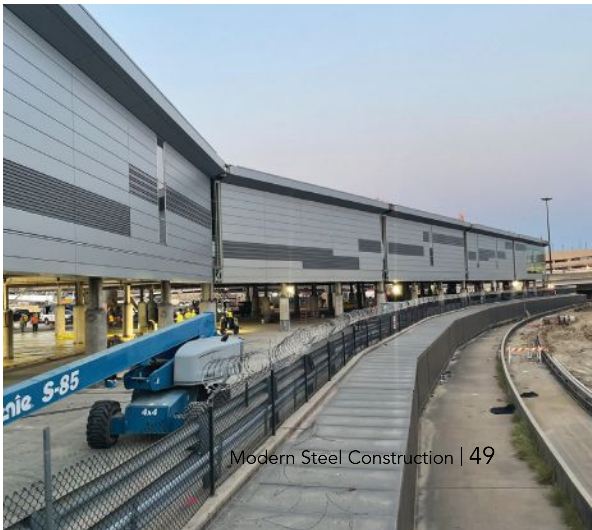
Erector
Acero Construction Services (AISC Certified Erector), Kyle, Texas



"This modular installation is a great way to showcase the efficiency of using steel in a tightly constrained site."
—David Horowitz

All photos: Henderson and Rogers Structural Engineer, LLC





GREATER THAN $200 MILLION National Award

SoFi Stadium, Inglewood, Calif.

IT TAKES TRUE INNOVATION to make a below-grade structure surrounded by a 100-ft-tall, mechanically stabilized earth wall feel light, but the SoFi Stadium project team did just that.

Home to the Los Angeles Rams and Los Angeles Chargers of the NFL, the 3.1 million-sq.-ft stadium seats 70,000 and can be expanded to 100,000. It sits in close proximity to the Newport-Inglewood fault and also in between flight paths to Los Angeles International Airport (LAX), just three miles away. Due to its proximity to LAX and the subsequent FAA requirements, the playing field was driven 100 ft into the ground, and a record-breaking 100-ft-tall mechanically stabilized earth wall created a moat around the entire stadium, giving it room to safely move during a seismic event. In addition, an advanced structural system featuring buckling-restrained braces (BRBs) and lock-up devices provides needed lateral strength.

The stadium realizes a grand vision that redefines what a venue can be, transcending NFL football to include a wide range of entertainment events, including Super Bowl LVI, the College Football National Championship Game in 2023, and the Opening and Closing Ceremonies of the Olympic Games in 2028. It's topped by a sinuous, semi-transparent roof canopy, which is supported by the largest double cable-net system in the world. The canopy includes micro-operable panels to help maintain climate certainty for events, and the ethylene tetra-

all photos by SoFi Stadium

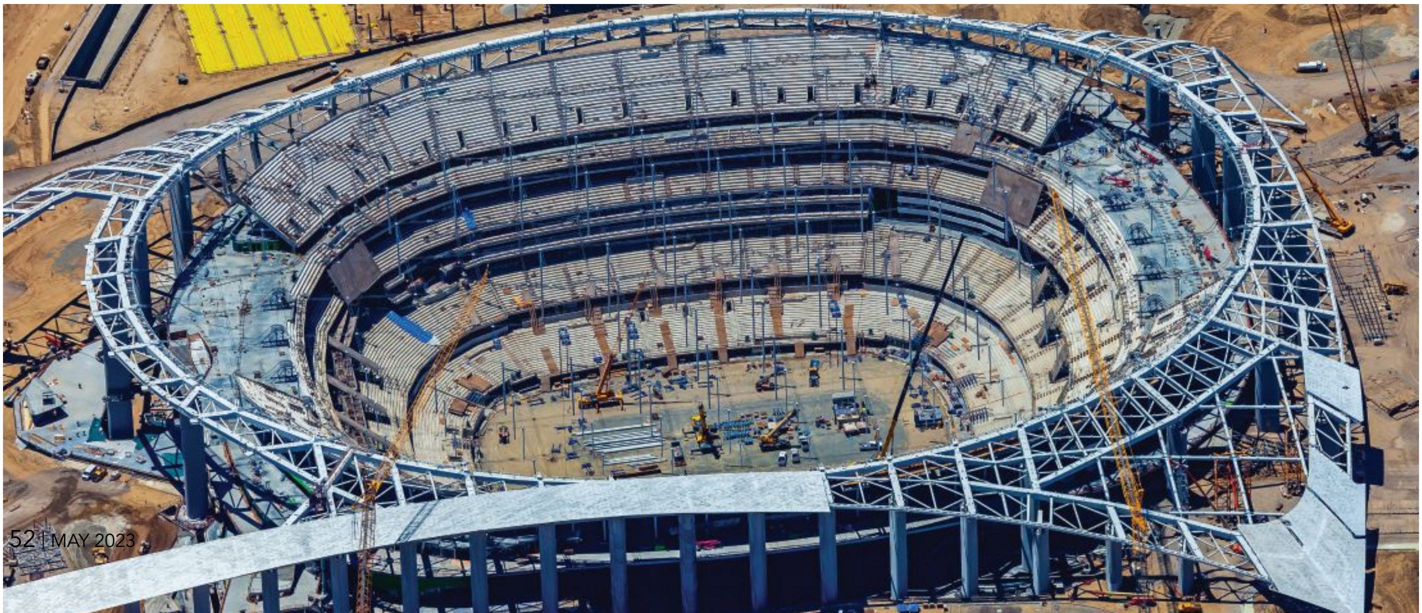
fluoroethylene (ETFE) roof canopy columns are supported on a complex soil-isolated foundation system that extends outward from the stadium.

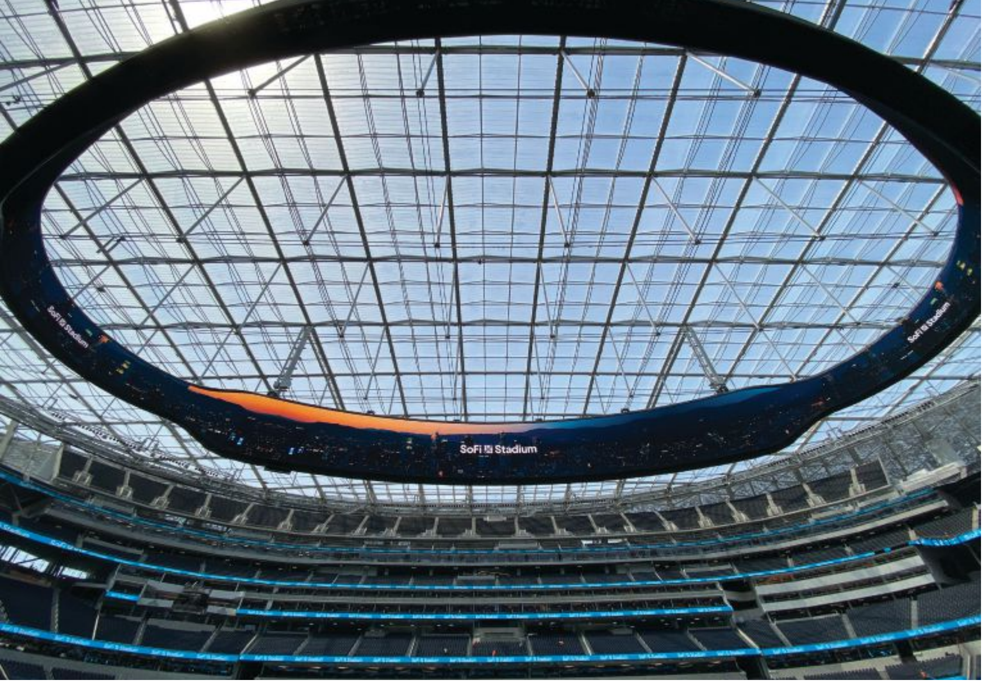
Steel was the right material for this project. Lightweight and strong, with excellent ductility, steel helps minimize seismic activity while providing excellent resistance. Just as the lightweight roof enabled the efficient spanning of the new stadium, the lightweight framing structure allowed efficient seismic resistance in a near-fault location. The cable net ETFE roof canopy and supporting steel frame with columns were designed with aesthetics in mind and driven by the indoor-outdoor nature of the stadium. They also support the Infinity Screen by Samsung, a circular video screen that hangs above the playing field.

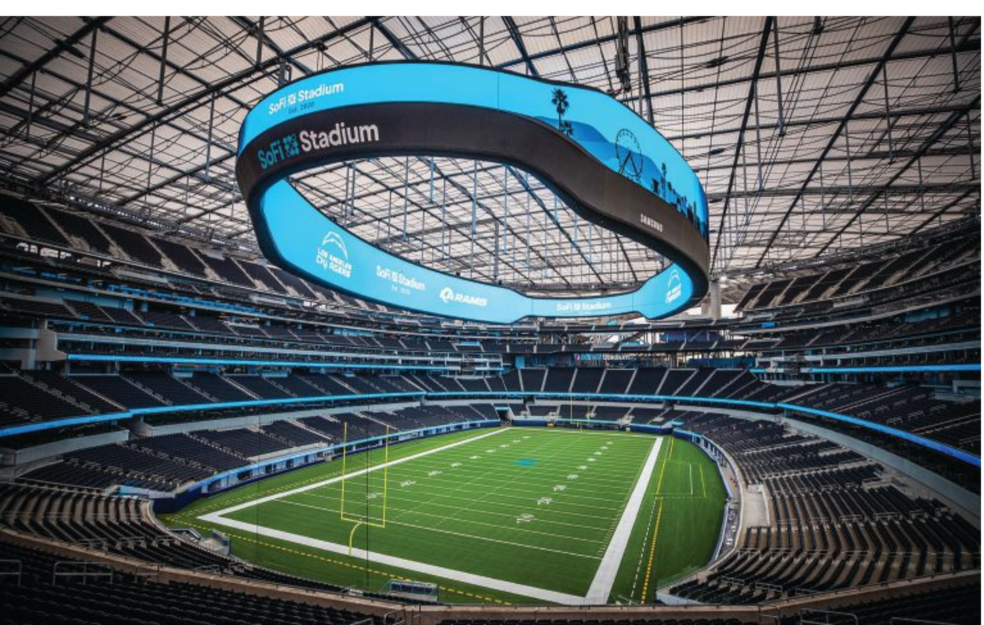
The long-span roof canopy demanded a design that maximized material efficiency and lowered tonnage, resulting in seismic isolation and greatly reducing the roof accelerations, permitting a lighter and more elegant design. The use of isolation on a form so different from traditional buildings necessitated performance-based engineering with nonlinear dynamic analysis of the structural elements under numerous seismic ground motions. The roof canopy cable net structure was analyzed under a variety of support conditions, including superimposed loads from the 1,100-ton suspended video screen using 3D seismic acceleration. Additionally, an independent geotechnical analysis of the soil behavior under those same ground motions was performed to validate the final design, ensuring adequate decoupling of behaviors of the roof canopy, perimeter shell, column supports, grandstand, and MSE wall systems.

The stadium bowl was achieved by optimizing the 1,000+ discrete BRBs in the main grandstand and the surgical placement of 48 discrete custom viscous-damper “lock-up devices” (LUDs).


SoFi Stadium







These custom LUDs securely link the lower seating bowl levels during the potential occurrence of seismic activity while allowing the structure to expand and contract under normal thermal loads typical of an outdoor stadium. This required large-scale use of thermal analysis and lock-up devices with buckling-restrained braced frames (BRBFs) to permit partial-height thermal joints, allowing uninterrupted concourses at upper levels by elimination of upper-level seismic joints.

The ETFE roof canopy is supported by the largest known double cable-net system at 1.3 million sq. ft. The cable net rests on a massive asymmetric steel compression ring that is, in turn, supported atop a system of 38 150-ft-tall segmental precast concrete columns located outside of the MSE wall. The compression ring is seismically isolated atop the columns with triple pendulum isolators. In another first, the roof canopy includes 46 operable mechanical panels that draw outside air from the sides and promote passive air circulation throughout the building. The canopy columns are supported on a complex soil-isolated foundation system extending outwardly from the stadium.

Nestled under the same roof canopy as SoFi Stadium is YouTube Theater, a 6,000-seat performance venue, and the 2.5-acre American Airlines Plaza. On the southwest side of the stadium is Lake Park, which features a six-acre lake that functions as a novel water recycling system by collecting 70% to 80% percent of the stormwater runoff from around the site, filtering it through natural wetlands and mechanical systems, and then using it to irrigate the surrounding parkland.

Owner
Hollywood Park, Inglewood, Calif.

General Contractor
Turner Hunt Joint Venture, Inglewood, Calif.

Architect
HKS Architects, Inc., Dallas

Structural Engineer
Walter P Moore, San Francisco

Steel Fabricator, Erector, and Detailer
SME Steel Contractors (AISC Certified Fabricator & Erector), West Jordan, Utah (stadium bowl)


Mortenson, Photographer: Anna Halstead


Mortenson, Photographer: Anna Halstead


Mortenson, Photographer: Anna Halstead

GREATER THAN $200 MILLION Merit Award

Climate Pledge Arena, Seattle

THE NEW HOME of the Seattle Kraken scores a hat trick: It involved the near-total demolition of the existing structure and construction of a largely below-grade arena while keeping the landmarked façade and iconic roof intact, it was completed in time to meet NHL scheduling requirements, and it was designed to be the first net-zero certified arena in the world.

The resulting facility, Climate Pledge Arena, is a major transformation of the former KeyArena, once home to the NBA's Seattle SuperSonics. The $930 million renovation and expansion has created an 800,000-sq.-ft, mostly below-grade venue that holds more than 17,000 fans.

The transformation required near-total demolition of the old structure and construction of a new one, all while keeping the landmarked façade intact and the 22,000-ton roof supported above. The arena is in a high-seismic zone, requiring a roof and column retrofit as well as extensive excavation and shoring to build the new facility under the existing roof. Tuned mass dampers provide vibration control for a 275-ft-long press level bridge using two trusses, a composite steel beam floor system is used throughout the structure, and steel rakers support precast concrete stadia units at seating areas. In addition, an expansive rigging grid supports more than 100 tons of loading.

From the initial phases of the project, a steel structure was the clear structural system of choice for the complicated below-grade bowl structure and the press level bridge. While the temporary roof support system was not fully designed and coordinated until the latter part of the design process, the design team envisioned an extensive temporary steel structure that would be required to be removed and disassembled after the permanent structure was in place. A temporary system using concrete was not feasible, and the temporary roof support system would also require an independent lateral system designed to resist any potential temporary seismic forces. A structural system that could be woven in and around the temporary roof support steel elements won out over a permanent concrete structure that required challenging formwork and shoring conditions. Other factors tipping the scales towards a steel structure included a reduction in self-weight to reduce the seismic forces by minimizing the weight of the floor system.

The steel and concrete structure that now covers the arena was designed by Paul Thiry in the late 1950s and constructed in 1961, and in 2017, the Seattle Landmarks Preservation Board classified Key Arena as a local landmark. This distinction required that the roof, curtain wall, and exterior concrete elements be preserved as part of the renovation with virtually zero impacts on their aesthetics. The central challenge became how to support the existing roof while work continued below it.

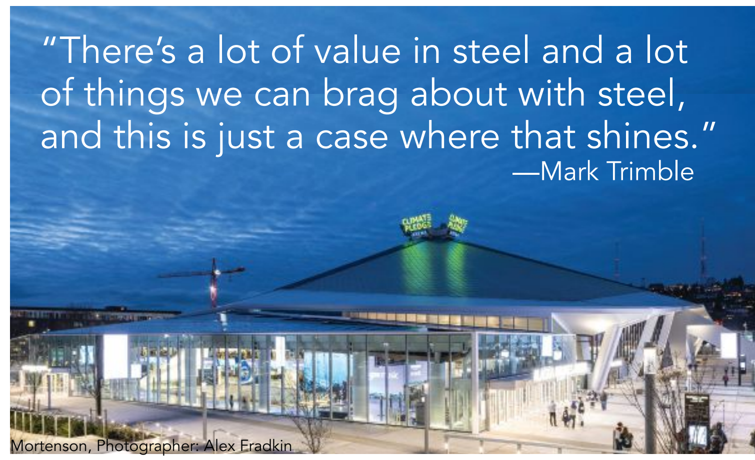
Since the new foundations and 55-ft-below-grade event level would undermine all of the existing roof supports, the engineering team designed a temporary system entailing 3,700 tons of temporary steel framing to uphold the majority of the roof's gravity load and resist wind and lateral seismic forces during twenty months of construction. The historic roof had to be supported in the air during the demolition of the remaining structure without incurring damage while also allowing sufficient access and clearance to remove 680,000 cubic yards of soil and install the permanent structure around the temporary structure.

The team performed a seismic retrofit of the existing roof to ensure that it would resist the seismic demands of modern

Mortenson, Photographer: Alex Fradkin


Mortenson, Photographer: Alex Fradkin


Mortenson, Photographer: Alex Fradkin


"There's a lot of value in steel and a lot of things we can brag about with steel, and this is just a case where that shines."
—Mark Trimble

Mortenson, Photographer: Alex Fradkin

codes, using a computationally demanding performance-based design process that relied on realistic ground motions based on site-specific seismicity and accounts for the structure's nonlinear behavior. Using these advanced analysis techniques allowed the team to significantly reduce the number of steel roof members requiring retrofitting.

The project team also employed strategically placed seismic fuses to minimize retrofits in the exposed concrete elements and preserve the aesthetics of the landmarked structure. To limit seismic demands on the existing Y-shaped columns supporting the roof, the team seismically isolated them from the upper levels of the new bowl structure using low-friction slider connections. One of the primary existing lateral bracing elements, the south buttress, was cut back above its foundation to allow for the construction of a new below-grade parking garage. The team employed selective hydro demo techniques to preserve the existing reinforcing in the buttress and supported it in the permanent condition using an 8-ft-thick shear wall on a large pile cap.

The new bowl structure lateral system consists of buckling-restrained braces (BRBs) in the elevator cores and concrete shear walls at the perimeter basement walls and strategically located at the interior. BRBs also brace a new catwalk and a 100-ton-capacity rigging grid to the existing roof structure to control the forces between the new and existing structures. In addition, tuned mass dampers control vibrations in the long-span floor system, and slide bearings between the new elevator core steel and the existing roof structure seismically isolate the roof from the new bowl structure below.

An integrated approach to solving challenges was critical to the project's overall success. The structural engineer provided its Advanced Project Delivery (APD) services, which helped to achieve considerable schedule and cost efficiencies, and the construction engineering and structural design teams worked in parallel with the steel team to provide a fully coordinated and connected Tekla model for the 8,700 tons of permanent steel for the arena and parking garage while also producing full shop drawings for the 3,700 tons of temporary roof shoring structural steel.

For more on the Climate Pledge Arena project, see "Inside Job" in the April 2021 issue, available at ***www.modernsteel.com****.*

Owner
Oak View Group, Los Angeles

Owner's Representative
CAA ICON, Denver

General Contractor
Mortenson, Kirkland, Wash.

Architect
Populous, Kansas City, Mo.

Structural Engineer
Thornton Tomasetti, Inc., Kansas City, Mo.

Civil Engineer
DCI Engineers, Seattle

Steel Team

Fabricators
LeJeune Steel Company AISC CERTIFIED FABRICATOR, Minneapolis
Corebrace, LLC/SME Steel Contractors, Inc. AISC CERTIFIED FABRICATOR, West Jordan, Utah (BRBs)

Erector
Danny's Construction Company, Inc. AISC ASSOCIATE AISC CERTIFIED ERECTOR, Shakopee, Minn.

Detailer
LTC, Inc. AISC DETAILER, Onalaska, Wis.

GREATER THAN $200 MILLION Merit Award

Moynihan Train Hall, New York

NEW YORK ONCE AGAIN has a grand rail entrance, thanks to the transformation of an early-20th-century postal building into a 21st-century transportation hub.

Moynihan Train Hall expands New York City's Penn Station across Eighth Avenue and into the landmarked James A. Farley Post Office, designed by McKim, Mead and White in 1912 as a sister to their original Pennsylvania Station. Five decades after the demolition of that Penn Station and 30 years after the plan's conception, the 255,000-sq.-ft Moynihan Train Hall once again provides visitors with a grand entrance to New York City. Its central feature—the 30,000-sq.-ft, skylit main boarding concourse—increases public space at America's busiest transit hub by 50%.

For decades, the Farley Building served as Manhattan's General Post Office. The building's location over the railroad tracks greatly facilitated the distribution of mail to and from the rest of the country, and operations there increased through the late 20th century. As long-distance delivery transitioned from rail to truck, however, the Postal Service shifted work to other facilities. In 1992, Amtrak proposed a move into the then mostly vacant building. The idea was championed by U.S. Senator Daniel Patrick Moynihan of New York, in whose honor the facility was eventually named.

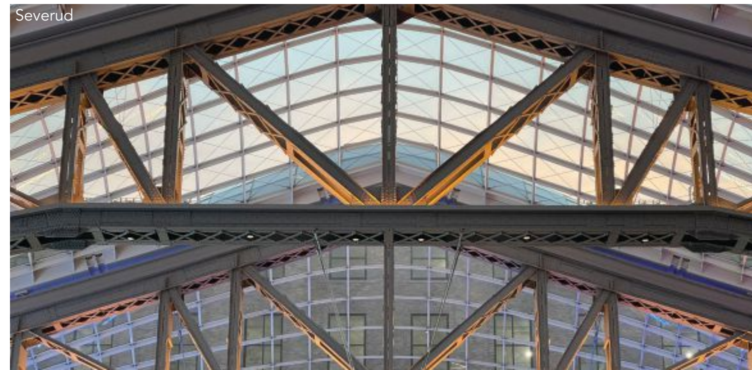
The Farley building's historical designation was a direct result of Penn Station's demolition and the onset of a preservation movement that is still active today. As a landmark, the Beaux-Arts exterior and retail post office could not be altered in any way. However, as a steel-framed structure—one that represents an almost encyclopedic history of the early-20th-century American steel industry, with contributions from Carnegie Brothers, U.S. Steel, and Bethlehem Steel, among other notable shops—Farley was readily adaptable. Reinforcement of roof trusses, reconfiguration of concourse girders framing over live railroad tracks below, and concealed framing within the landmarked walls helped transform the building from a mostly functional 20th-century postal building into a 21st-century transportation hub while maintaining its outward elegance.

Structural steel was the natural choice for redeveloping the Farley building. The original Eighth Avenue building, constructed in 1912, and the Annex, which was built in 1933 and extended Farley all the way west to Ninth Avenue, are framed almost entirely in steel. The original engineers would have chosen steel for its ability to span over multiple railroad tracks—up to 70 ft—while also transferring loads from five levels of framing above. Similarly, the strength of steel allowed the original engineers to use a generous 32-ft by 40-ft column spacing in the Annex. Given the original building's age, the engineering team cut coupons from portions of the existing steel and tested them for tensile properties, chemical composition, and base metal notch toughness and determined that they typically met or exceeded current standards. In all, 1,000 tons of the building's existing steel were removed, 4,000 tons were modified, and 6,000 tons of new steel were added. Together, the improvements add station entrances, track access points, and interconnectivity between rail, subway, and street-level modes of transportation.

Aesthetics also played a role in the use of structural steel for Moynihan Train Hall. Steel trusses that span across and enclose the former mail sorting room are now exposed to view. Their latticed members add an extra sense of lightness that could not be attained with another material and establish a modern aesthetic while dis-


Dave Burk
Empire State Development–SOM

"It shows the resilience of steel. You can take that 110-year-old truss and still keep it working."
—Helen Torres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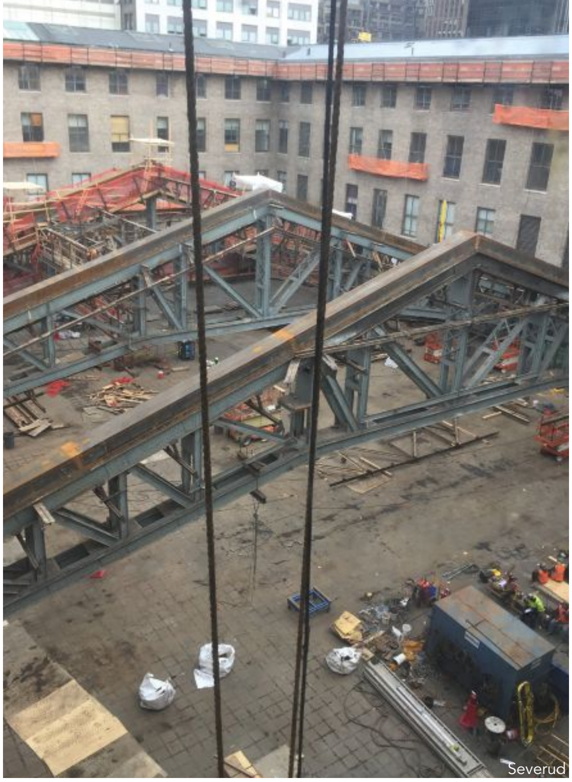

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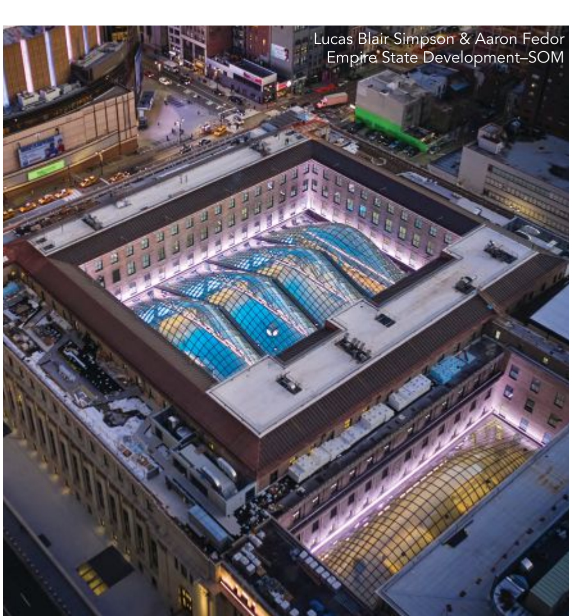


Lucas Blair Simpson & Aaron Fedor
Empire State Development–SOM

playing neoclassical workmanship. Boxes of steel plate, compact and concealed between the top chords and skylights, do nothing to detract from this aesthetic.

Moynihan Train Hall's central feature is the main boarding concourse. Located in Farley's former mail sorting room, the 150-ft by 200-ft space is column-free due to three existing steel roof trusses—invisible a century ago—that were uncovered and reinforced to become a significant focal point of the design. Their latticed configuration and riveted connections are reminiscent of framing in the old Penn Station and add delicacy of detail and a sense of lightness, despite their large scale.

The existing trusses had sufficient capacity to carry a new roof. However, all existing framing between the trusses had to be removed to maximize the skylight's function and appearance. This left them unbraced at their ends and for the full length of their gabled top chords. Restoring the trusses' stability was, therefore, a central component of the structural design plan.

Each truss is composed of two identical and parallel bents, spaced about 3 ft apart, initially to form an observation gallery for postal inspectors. The bents are tied together with diaphragm plates and latticed straps that terminate about six feet above the bottom chords. A box beam 36 in. wide by 24 in. deep, composed of 3.5-in.-thick steel plates and located along the top of each truss, provided sufficient lateral support while remaining concealed beneath the skylights. The box beams also deliver lateral loads to the ends of the trusses and eliminate the need for bracing between them.

The skylights themselves were designed as four independent modules, 50 ft by 150 ft, and arched in cross section, which follow the top truss chords and enclose the concourse. The structures are lightweight grids of steel tees of varying depths spaced with 3 ft to 4 ft between them. The frameworks are internally braced with in-plane diagonal cables and transverse "spiderwebs" of cables at the existing truss third points.

The trusses required additional reinforcements to maintain stability under the skylight loading. Diaphragm plates were welded between each pair of existing truss bents, at the top of the top chords and just below them, and then diagonal bracing plates were welded to the diaphragms to prevent rotation where the bracing cables connect. Finally, plates were welded to tie together pairs of truss bottom chords at each panel point as a replacement for framing elements that were removed.

Existing double-bent trusses also frame the perimeter of the train hall, supporting the low roof between the skylights and Farley building office wings, and are now exposed to view. With a uniform horizontal profile but located at about the main truss bottom chord level, the perimeter trusses are too low to support the new skylights directly. So instead, existing columns were extended up to the box beam elevation, and new framing was installed between them. At the ends of the box beams, steel tube diagonals were welded from each side down to the first perimeter truss panel point to prevent rotation and transfer lateral loads into the building frame.

For more on the Moynihan Train Hall project, see "Station to Station" in the August 2021 issue, available at ***www.modernsteel.com****.*

Owner
New York State/Empire State Development, New York

General Contractors
Vornado Realty Trust, The Related Companies, and Skanska, East Elmhurst, N.Y.

Architect
Skidmore, Owings and Merrill, New York

Structural Engineer
Severud Associates Consulting Engineers, PC, New York

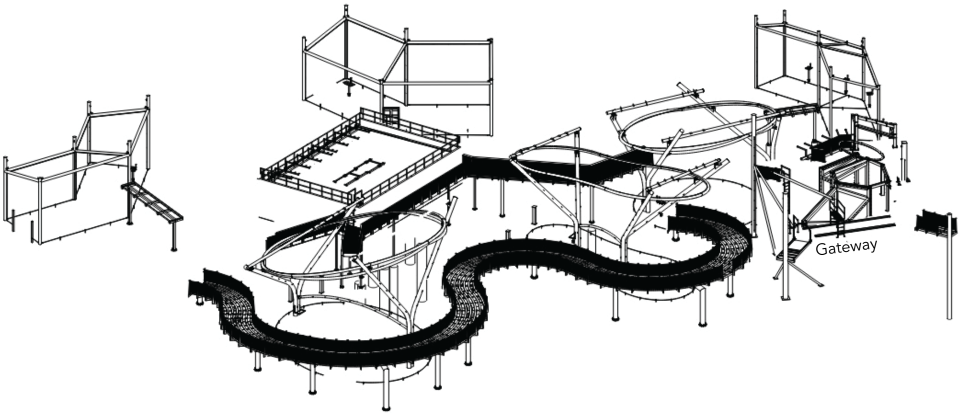
Steel Team

Fabricators
Crystal Steel Fabricators/Crystal Metalworks, Delmar, Del. (primary)
L & M Fabrication and Machine, Bath, Pa. (plate reinforcement)

Detailers
Anatomic Iron Steel Detailing, North Vancouver, B.C., Canada
International Design Services, Inc., St. Louis


Brian Tulgetske


Brian Tulgetske



"I don't think this project could have been made with anything other than steel. The way the paths are nestled through the trees seems almost natural."
—Mark Trimble


Emi Lampman


Emi Lampman


Emi Lampman


Brian Tulgetske


Emi Lampman

SCULPTURE/ART INSTALLATION/NON-BUILDING STRUCTURE Merit Award

Michael and Quirsis Riney Primate Canopy Trails, St. Louis

THE PROJECT TEAM behind the Michael and Quirsis Riney Primate Canopy Trails weren't monkeying around when it came to seamlessly interweaving steel paths and climbing structures with live trees and other natural elements to give visitors a treetop experience—but the real star of the show is uncoated weathering steel, which can gracefully withstand the seasonal changes of the Midwest.

This one-of-a-kind interactive outdoor primate exhibit offers Saint Louis Zoo a unique experience within its 35,000-sq.-ft space, allowing visitors to walk through the forest floor via a see-through tunnel framed in steel and float through the treetops via an elevated winding steel boardwalk. It features eight different steel-framed habitats for primates—including Old World monkeys, New World monkeys, and lemurs—that contain enrichment play areas as well as shelters for the animals.

Climbing structures of steel intertwine with live trees to create a habitat that showcases industrial steel interwoven beautifully with nature. The boardwalk is supported by a round HSS spine that winds through the exhibit. In the three largest habitats, painted round HSS structures are interwoven between sycamore and blue ash trees that create additional climbing and enrichment activities for the animals. Above this is an assembly of weathering steel that holds in place the netting that encloses the habitats. Sixteen steel shelter boxes throughout the habitats, fabricated from weathering HSS, provide the animals with a place to find shade in the summer, heat in the winter, or just a place to hang out when not swinging around the steel and natural treetops.

The project's design included multiple complex curves and elevation changes throughout. The boardwalk had to be fabricated in fifteen separate pieces, with each section having a unique curve and elevation. The curved HSS that made up the spine required the fabricator to hand torch the ends to the correct pitches and angles, with each cut being unique to each piece of the boardwalk and each end. This was achieved through extensive manual calculations in the fabrication shop as well as continued communication between the detailer and the fabricators. The handrail and mesh panels that lined each boardwalk piece were also hand calculated in the fabrication shop to ensure the straight panels could follow the curve and pitch of each section of the boardwalk. An added challenge was the egg shape that the tubes took on after being rolled. While this a common hurdle to overcome with any rolled member, it was an added complexity within an already complex project.

Along with the challenges that were presented with the boardwalk, there were also the curved members that made up the steel trees in three of the habitats. The fabrication shop had certain coordinates that they had to keep constant for the rolled members to hit, and each bracket attached to the curved members needed to be custom fabricated by hand to match the curve of the tube. An additional challenge involved the three steel halos that were attached to hold a mesh netting that encloses the habitat. Each of these halos is a different size and shape and had to be fabricated at a specific radius. The brackets attaching them to the curved steel trees had to be hand calculated for the proper angle to ensure erection in the field could be performed without hitting the existing sycamore and blue ash trees.

One of the largest challenges with connecting the trees to the halos involved the ball that sat in the halo pipe, which had to be hand cut at the correct angle for erection in the field. In addition, the ironworkers were tasked with erecting these pieces among trees that could not be touched or damaged, so each angle and radius had very little room for movement. ■

*For more information on the Michael and Quirsis Riney Primate Canopy Trails project, see "What's Cool in Steel" in the December 2022 issue, available at **www.modernsteel.com**. Note that Joe Nicoloff (deceased) of Nicoloff Detailing was also a steel detailer on this project.*

Owner
Saint Louis Zoo

General Contractor
Tarlton Corporation, St. Louis

Architect
PGAV Destinations, St. Louis

Structural Engineer
Leigh & O'Kane, Kansas City, Mo.

Animal Enclosure Consultant
A Thru Z Consulting, Tucson, Ariz.

Steel Team

Fabricator
The Gateway Company of Missouri, Berkeley, Mo.

Erector
Acme Erectors Inc., St. Louis

Detailer
Pan Gulf Technologies

Bender-Roller
Max Weiss Company, Milwaukee